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THE STUDY OF SOCIOLOGY.

By HERBERT SPENCER.

I.—Our Need of It.

OVER his pipe in the village ale-house, the laborer says very positively what Parliament should do about the "foot and mouth disease." At the farmer's market-table his master makes the glasses jingle as, with his fist, he emphasizes the assertion that he did not get half enough compensation for his slaughtered beasts during the cattle-plague. These are not hesitating opinions. On a matter affecting the agricultural interest, it is still as it was during the Anti-Corn-Law agitation, when, in every rural circle, you heard that the nation would be ruined if the lightly-taxed foreigner was allowed to compete in our markets with the heavily-taxed Englishman: a proposition held to be so self-evident that dissent from it implied either stupidity or knavery.

Now, as then, may be daily heard, among other classes, opinions just as decided and just as unwarranted. By men called educated, the old plea for extravagant expenditure, that "it is good for trade," is still continually urged with full belief in its sufficiency. Scarcely any decrease is observable in the fallacy that whatever gives employment is beneficial—no regard being had to the value for ulterior purposes of that which the labor produces; no question being asked what would have resulted had the capital which paid for the labor taken some other channel and paid for some other labor. Neither criticism nor explanation appreciably modifies these beliefs. When there is again an opening for them, they are expressed with undiminished confidence. Along with these delusions go whole families of others. People who think that the relations between expenditure and production are so simple, naturally assume simplicity in other relations among social phenomena. Is there distress somewhere? They suppose nothing more is required than to subscribe money for relieving it. On the one hand, they never trace the reactive effects which charitable donations work on bank-accounts, on the surplus capital bankers have to lend, on the productive activity which the capital now abstracted would have set up, on the number of laborers who would have received wages and who now go without wages; they do not perceive that certain necessaries of life have been withheld from one man who would have exchanged useful work for them, and given to another who perhaps persistently evades working. Nor, on the other hand, do they look beyond the immediate mitigation of misery; but deliberately shut their eyes to the fact that as fast as you increase the provision for those who live without labor, so fast do you increase the number of those who live without labor; and that, with an ever-increasing distribution of alms, there comes an ever-increasing outcry for more alms. Similarly throughout all their political thinking. Proximate causes and proximate results are alone contemplated; and there is scarcely any consciousness that the original causes are often numerous and widely different from the apparent cause, and that beyond each immediate result there will be multitudinous remote results, most of them quite incalculable.

Minds in which the conceptions of social actions are thus rudimentary, are also minds ready to harbor wild hopes of benefits to be achieved by administrative agencies. In each such mind there seems to be the unexpressed postulate that every evil in a society admits of cure; and that the cure lies within the reach of law. "Why is not there a better inspection of the mercantile marine?" asked a correspondent of the *Times* the other day; apparently forgetting that within the preceding twelve months the power he invoked had lost two of its own vessels, and barely saved a third. "Ugly buildings are eyesores, and should not be allowed," urges one who is anxious for æsthetic culture; and, meanwhile, from the agent which is to foster good taste, there have come monuments and public buildings of which the less said the better, and its chosen design for the Law-Courts incurs almost universal condemnation. "Why did those in authority allow such defective sanitary arrangements?" was everywhere asked, after the fevers at Lord Londesborough's; and this question you heard repeated, regardless of the fact that sanitary arrangements, having such results in this and other cases, were themselves the outcome of appointed sanitary administrations—regardless of the fact that the authorized system had itself been the means of introducing foul gases into houses.[1] "The State should purchase the railways," is confident-

[1] Of various testimonies to this, one of the most striking was that given by Mr. Charles Mayo, M.B., of New College, Oxford, who, having had to examine the drainage of Windsor, found that, "in a previous visitation of typhoid fever, the poorest and lowest part of the town had entirely escaped, while the epidemic had been very fatal in good houses. The difference was this, that, while the better houses were all connected with the sewers, the poor part of the town had no drains, but made use of cesspools in the gardens. And tnis is by no means an isolated instance."

ly asserted by those who, every morning, read of chaos at the Admiralty, or cross-purposes in the dock-yards, or wretched army organization, or diplomatic bungling that endangers peace, or frustration of justice by technicalities and costs and delays—all without having their confidence in officialism shaken. "Building Acts should insure better ventilation in small houses," says one who either never knew or has forgotten that, after Messrs. Reid & Barry had spent £200,000 in failing to ventilate the Houses of Parliament, the First Commissioner of Works proposed that "the House should get some competent engineer, above suspicion of partiality, to let them see what ought to be done."[1] And similarly there are continually cropping out in the press, and at meetings, and in conversations, such notions as that the State might provide "cheap capital" by some financial sleight of hand; that "there ought to be bread-overseers appointed by Government;"[2] that "it is the duty of Government to provide a suitable national asylum for the reception of all illegitimate children."[3] And here it is doubtless thought by some, as it is in France by M. de Lagevenais, that Government, by supplying good music, should exclude the bad, such as that of Offenbach.[4] We smile on reading of that French princess, celebrated for her innocent wonder that people should starve when there was so simple a remedy. But why should we smile? A great part of the current political thought evinces notions of practicability not much more rational.

That connections among social phenomena should be so little understood need not surprise us, if we note the ideas which prevail respecting the connections among much simpler phenomena. Minds left ignorant of physical causation are unlikely to appreciate clearly, if at all, that causation, so much more subtle and complex, which runs through the actions of incorporated men. In almost every house, servants, and those who employ them, alike believe that a poker leaned up in front of the bars, or across them, makes the fire burn; and you will be told, very positively, that experience proves the efficacy of the device—the experience being that the poker has been repeatedly so placed and the fire has repeatedly burned; and no comparison having been made with cases in which the poker was absent, and all other conditions as before. In the same circles the old prejudice against sitting down thirteen to dinner still survives: there actually exists, among ladies who have been at finishing-schools of the highest character, and among some gentlemen who pass as intelligent, the conviction that adding or subtracting one, from a number of people who eat together will affect the fates of some among them. And this state

[1] Debates, *Times*, February 12, 1852.

[2] Letter in *Daily News*, November 28, 1851.

[3] Recommendation of a Coroner's Jury, *Times*, March 26, 1850.

[4] *Revue des Deux Mondes*, February 15, 1872.

of mind is again displayed at the card-table, by the opinion that So-and-so is always lucky or unlucky—that influences are at work which, on the average, determine more good cards to one person than to another. Clearly, those, in whom the consciousness of causation in these simple cases is so vague, may be expected to have the wildest notions of social causation. Whoever even entertains the supposition that a poker put across the fire can make it burn, proves himself to have neither a qualitative nor a quantitative idea of physical causation; and if, during his life, his experiences of material objects and actions have failed to give him an idea so accessible and so simple, it is not likely that they have given him ideas of the qualitative and quantitative relations of cause and effect holding throughout society. Hence, there is nothing to exclude irrational interpretations and disproportioned hopes.

Where other superstitions flourish, political superstitions will take root. A consciousness in which there lives the idea that spilling salt will be followed by some evil, obviously allied as it is to the consciousness of the savage filled with belief in omens and charms, gives a home to other beliefs like those of the savage. It may not have faith in the potency of medicine-bags and idols, and may even wonder how any being can reverence a thing shaped with his own hands; and yet it readily entertains subtler forms of the same feelings. For, in those whose modes of thought we have been contemplating, there is a tacit supposition that a government moulded by themselves has some efficiency beyond that naturally possessed by a certain group of citizens subsidized by the rest of the citizens. True, if you ask them, they may not deliberately assert that a legislative and administrative apparatus can exert power, either mental or material, beyond the power proceeding from the nation itself. They are compelled to admit, when cross-examined, that the energies moving a governmental machine are energies which would cease were citizens to cease working and furnishing the supplies. But, nevertheless, their projects imply an unexpressed belief in some store of force that is not measured by taxes. When there arises the question—Why does not Government do this for us? there is not the accompanying thought—Why does not Government put its hands in our pockets, and, with the proceeds, pay officials to do this, instead of leaving us to do it ourselves; but the accompanying thought is—Why does not Government, out of its inexhaustible resources, yield us this benefit?

Such modes of political thinking, then, naturally go along with such conceptions of physical phenomena as are current. Just as the perpetual-motion schemer hopes, by a cunning arrangement of parts, to get from one end of his machine more energy than he puts in at the other; so the ordinary political schemer is convinced that out of a legislative apparatus, properly devised and worked with due dexterity, may be had beneficial State-action without some corresponding detrimental reaction. He expects to get out of a stupid people the effects of intelligence, and to evolve from inferior citizens superior conduct.

But, while the prevalence of crude political opinions, among those whose conceptions about simple matters are so crude, might be anticipated, it is somewhat surprising that the class specially disciplined by scientific culture should bring to the interpretation of social phenomena methods but little in advance of those used by others. Now that the transformation and equivalence of forces is seen by men of science to hold not only throughout all inorganic actions, but throughout all organic actions; now that even mental changes are recognized as the correlatives of cerebral changes, which also conform to this principle; and now that there must be admitted the corollary that all actions going on in a society are measured by certain antecedent energies, which disappear in effecting them, while they themselves become actual or potential energies, from which subsequent actions arise; it is strange that there should not have arisen the consciousness that these highest phenomena are to be studied as lower phenomena have been studied—not, of course, after the same physical methods, but in pursuance of the same principles. And yet scientific men rarely display such a consciousness.

A mathematician, who had agreed or disagreed with the view of Prof. Tait respecting the value of Quaternions for pursuing researches in Physics, would listen with raised eyebrows were one without mathematical culture to express a decided opinion on the matter. Or, if the subject discussed was the doctrine of Helmholtz, that hypothetical beings, occupying space of two dimensions, might be so conditioned that the axioms of our geometry would prove untrue, the mathematician would marvel if an affirmation or a negation came from a man who knew no more of the properties of space than is to be gained by daily converse with things around, and no more of the principles of reasoning than the course of business taught him. And yet, were we to take members of the Mathematical Society, who, having severally devoted themselves to the laws of quantitative relations, know that, simple as these are intrinsically, a life's study is required for the full comprehension of them—were we to ask each of these his opinion on some point of social policy, the readiness with which he answered would seem to imply that in these cases, where the factors of the phenomenon are so numerous and so much involved, a general survey of men and things gives data for trustworthy judgment.

Or, to contrast more fully the mode of reaching a conclusion which the man of science uses in his own department, with that which he regards as satisfactory in the department of politics, let us take a case from a concrete science—say, the question, What are the solar spots, and what constitution of the Sun is implied by them? Of tentative answers to this question there is first Wilson's, adopted by Sir William

Herschel, that the visible surface of the Sun is a luminous envelope, within which there are cloudy envelopes covering a dark central body; and that, when by some disturbance the luminous envelope is broken through, portions of the cloudy envelope and of the dark central body become visible as the penumbra and umbra respectively. This hypothesis, at one time received with favor mainly because it seemed to permit that teleological interpretation which required that the Sun should be habitable, accounted tolerably well for certain of the appearances—more especially the appearance of concavity which the spots have when near the limb of the Sun. But, though Sir John Herschel supported his father's hypothesis, pointing out that cyclonic action would account for local dispersions of the photosphere, there has of late years become more and more manifest the fatal objection that the genesis of light and heat remained unexplained, and that no supposition of auroral discharges did more than remove the difficulty a step back; since, unless light and heat could be perpetually generated out of nothing, there must be a store of force perpetually being expended in producing them.

A counter-hypothesis, following naturally from the hypothesis of nebular origin, is that the mass of the Sun must be incandescent; that its incandescence has been produced, and is maintained, by progressing aggregation of its once widely-diffused matter; and that surrounding its molten surface there is an atmosphere of metallic gases continually rising, condensing to form the visible photosphere, and thence precipitating. What, in this case, are the solar spots? Kirchhoff, proceeding upon the hypothesis just indicated, which had been set forth before he made his discoveries by the aid of the spectroscope, contended that the solar spots are simply clouds, formed of these condensed metallic gases, so large as to be relatively opaque; and he endeavored to account for their changing forms as the Sun's rotation carries them away, in correspondence with this view. But the appearances as known to observers are quite irreconcilable with the belief that the spots are simply drifting clouds. Do these appearances, then, conform to the supposition of M. Faye, that the photosphere encloses matter which is wholly gaseous and non-luminous; and that the spots are produced when occasional up-rushes from the interior burst through the photosphere? This supposition, while it may be held to account for certain traits of the spots, and to be justified by the observed fact that there *are* up-rushes of gas, presents difficulties not readily disposed of. It does not explain the manifest rotation of many spots; and, indeed, it does not seem really to account for that darkness which constitutes them spots; since a non-luminous gaseous nucleus would be permeable by light from the remoter side of the photosphere, and hence holes through the near side of the photosphere would not look dark.

There is, however, another hypothesis which more nearly reconciles the facts. Assuming the incandescent molten surface, the ascending metallic gases, and the formation of a photosphere at that outer limit where the gases condense; accepting the suggestion of Sir John Herschel, so amply supported by evidence, that zones north and south of the Sun's equator are subject to violent cyclones; this hypothesis is, that if a cyclone occurs within the atmosphere of metallic gases between the molten surface and the photosphere, its vortex will become a region of rarefaction, of refrigeration, and therefore of precipitation. There will be formed in it a dense cloud extending far down toward the body of the sun, and obstructing the greater part of the light radiating from below. Here we have an adequate cause for the formation of an opaque vaporous mass—a cause which also accounts for the frequently-observed vortical motion; for the greater blackness of the central part of the umbra; for the formation of a penumbra by the drawing in of the adjacent photosphere; for the elongation of the luminous masses forming the photosphere, and the turning of their longer axes toward the centre of the spot; and for the occasional drifting of them over the spot toward the centre. Still, there is the difficulty that vortical motion is by no means always observable; and it remains to be considered whether its non-visibility in many cases is reconcilable with the hypothesis. At present none of the interpretations can be regarded as established.

Here are sundry suppositions which the man of science severally tests by observations and necessary inferences. In this, as in other cases, he rejects such as unquestionably disagree with unquestionable truths. Continually excluding untenable hypotheses, he waits to decide among the more tenable ones until further evidence discloses further congruities or incongruities. Checking every statement of fact and every conclusion drawn, he keeps his judgment suspended until no anomaly remains unexplained. Not only is he thus careful to shut out all possible error from inadequacy in the number and variety of data, but he is careful to shut out all possible error caused by idiosyncrasy in himself. Though not perhaps in astronomical observations such as those above implied, yet in all astronomical observations where the element of time is important, he makes allowance for the intervals occupied by his nervous actions. To fix the exact moment at which a certain change occurred, his perception of it has to be corrected for the "personal equation." As the speed of the nervous discharge varies, according to the constitution, from thirty to ninety metres per second, and is somewhat greater in summer than in winter; and as, between seeing a change and registering it with the finger, there is an interval which is thus appreciably different in different persons; the particular amount of this error in the particular observer has to be taken into account.

Suppose now, that, to a man of science, thus careful in testing all possible hypotheses and excluding all possible sources of error, we put a sociological question—say, whether some proposed institution will be beneficial? An answer, and often a very decided one, is forthcoming at once. It is not thought needful, proceeding by deliberate induction, to ascertain what has happened in each nation where an identical institution, or an institution of allied kind, has been established. It is not thought needful to look back in our own history to see whether kindred agencies have done what they were expected to do. It is not thought needful to ask the more general question—how far institutions at large, among all nations and in all times, have justified the theories of those who set them up. Nor is it thought needful to infer, from analogous cases, what is likely to happen if the proposed appliance is not set up—to ascertain, inductively, whether in its absence some equivalent appliance will arise. And still less is it thought needful to inquire what will be the indirect actions and reactions of the proposed organization—how far it will retard other social agencies, and how far it will prevent the spontaneous growth of agencies having like ends. I do not mean that none of these questions are recognized as questions to be asked; but I mean that no attempts are made after a scientific manner to get together materials for answering them. True, some data have been gathered from newspapers, periodicals, foreign correspondence, books of travel; and there have been read sundry histories, which, besides copious accounts of royal misdemeanors, contain minute details of every military campaign, and careful disentanglings of diplomatic trickeries. And on information thus acquired a confident opinion is based.

Most remarkable of all, however, is the fact that no allowance is made for the personal equation. In political observations and judgments, the qualities of the individual, natural and acquired, are by far the most important factors. The bias of education, the bias of class-relationships, the bias of nationality, the political bias, the theological bias—these, added to the constitutional sympathies and antipathies, have much greater influence in determining beliefs on social questions than has the small amount of evidence collected. Yet, though, in his search after a physical truth, the man of science allows for minute errors of perception due to his own nature, he makes no allowance for the enormous errors which his own nature, variously modified and distorted by his conditions of life, is sure to introduce into his perceptions of political truth. Here, where correction for the personal equation is all-essential, it does not occur to him that there is any personal equation to be allowed for.

This immense incongruity between the attitude in which the most disciplined minds approach other orders of natural phenomena, and the attitude in which they approach the phenomena presented by societies, will be best illustrated by a series of antithesis thus: The material media, through which we see things, always more or less falsify the facts: making, for example, the apparent direction of a star slightly different from its real direction, and sometimes, as when a fish is seen in the water, its apparent place is so far from its real place, that great misconception results unless large allowance is made for refraction; but sociological observations are not thus falsified: through the daily press light comes without any bending of its rays, and in studying past ages it is easy to make allowance for the refraction due to the historic medium.

The motions of gases, though they conform to mechanical laws which are well understood, are nevertheless so involved, that the art of controlling currents of air in a house is not yet mastered; but the waves and currents of feeling running through a society, and the consequent directions and amounts of social activities, may be readily known beforehand.

Though molecules of inorganic substances are very simple, yet prolonged study is required to understand their modes of behavior to one another, and even the most instructed frequently meet with interactions of them producing consequences they never anticipated; but, where the interacting bodies are not molecules but living beings of highly-complex natures, it is easy to foresee all results which will arise. Physical phenomena are so connected that, between seeming probability and actual truth, there is apt to be a wide difference, even where but two bodies are acting: instance the natural supposition that during our northern summer the Earth is nearer to the Sun than during the winter, which is just the reverse of the fact; but among sociological phenomena, where the bodies are so multitudinous, and the forces by which they act on one another so many, and so multiform, and so variable, the probability and the actuality will naturally correspond.

Matter often behaves paradoxically, as when two cold liquids added together become boiling hot, as when the mixing of two clear liquids produces an opaque mud, or as when water immersed in sulphurous acid freezes on a hot iron plate; but what we distinguish as Mind, especially when massed together in the way which causes social action, evolves no paradoxical results—always such results come from it as seem likely to come.

The acceptance of contradictions like these, tacitly implied in the beliefs of the scientifically cultivated, is the more remarkable when we consider how abundant are the proofs that human nature is difficult to manipulate; that methods apparently the most rational disappoint expectation; and that the best results frequently arise from courses which common-sense thinks unpractical. Even individual human nature shows us these startling anomalies. A man of leisure is the man naturally fixed upon, if something has to be done; but your man of leisure cannot find time, and the man to be trusted to do what is wanted, is the man who is already busy. The boy who studies longest will learn the most, and a man will become wise in proportion as he reads much, are propositions which look true but are quite untrue

—as teachers are nowadays finding out in the one case, and as Hobbes long ago found out in the other. How obvious it appears that, when minds go deranged, there is no remedy but replacing the weak internal control by a strong external control! Yet the "non-restraint system" has had far more success than the system of strait-waistcoats. Dr. Tuke, a physician of much experience in treating the insane, has lately testified that the desire to escape is great when locks and keys are used, but almost disappears when they are disused. And in further evidence of the mischief often done by measures supposed to be curative, here is Dr. Maudsley, also an authority on such questions, speaking of "asylum-made lunatics." Again, is it not clear that the repression of crime will be effectual in proportion as the punishment is severe? Yet the great amelioration in our penal code, initiated by Romilly, has not been followed by increased criminality, but by decreased criminality; and the testimonies of those who have had most experience—Maconochie in Norfolk Island, Dickson in Western Australia, Obermier in Germany, Montesinos in Spain—unite to show that, in proportion as the criminal is left to suffer no other penalty than that of maintaining himself under such restraints only as are needful for social safety, the reformation is great: exceeding, indeed, all anticipation. French school-masters, never questioning the belief that boys can be made to behave well only by rigid discipline and spies to aid in carrying it out, are astonished on visiting England to find how much better boys behave when they are less governed—nay, among English schools themselves, Dr. Arnold has shown that more trust is followed by improved conduct. Similarly with the anomalies of incorporated human nature. We habitually accept the assumption that only by legal restraints are men to be kept from aggressing on their neighbors; and yet there are facts which should lead us to qualify this assumption. So-called debts of honor, for the non-payment of which there is no legal penalty, are held more sacred than debts that can be legally enforced; and on the Stock-Exchange, where only pencil memoranda in the respective note-books of two brokers guarantee the sale and purchase of many thousands, contracts are far safer than those which, in the outside world, are formally registered in signed and sealed parchments.

Multitudes of cases might be accumulated showing how, in other directions, men's thoughts and feelings produce kinds of conduct which, *a priori*, would be judged very improbable. And, if, going beyond our own society and our own time, we observe what has happened among other races, and among the earlier generations of our own race, we meet, at every step, workings-out of human nature utterly unlike those which we assume when making political forecasts. Who, generalizing the experiences of his daily life, would suppose that men, to please their gods, would swing for hours from hooks drawn through the muscles of their backs, or let their nails grow through the palms of their clinched hands, or roll over and over hundreds of miles to visit a shrine? Who would have thought it possible that a public sentiment and a force of custom might be such that a man should revenge himself on one who insulted him by disembowelling himself, and so forcing the insulter to do the like? Or to take historical cases more nearly concerning ourselves—Who foresaw that the beliefs in purgatory and priestly intercession would cause the lapse of one-third or more of England into the hands of the Church? Or who foresaw that a flaw in the law of mortmain might lead to bequests of large estates consecrated as graveyards? Who could have imagined that robber-kings and bandit-barons, with vassals to match, would, generation after generation, have traversed all Europe through hardships and dangers to risk their lives in getting possession of the reputed burial-place of one whose injunction was to turn the left cheek when the right was smitten? Or who, again, would have anticipated that, when, in Jerusalem, this same teacher disclaimed political aims, and repudiated political instrumentalities, the professed successors of his disciples would by-and-by become rulers dominating over all the kings of Europe? Such a result could be as little foreseen as it could be foreseen that an instrument of torture used by the Jews would give the ground-plans to Christian temples throughout Europe; and as little as it could be foreseen that the process of this torture, recounted in Christian narratives, might come to be mistaken for a Christian institution, as it was by the Malay chief who, being expostulated with for crucifying some rebels, replied that he was following "the English practice," which he read in "their sacred books."[1]

Look where we will at the genesis of social phenomena, and we shall similarly find that, while the particular ends contemplated and arranged for have commonly not been more than temporarily attained, if attained at all, the changes actually brought about have arisen from causes of which the very existence was unknown.

How, indeed, can any man, and how more especially can any man of scientific culture, think special results of special political acts can be calculated, when he contemplates the incalculable complexity of the influences under which each individual, and *a fortiori* each society, develops, lives, and decays? The multiplicity of these factors is illustrated even in the material composition of a man's body. Every one, who watches closely the course of things, must have observed that at a single meal he may take in bread made from Russian wheat, beef from Scotland, potatoes from the midland counties, sugar from the Mauritius, salt from Cheshire, pepper from Jamaica, curry-powder from India, wine from France or Germany, currants from Greece, oranges from Spain, as well as various spices and condiments from other places; and if he considers whence came the draught of water he swallows, tracing it back from the reservoir through the stream and the brook and the rill, to the separate rain-drops which fell wide apart,

[1] Boyle's "Borneo," p. 116.

and these again to the eddying vapors which had been mingling and parting in endless ways as they drifted over the Atlantic, he sees that this single mouthful of water contains molecules which, a little time ago, were dispersed over hundreds of square miles of ocean-swell Similarly tracing back the history of each solid he has eaten, he finds that his body is made up of elements which have lately come from all parts of the Earth's surface.

And what thus holds of the substance of the body, holds no less of the influences, physical and moral, which modify its actions. You break your tooth with a small pebble among the currants, because the industrial organization in Zante is so imperfect. A derangement of your digestion goes back for its cause to the bungling management in a vineyard on the Rhine several years ago; or to the dishonesty of the merchants at Cette, where imitation wines are produced. Because there happened a squabble between a consul and a king in Abyssinia, an increased income-tax obliges you to abridge your autumn holiday; or, because slave-owners in North America try to extend the "peculiar institution" farther west, there results here a party dissension which perhaps entails on you loss of friends. If from these remote causes you turn to causes at home, you find that your doings are controlled by a *plexus* of influences too involved to be traced beyond their first meshes. Your hours of business are predetermined by the general habits of the community, which have been slowly established no one knows how. Your meals have to be taken at intervals which do not suit your health; but under existing social arrangements you must submit. Such intercourse with friends as you can get is at hours and under regulations which everybody adopts, but for which nobody is responsible; and you have to yield to a ceremonial which substitutes trouble for pleasure. Your opinions, political and religious, are ready moulded for you; and, unless your individuality is very decided, your social surroundings will prove too strong for it. Nay, even such an insignificant event as the coming of age of grouse affects your goings and comings throughout life. For has not the dissolution of Parliament direct reference to the 12th of August? and does not the dissolution end the London season? and does not the London season determine the times for business and relaxation, and so affect the making of arrangements throughout the year? If from coexisting influences we turn to influences that have been working through past time, the same general truth becomes still more conspicuous. Ask how it happens that men in England do no work every seventh day, and you have to seek through thousands of past years to find the initial cause. Ask why in England, and still more in Scotland, there is not only a cessation from work, which the creed interdicts, but also a cessation from amusement, which it does not interdict; and for an explanation you must go back to successive waves of ascetic fanaticism in generations long dead. And what thus holds of religious ideas and usages, holds of all others, political and social. Even the industrial activities are often permanently turned out of their normal directions by social states that passed away many ages ago; as witness what has happened throughout the East, or in Italy, where towns and villages are still perched on hills and eminences chosen for defensive purposes in turbulent times, and where the lives of the inhabitants are now made laborious by having daily to carry themselves and all the necessaries of life from a low level to a high level.

The extreme complexity of social actions, and the transcendent difficulty which hence arises of counting on special results, will be still better seen if we enumerate the factors which determine one simple phenomenon, as the price of a commodity—say, cotton. A manufacturer of calicoes has to decide whether he will increase his stock of raw material at its current price. Before doing this, he must ascertain, as well as he can, the following data: whether the stocks of calico in the hands of manufacturers and wholesalers at home are large or small; whether by recent prices retailers have been led to lay in stocks or not; whether the colonial and foreign markets are glutted or otherwise; and what is now, and is likely to be, the production of calico by foreign manufacturers. Having formed some idea of the probable demand for calico, he has to ask what other manufacturers have done, and are doing, as buyers of cotton—whether they have been waiting for the price to fall, or have been buying in anticipation of a rise. From cotton-brokers' circulars he has to judge what is the state of speculation at Liverpool—whether the stocks there are large or small, and whether many or few cargoes are on their way. The stocks and prices at New Orleans, and other cotton-ports throughout the world, have also to be taken note of; and then there come questions respecting forthcoming crops in the Southern States, in India, in Egypt, and elsewhere. Here are sufficiently numerous factors, but these are by no means all. The consumption of calico, and therefore the consumption of cotton, and therefore the price of cotton, depends in part on the supplies and prices of other textile fabrics. If, as happened during the American Civil War, calico rises in price because its raw material becomes scarce, linen comes into more general use, and so a further rise in price is checked. Woollen fabrics, also, may to some extent compete. And, besides the competition caused by relative prices, there is the competition caused by fashion, which may or may not presently change. Surely the factors are now all enumerated? By no means. There is the estimation of mercantile opinion. The views of buyers and sellers respecting future prices, never more than approximations to the truth, often diverge from it very widely. Waves of opinion, now in excess, now in defect of the fact, rise and fall daily, and larger ones weekly and monthly, tending, every now and then, to run into mania or panic; for it is among men of business as among other men, that they stand hesitating until some one sets the example, and then rush all one way, like a flock of sheep after a leader. These characteristics in human nature, leading to these perturbations, the far-seeing buyer takes into account—judging how far existing influences have made opinion deviate from the truth, and how far impending influences are likely to do it. Nor has he got to the end of the matter even when he has considered all these things. He has still to ask what are the general mercantile conditions of the country, and what the immediate future of the money market will be; since the course of speculation in every commodity must be affected by the rate of discount. See, then, the enormous complication of causes which determine so simple a thing as the rise or fall of a farthing per pound in cotton some months hence!

If the genesis of social phenomena is so involved in cases like this, where the effect produced has no concrete persistence but very soon dissipates, judge what it must be where there is produced something which continues thereafter to be an increasing agency, capable of self-propagation. Not only has a society, as a whole, a power of growth and development, but each institution set up in it has the like—draws to itself units of the society and nutriment for them, and tends ever to multiply and ramify. Indeed, the instinct of self-preservation in each institution soon becomes dominant over every thing else; and maintains it when it performs some quite other function than that intended, or no function at all. See, for instance, what has come of the "Society of Jesus," Loyola set up; or see what grew out of the company of traders who got a footing on the coast of Hindostan.

To such considerations as these, set down to show the inconsistency of those who think that prevision of social phenomena is possible without much study, though much study is needed for prevision of other phenomena, it will doubtless be replied that time does not allow of systematic inquiry. From the scientific, as from the unscientific, there will come the plea that, in his capacity of citizen, each man has to act; must vote, and must decide before he votes; must conclude, to the best of his ability, on such information as he has.

In this plea there is some truth, mingled with a good deal more that looks like truth. It is a product of that "must-do-something" impulse which is the origin of much mischief, individual and social. An amiable anxiety to undo or neutralize an evil often prompts to rash courses, as you may see in the hurry with which one who has fallen is snatched up by those at hand; just as though there were danger in letting him lie, which there is not, and no danger in incautiously raising him, which there is. Always you find among people, in proportion as they are ignorant, a belief in specifics, and a great confidence in pressing the adoption of them. Has some one a pain in the side, or in the chest, or in the bowels? Then, before any careful inquiry as to its probable cause, there comes an urgent recommendation of a never-failing remedy, joined probably with the remark that, if it does no good, it can do no harm. There still prevails in the average mind a large amount of the fetishistic conception clearly shown by a butler to some friends of mine, who, having been found to drain the half-emptied medicine-bottles, explained that he thought it a pity good physic should be wasted, and that what benefited his master would benefit him. But, as fast as crude conceptions of diseases and remedial measures grow up into Pathology and Therapeutics, we find increasing caution, along with increasing proof that evil is often done instead of good. This contrast is traceable not only as we pass from popular ignorance to professional knowledge, but as we pass from the smaller professional knowledge of early times to the greater professional knowledge of our own. The question with the modern physician is not as with the ancient—shall the treatment be bloodletting? shall cathartics, or shall diaphoretics be given? or shall mercurials be administered? But there rises the previous question—shall there be any treatment beyond a healthy regimen? And even among existing physicians it happens that, in proportion as the judgment is most cultivated, there is the least yielding to the "must-do-something" impulse.

Is it not possible, then—is it not even probable—that this supposed necessity for immediate action, which is put in as an excuse for drawing quick conclusions from few data, is the concomitant of deficient knowledge? Is it not probable that, as in Biology so in Sociology, the accumulation of more facts, the more critical comparison of them, and the drawing of conclusions on scientific methods, will be accompanied by increasing doubt about the benefits to be secured, and increasing fear of the mischiefs which may be worked? Is it not probable that what in the individual organism is improperly, though conveniently, called the *vis medicatrix naturæ*, may be found to have its analogue in the social organism? and will there not very likely come, along with the recognition of this, the consciousness that in both cases the one thing needful is to maintain the conditions under which the natural actions may have fair play? Such a consciousness, to be anticipated from increased knowledge, will diminish the force of this plea for prompt decision after little inquiry; since it will check this tendency to think of a remedial measure as one that may do good and cannot do harm. Nay, more, the study of Sociology, scientifically carried on by tracing back proximate causes to remote ones, and tracing down primary effects to secondary and tertiary effects which multiply as they diffuse, will dissipate the current illusion that social evils admit of radical cures. Given an average defect of nature among the units of a society, and no skilful manipulation of them will prevent that defect from producing its equivalent of bad results. It is possible to change the form of these bad results; it is possible to change the places at which they are manifested; but it is not possible to get rid of them. The belief, that faulty character can so organize itself socially as to get out of itself a conduct which is not proportionately faulty, is an utterly baseless belief. You may alter the incidence of the mischief, but the amount of it must inevitably be borne somewhere. Very generally it is simply thrust out of one form into another; as when, in Austria, improvident marriages being prevented, there come more numerous illegitimate children; or as when, to mitigate the misery of foundlings, hospitals are provided for them, and there is an increase in the number of infants abandoned; or as when, to insure the stability of houses, a Building Act prescribes a structure which, making small houses unremunerative, prevents due multiplication of them, and so causes overcrowding; or as when a Lodging-House Act forbids this overcrowding, and vagrants have to sleep under the Adelphi-arches, or in the Parks, or even, for warmth's sake, on the dung-heaps in mews. Where the evil does not, as in cases like these, reappear in another place or form, it is necessarily felt in the shape of a diffused privation. For, suppose that by some official instrumentality you actually suppress an evil, instead of thrusting it from one spot into another—suppose you thus successfully deal with a number of such evils by a number of such instrumentalities—do you think these evils have disappeared absolutely? To see that they have not, you have but to ask, Whence comes the official apparatus? What defrays the cost of working it? Who supplies the necessaries of life to its members through all their gradations of rank? There is no other source but the labor of peasants and artisans. When, as in France, the administrative agencies occupy some 600,000 to 700,000 men, who are taken from industrial pursuits, and, with their families, supported in more than average comfort, it becomes clear enough that heavy extra work is entailed on the producing classes. The already-tired laborer has to toil an additional hour; his wife has to help in the fields as well as to suckle her infant; his children are still more scantily fed than they would otherwise be; and, beyond a decreased share of returns from increased labor, there is a diminished time and energy for such small enjoyments as the life, pitiable at the best, permits. How, then, can it be supposed that the evils have been extinguished or escaped? The repressive action has had its corresponding reaction; and, instead of intenser evils here and there, or now and then, you have got an evil that is constant and universal.

When it is thus seen that the evils are not got rid of, but, at best, only redistributed, and that the question in any case is, whether redistribution, even if practicable, is desirable, it will be seen that the "must-do-something" plea is a quite insufficient one. There is ample reason to believe that, in proportion as scientific men carry into this most involved class of phenomena the methods they have successfully adopted with other classes, they will see that, even less in this class than in other classes, are conclusions to be drawn and action to be taken without prolonged and critical investigation.

Still there will recur the same plea under other forms. "Political conduct must be matter of compromise." "We must adapt our measures to immediate exigencies, and cannot be deterred by remote considerations." "The data for forming scientific judgments are not to be had: most of them are unrecorded, and those which are recorded are difficult to find as well as doubtful when found." "Life is too short, and the demands upon our energies too great, to permit any such elaborate study as seems required. We must, therefore, guide ourselves by common-sense as best we may."

And then, behind the more scientifically-minded who give this answer, there are those who hold, tacitly or overtly, that guidance of the kind indicated is not possible, even after any amount of inquiry. They do not believe in any ascertainable order among social phenomena—there is no such thing as a social science. This proposition we will discuss in the next chapter.

THE RECENT ECLIPSE OF THE SUN.

By R. A. PROCTOR, B. A., F. R. A. S.

THE eclipse of the sun which took place on December 12th last was looked forward to by astronomers with some anxiety, because many months must pass before they will have any similar opportunity of studying the sun's surroundings. Year after year, for four years in succession, there have been total eclipses of the sun—in each year one —and each eclipse has taught us much that has been worth knowing; but during the present year there will be no total solar eclipse worth observing; there will be none in 1873, only one (and not a very important one) in 1874, while during the total eclipse of 1875 the moon's shadow will traverse a path very inconveniently situated for intending observers.

Besides, the inquiries and discussions of astronomers had reached a very interesting stage before the recent eclipse occurred. A sort of contest—though, of course, a friendly and philosophic contest—had been waged over the sun's corona, the halo or glory which is seen around the black disk of the moon when the sun is totally concealed; and, though, in the opinion of most astronomers, the contest had really been decided by the observations made during the total eclipse of December, 1870, some slight doubts still existed in the minds of a few.

It was hoped—and the hope would appear to have been justified—that during the late eclipse these doubts would be finally removed. A few weeks must elapse even after the present paper appears, and five or six from the present time of writing, before the sun-painted pictures, which are to decide the question, can be in the hands of the judges. But, from the description which has already reached us, we can feel very little doubt as to the nature of the decision which will be arrived at.

A brief sketch of the progress of the inquiry into the subject of the solar corona will serve to exhibit the nature of the doubts which the recent expeditions to the Indian seas were intended to remove.

From very early ages it had been known that when the sun's disk is wholly concealed by the moon, a glory of light starts into view, rendering the scene less terrible, though scarcely less striking, than it would be were total darkness to prevail.

Now, gradually, it began to be recognized that this glory around the sun consisted of several distinct portions. In the first place, quite close to the moon's black body, a very narrow ring of light had been observed, so bright that many astronomers were led to believe that the sun was not in reality totally concealed, but that a ring of sunlight remained even at the moment of central eclipse. This excessively bright ring of light is not, however, always seen, if (as many accounts suggest) it is to be distinguished from the bright inner corona of which I shall presently have to speak. During the recent eclipses we have had no clear evidence respecting this brilliant but very narrow ring; and it is just possible that the accounts derived from earlier eclipses have been a little exaggerated.

Then, secondly, a red border is seen around portions of the black disk of the moon. This border has commonly a serrated edge, and has been called the *sierra*, from a well-known Spanish name for a range of hills. From what thus resembles a chain of rose-colored mountains, appear to spring certain red projections which have been called the solar prominences. Their general appearance during eclipse may be inferred from the description given by those who first observed them, in 1842, who compared the moon's disk surrounded by these glowing objects to a black brooch set round with garnets. But it is now known that such names as *prominences* and *protuberances* are not properly applicable to these red objects, and that the word *sierra* is equally inapplicable to the rim of colored light beneath the red projections. The prominences as well as the sierra (for, however unsuitable, the names continue in use) are in reality formed of glowing gas, hydrogen being their chief constituent element, but other elements being also present in a gaseous form. Only, the reader must not run away with the notion that these great red masses, some of which are more than a hundred thousand miles in height, are of the nature of our gas-flames. They are not, properly speaking, flames at all, but masses of gas glowing with intensity of heat.[1]

Many of the most important discoveries recently made respecting the sun relate to these wonderful objects; but in this place I shall refrain from speaking more about them than seems necessary to illustrate the subject of the corona; for, as a matter of fact, the observers during the late eclipse turned scarcely a thought to the colored prominences, nor is it likely that any thing new respecting them will ever be learned during total eclipses of the sun.

Outside the sierra and the prominences, the true corona is seen. To ordinary vision, and probably also even under the scrutiny of powerful telescopes, it appears to be divided into two distinct portions. There is in the first place an inner and brighter region, extending apparently to a distance from the sun equal to about one-fifth of his diameter. The outline of this inner corona is uneven but not radiated, and, though not sharply defined, appears yet to be very definitely indicated by the rapid falling off of lustre beyond its limits. The inner corona has been described as of a white, pearly lustre by some observers; but under the most favorable conditions it appears, when carefully observed, to have a somewhat ruddy hue.

Extending much farther from the sun, how far is not as yet known, is the radiated corona. It is much fainter than the inner corona, and its light grows fainter and fainter with distance from the sun, until lost to view on the dark but not black background of the sky. Through this faint and softly-graduated corona extend radiations of somewhat greater brightness. It is between these radiations that those dark gaps or rifts appear, which have figured so much in the narratives of recent eclipse observations. The dark gaps are, indeed, more striking features than the radiations which form them; but it must be remembered, nevertheless, that the radiations are the only positive features in this case, the gaps being merely regions where there are no radiations.

We may typically represent the corona, as it had been revealed to us during former eclipses, by the accompanying sketch from a photograph taken by Mr. Brothers at Syracuse during the eclipse of December, 1870. Only, it must be remembered that the photograph may not represent the full extent of the corona, while many details of its structure are too delicate to be shown in a figure so small as is here given. It will be understood further that the inner part, marked R, is much brighter than the whole of the outer part, marked C, and that this outer part shades off gradually into the dark background of the sky.

[1] In a gas-flame there is (as our meters tell us) a continual supply of gas, which mixes with the oxygen of the air, and undergoes what is called combustion. But in the sun's colored prominences the hydrogen enters into no chemical combination, at least none such as we are familiar with. Simply by the intense heat to which it is exposed it glows, just as iron glows when it is heated sufficiently.

Now, the question which has agitated astronomy during the past few years has been simply whether the glory of light seen around the sun is in reality a solar appendage, or may not be due wholly or in part to the illumination either of our own atmosphere or of some other matter (not necessarily atmospheric) lying much nearer to us than the sun does. If we consider the figure, we can see at once that if we have here a real solar appendage—that is, matter which exists all around the sun's globe—it is an appendage of the most amazing extent. The black disk which forms the centre of the figure is of course intended to represent the moon, whose diameter we know is about 2,200 miles, and if for a moment we suppose the corona C and R surrounds the moon, we see that it must extend on one side to about 5,000 miles, and elsewhere to about 2,800 miles. But exactly behind the moon lies the sun, a little more than concealed by the moon; and the sun's diameter is about 850,000 miles. So that, if the corona is something which surrounds the sun, it extends, as the picture shows, to at least 2,000,000 miles on one side, and elsewhere to about 1,200,000 miles. Neglecting the dark rifts for the moment, and regarding the whole corona as shaped like a globe, and having a diameter four times as great as the sun's, we should have to regard its volume as exceeding his *not* four times, nor sixteen times, but sixty-four times. And when we are reminded that the sun's own volume exceeds that of this earth on which we live some 1,200,000 times, we see what a stupendous conclusion we must arrive at, if we regard the corona as a solar appendage. Of course, we need not imagine that the corona has a continuous substance completely filling a space some 77,000,000 times larger than the earth. It may be made up of multitudes of minute bodies, with vacant spaces between. But the conclusion remains that a region of space, exceeding our earth's volume so many millions of times, is thus occupied by matter of some sort.

Nor is the conclusion rendered a whit less surprising if we take the dark rifts into account. Nay, we obtain an enhanced idea of the wonderful nature of the corona, regarded as a solar appendage, when we consider that it possesses so remarkable a structure that, as seen from our distant stand-point, it shows well-defined gaps or rifts. For unquestionably it is not to be regarded as something flat or plane-shaped, like its picture, or a decoration (which in appearance it often strikingly resembles). It must extend *on all sides* from the sun (if it is indeed a solar appendage), and not merely from the sides of the disk he turns toward us at the time of an eclipse; and it can easily be seen that its shape, in length and breadth and thickness, must be strange, to account for such rifts as are shown in the figure. If we take an orange to represent the sun, and, boring holes all over it, stick spills in these holes to represent the region occupied by the corona, we shall find that, in order that our spillikined orange may exhibit a rifted corona in whatever position it is placed, we must either leave several large parts of its surface without spills, or that the spills over many such parts must be very short. When this consideration is attended to, the spillikin corona will be found to have a very complex and remarkable figure.

It is not to be wondered at that, so soon as the corona began to be thought about at all, astronomers were led to believe that it is not of the nature of a solar appendage, but either a sort of halo in our own atmosphere, or else an appendage belonging in some way to the moon. Kepler and Halley and Newton, to say nothing of a host of other astronomers who considered the question during the infancy of modern astronomy, were led to different conclusions, by the comparatively imperfect evidence available in their day. We may pass over the arguments adduced in favor of the three several theories which were in question. Suffice it that, gradually, it was admitted more and more generally that the corona must be some appendage surrounding the sun; and, in comparatively recent times—a quarter of a centuary ago, or thereabouts—the opinion began to prevail that the corona is in fact the sun's atmosphere.

But quite recently discoveries were made which seemed to throw great doubt upon this opinion. By means of the instrument called the spectroscope, astronomers have learned not only how to study the sun's colored prominences when the sun is shining in full splendor, but also to determine to some extent the condition of the glowing gas of which those prominences are formed. When this was done, it did not appear that the density of the glowing gas—even close by the sun's body—was so great as might be expected if the corona were an atmosphere properly so called. Some prominences are shown in the figure; and if we consider the pressure to which objects so placed must be subjected, supposing them to lie at the bottom of an atmosphere more than a million miles in height, we shall at once see that the pressure of our own air at the sea-level would be a mere nothing by comparison. It is supposed that our air may be two or three hundred miles in depth, but, even if we suppose it to be ten times as deep as this, the depth of the imagined solar atmosphere would be many times greater. And then the pressure of our air is caused by the earth's attraction, and would be greater if the earth exerted a greater attraction. But the attractive energy of the sun (at his surface) exceeds the force of the earth's gravity about twenty-seven times. We may safely infer, then, that an atmosphere such as the corona was supposed to be, would cause a pressure exceeding the atmospheric pressure we experience some thousands of times. The gas forming the prominences would be correspondingly compressed under these circumstances. But as a matter of fact the pressure at the very base of the colored prominences appears to be a mere fraction of that which our own air exerts at the sea-level.

Accordingly, Mr. Lockyer, who had taken a prominent part in establishing this very interesting result, was led to express the opinion that the sun's atmosphere has no such extent as had been imagined, and that the corona is an appearance (only) in our own air, "an atmospheric effect merely," "due to the passage of the sun's rays through our own atmosphere."

This conclusion was, however, not very generally accepted. Several astronomers at once pointed out that the air which lies toward the place on the heavens where the corona is seen, is not illuminated at all by the sun's rays during total eclipse. I also pointed out that whatever light that particular part of the air receives during totality —not direct sunlight, but light from the prominences, and so much of the corona as might be admitted to be solar—would extend over the very place of the moon, and gradually *increase* thence on all sides instead of gradually diminishing, as happens with the corona. This would not be the place to exhibit the reasoning by which these results can be demonstrated; for mathematical considerations, not altogether simple, are involved in the complete discussion of the matter. Let it suffice to say, as respects the air between the observer and the moon, that, since the observer can see the colored prominences and the inner bright corona during totality, the air all around him (toward the moon as well as elsewhere) must be lit up by their light. And as respects the gradual increase of brightness on all sides of the place where the eclipsed sun is, let the reader consider that, if, at any time during totality, a bird were to fly (with enormous rapidity) from the observer's station directly toward the moon's centre, that bird would remain in the moon's shadow as he so flew; but if he flew in any other direction he would presently pass out of the shadow—that is, he would reach a place where the air is illuminated. And he would so much the more quickly reach the illuminated air, as he flew more directly from the moon's place on the sky. So that, putting the line of the observer's sight instead of the swiftly-flying bird, we see that this line will so much the sooner reach illuminated air, according as it is turned farther from the place of the moon on the heavens. Thus the air toward the place of the moon, though illuminated, is less brightly illuminated than that lying toward any other part of the sky; and the atmospheric illumination must gradually increase the farther we turn our eyes from the moon's place.

So matters stood when preparations were being made for the expeditions to view the eclipse of 1870. Evidence had, indeed, been obtained during the eclipse of 1869 in America, which seemed to show that the substance of the corona is gaseous; and singularly enough it appeared as though this substance, whatever it might be, shone with a light resembling that of the aurora borealis. But those who regarded the corona as a mere glare in our own atmosphere, rejected these results because they seemed "bizarre and perplexing in the extreme." The American astronomers, however, were not willing to have their observations rejected in this summary fashion; and they, therefore, crossed the Atlantic in great force to observe the Mediterranean eclipse of December, 1870.

It was with some little regret, I must confess, that, as the eclipse of 1870 drew near, I found many of the intending observers proposing to direct their chief attention to the question whether the corona is a solar appendage or a mere glare in our own atmosphere. It seemed to me clear that the atmospheric theory was completely disposed of by the evidence, while a host of interesting questions remained to be answered respecting the nature of the amazing solar appendage thus shown to exist. "I think I have not erred," I wrote in October, 1870, "in insisting that we have ample evidence to prove that the corona is a solar appendage; but what sort of appendage it may be, remains yet to be shown. Observations directed to show whether it is or not a solar appendage will, I apprehend, be a total waste of time; and it is for this reason that I have, at the meetings of the Astronomical Society and elsewhere, deprecated all such observations."—(Preface to second edition of "Other Worlds.") Nay, I fear I even offended one or two by the zeal with which I urged the importance of endeavoring to determine, not whether the corona is a solar appendage, but what sort of solar appendage it may be.

However, the observations were made, photographs and sketches were taken, and the general conclusion drawn from the work of 1870 was that which Sir John Herschel, only six weeks before his lamented decease, enunciated in the following terms in a letter addressed to myfelf: "The corona is certainly extra-terrestrial and ultra-lunar."

Even then, however, some doubts still remained in a few minds. The question of the corona was still mooted in essays and lectures—nay, the atmospheric theory was so successfully defended before the British Association last August, as to lead Prof. Tait to remark that, in his opinion, it was in the main true; while the president of the meeting—Prof. Thompson—even expressed the opinion that the special observations made last December proved that the greater part of the corona was a mere phenomenon of our own atmosphere. It must be pointed out, however, in justice to these eminent mathematicians, that only one side of the question had been adequately presented to them.

Thus another year had passed, and the subject of the corona stood almost exactly as in the autumn of 1870. Well-appointed expeditions were again about to set forth to view an important eclipse, and again the question which the observers had before them was the worn-out problem whether the corona is or is not a solar appendage.

But much more faith was placed in photography than had been the case in 1870. *Then*, men doubted whether photography *could* give good pictures of the corona. The colored prominences had been photographed repeatedly; but the finest telescopes had failed to bring the corona fairly on to the glass. Mr. Brothers, of Manchester, however, showed how this difficulty was to be surmounted. He discarded the telescope and employed the ordinary photographic camera. The results were most satisfactory. The eclipsed sun was indeed partially hidden by clouds during all but the last few seconds of totality; but for eight seconds the camera was fairly at work; and the result was, "the corona as it had never been seen on glass before."

THE SUN'S CORONA.
R, the inner or ring-formed corona; C, the outer radiated corona.

During the late eclipse, Mr. Brothers's plan was adopted at several stations, and most successfully, by all the photographing parties whose accounts have yet reached Europe. For many weeks, however, these photographs will not be available for examination. The great point which we know already respecting them is this: that they show an extensive corona, with *persistent* rifts—those taken at the beginning of totality differing from those taken at the end only as respects parts of the corona very far from the sun. All those doubts, which had been based on the circumstance that Mr. Brothers's best photograph was taken nearly at the close of totality, are therefore removed by the photographs taken on the present occasion.

But, the corona was so favorably seen even with the naked eye, during the recent eclipse, as to dispose of all the doubts formerly entertained. In an interesting letter in the *Daily News*, an eye-witness at Bekul, describing Mr. Lockyer's observations, says that so soon as the totality began the corona appeared, *rigid* in the heavens, like a magnificent decoration, suggesting by its fixity the idea of perfect rest in those distant regions. It was marked with radial streaks of great brilliancy, separated by relatively dark furrows, and extending all round the upper and lower parts of the moon's circumference, but less conspicuous (or altogether wanting—the account is not very clear on this point) at the sides. This observation is of great interest, because the upper and lower parts of the sun's circumference at the moment of observation corresponded to the sun's equatorial regions, while the sides corresponded to the position of the solar poles. Mr. Lockyer's account thus seems to support a theory lately urged, according to which the corona is caused by radial emanations chiefly from the neighborhood of the solar equator. It is clear, however, from the rifts (especially as shown in the figure), that such emanations cannot be continuous, but must take place locally, and, as it were, fitfully.

But the most important account which has yet reached Europe is that contained in a letter from M. Janssen, the eminent spectroscopist, to M. Faye, the president of the French Academy of Sciences. It should be noted, in the first place, that in a letter to the secretary of the Academy Janssen says: "I have just observed the eclipse, only a few moments ago, with an admirable sky; and, while still under the emotion occasioned by the splendid phenomenon which I have but now witnessed, I send you a few lines by the *Bombay Courier.* The result of my observations at Sholoor indicates, without any doubt, the solar region of the corona and the existence of material substances (*matières*) outside the sierra." Then follows his letter to the president, which runs thus: "I have seen the corona as I could not in 1868, when I gave myself wholly to the prominences. Nothing could be more beautiful or more brilliant; and there were definite forms which exclude all possibility of an origin in our own atmosphere." He proceeds to describe the coronal spectrum, confirming the American observations—with one notable exception: he recognized the solar dark lines in the spectrum of the corona, a proof that no inconsiderable portion of its light is reflected sunlight. Then he draws his letter to a conclusion with these decisive words: "I conceive that the question whether the corona is due to our own atmosphere is disposed of (*tranchée*), and we have before us in perspective the study of the regions lying outside the sun, which must needs be most interesting and fruitful." I could wish that the same opinion had been received when it was advocated twenty-two months ago in almost the same words.—*Cassell's Magazine.*

SCIENCE AND IMMORTALITY.

By Rev. T. W. FOWLE.

HE who pretends to have any thing new to say upon so old a subject as the immortality of the soul, must expect to arouse certainly opposition, and probably contempt. Nevertheless, this at least is certain, that the tendency of science, which has powerfully affected every domain of thought in new and unexpected ways, cannot but place the old doctrine of immortality under new and, it may be, unexpected lights, abolishing old arguments, and suggesting new ones that have not yet obtained the consideration they deserve. My object in this paper is to endeavor, by the aid of all-victorious analysis, to throw some little light upon the relations of the belief in immortality with scientific thought; and, at the outset, I wish distinctly and positively to affirm that it is not my intention to construct any argument for the belief against science, but merely to explain the conditions under which, as it seems to me, the question must be debated. Those conditions, though in themselves plain and simple, are, I believe, very imperfectly understood, and much bewildering nonsense is talked upon both sides of the question by men who have not clearly realized the nature of evidence, the amount of proof required, or the sources from which that proof must be derived. I think it possible to lay down a series of propositions with which, in principle at any rate, most reasonable minds would agree, and which would have the effect of defining the area of debate and the true point of conflict. This may sound presumptuous; whether it be really so or not, the event alone can prove.

Now, the first demand of science is for an accurate definition of the object of discussion, that is, that both religious and scientific thinkers should be quite sure that they are discussing the same thing. Immortality is bound up in the minds of religious people with a vast amount of beautiful and endearing associations, which form no part of the hard, dry fact itself. The definition of immortality, viewed scientifically, is, I take it, something of this sort: the existence of a thinking, self-conscious personality after death, that is, after the bodily functions have ceased to operate. This personality may or may not exist forever; it may or may not be responsible for the past; it may or may not be capable of rest, joy, and love; it may or may not be joined to its old body or to a new body. These, and a hundred similar beliefs with which religion has clothed the mere fact of existence after death, form no essential part, I must again affirm, of the fact itself. And throughout the argument, this, and no other than this, will be the sense in which I use the word immortality; because it is the only one that I have a right to expect that the scientific mind will accept.

It may be well, also, before going further, to make it clear to ourselves in what sense we use the word religion. Men who would be very much ashamed of themselves if they were detected using scientific words inaccurately, do, nevertheless, attribute meanings to the word religion, which it is difficult to hear with patience. I have heard an eminent scientific man upon a public occasion, and in a serious manner, define religion to be duty, making a mere idle play upon the original meaning of the word. Without, however, entering into verbal discussions, it will be, surely, enough to define religion as a practical belief in, and consciousness of, God and immortality; and, as the latter is now absolutely essential to the idea of religion as a motive moral power, and as, moreover, it includes, or at any rate necessitates the belief in the existence of God, we may fairly conclude that, for all practical purposes, and certainly for the purpose of this argument, religion is synonymous with a belief in immortality. And if, for any reason, mankind does at any time cease to believe in its own immortality, then religion will also have ceased to exist as a part of the consciousness of humanity. To clear up, therefore, the relations between immortality and science becomes a matter of the utmost importance It will be well next to analyze briefly the effect which science has upon the nature of the proofs by which this, like all other facts, must be demonstrated. Let us, for convenience' sake, regard the world as a vast jury, before which the various advocates of many truths, and of still more numerous errors, plead the cause of their respective clients. However much a man may wrap himself up in the consciousness of ascertained truth, and affirm that it makes no matter to him what the many believe, yet Nature is in the long-run too powerful for him, and the instinct of humanity excites him to plead the cause of what he knows to be truth, and to mourn in his heart and be sore vexed if men reject it. Truth is ever generous and hopeful, though at the same time patient and long-suffering; she longs to make converts, but does not deny herself or turn traitress to her convictions if converts refuse to be made. There is a sense, indeed, in which it may be said that truth only becomes actual and vital by becoming subjective through receiving the assent of men. What, then, must the advocate for the fact of the immortality of the soul expect that science will require of him when he pleads before the tribunal of the world for that truth which, because it is dear to himself, he wishes to enforce on others?

The alterations in the minds of men, which the tendency of modern thought has effected in respect of evidence, may be summed up under two heads: First, the nature of the evidence required is altogether altered, and a great many arguments, that would in former days have gone to the jury, are now summarily suppressed. Fact can only be proved by facts, that is, by events, instances, things, which are submitted to experience and observation, and are confirmed by experiment and reason. And, secondly, the minds of the jury are subject to *a priori*, and, on the whole, perfectly reasonable prepossessions before the trial begins. The existence of changeless law, the regular, natural, and orderly march of life, the numerous cases in which what seemed to be the effect of chance or miracle have been brought within the limits of ascertained causation; all these things predispose the mind against pleadings for the supernatural or the divine. Most true, of course, it is, that there are most powerful prepossessions on the other side as well; but the difference is, that these are as old as man himself, while the former have only been of later times imported into the debate, and, if they have not been originated, have at least received their definite aim and vivid impulse from the results of scientific research.

Now, the first result which flows from these alterations is the somewhat startling one, that all the arguments for immortality derived from natural religion (so called) are, in the estimation of science, absolutely futile. To put this point in the strongest form, all the hopes, wishes, and convictions of all the men that ever lived, could not and cannot convince one single mind that disbelieves in its own immortality. Unless the advocates of religion clearly apprehend this truth, they are, it seems to me, quite disabled from entering into the discussion upon conditions which their opponents, by the very law of this opposition, cannot but demand. It is true, indeed, that this temper of mind is confined at present to a comparatively few persons, as in the last century it belonged to the philosophers and to their immediate followers. But then it is as clear as the day that, as science is getting a more and more practical hold upon men's minds by a thousand avenues, and mastering them by a series of brilliant successes, this temper is rapidly passing from the few into the popular mind; that it is becoming part of the furniture of the human intellect, and is powerfully influencing the very conditions of human nature. Sooner or later we shall have to face a disposition in the minds of men to accept nothing as fact, but what facts can prove, or the senses bear witness to. In vain will witness after witness be called to prove the inalienable prerogative, the intuitional convictions, the universal aspirations, the sentimental longings, the moral necessity, all which have existed in the heart of man since man was. Nor will the science of religion help us in the hour of need. There can be a science of religion exactly as there can be a science of alchemy. All that men have ever thought or believed about the transmutation of metals may be brought together, classified as facts, and form a valuable addition to our knowledge of the history of the human mind, but it would not thereby prove that the transmutation had taken place, or that the desire for it was any thing more than man's childlike strivings after that which could only be really revealed by the methods of natural science. So also the science of religion can prove what men have held, and suggest what they ought to hold. It can show that they have believed certain things to be true, it is utterly powerless to prove that they are true. It can strengthen the principle of faith in those who do not require positive demonstration for their beliefs; it cannot even cross swords with those, soon to be the majority of thinking men, to whom positive demonstration has become as necessary to their minds as food to their bodies. Nay, they will resent rather than welcome the attempt to put a multitude of hopes and myriads of wishes in the place of one solid fact, and will soon confirm themselves in their opinions, by the obvious argument that these hopes and wishes are peculiar to the childhood of the race, and form only one out of many proofs, that man is liable to perpetual self-deception until he confronts fact and law. Not indeed that they will indulge in the equally unscientific statement that there is no such thing as immortality. The attitude of mind which they will assume will be that of knowing nothing, and of having no reasonable hope of ever discovering any thing, about man's future destiny. And while they will think it good that man, or at any rate that some men, should allow themselves to hope for life after death, yet they will steadily oppose any assertion that these hopes ought to guide men's conduct, influence their motives, or form their character. Now, if this be true, it is difficult to overrate the importance of thoroughly and distinctly realizing it. That the evidence for the truths of natural religion is overwhelming, is one of the statements that are accepted as truisms, at the very moment that science is slowly leavening the human intellect with the conviction that all such evidence is scientifically worthless. Nevertheless the opposite idea has taken firm hold of the religious mind, and forms the basis of many an eloquent refutation of the "presumptuous assurance" and "illogical obstinacy" of modern thought. Men must have smiled to hear themselves alternately refuted and rebuked by controversialists who did not understand the tone of mind against which they were arguing, or who assumed as true the very things which their opponents resolved to know nothing about, either in the way of belief or rejection. It is very certain, however, that this error will not yield to the mere statement that it is an error, and therefore I will go on to examine a little more minutely the various arguments by which men seek to prove the doctrine of immortality These are mainly fourfold:

1. That it is an original intuition, and arising from this,
2. That it is a universal belief.
3. That it follows necessarily from the existence of God.
4. That it is essential as a motive for human morality.

1. I take the statement of this argument from the words of one than whom no man has a better right to be heard on such a subject. Prof. Max Müller, in his preface to the first volume of his "Chips from a German Workshop," writes as follows: "An intuition of God, a sense of human weakness and dependence, a belief in a Divine government of the world, a distinction between good and evil, and a hope of

a better life, these are the radical elements of all religions. . . . Unless they had formed part of the original dowry of the human soul, religion itself would have remained an impossibility." Now, I am not quite sure that I understand in what sense the writer means to assert that these intuitions, which, for practical purposes, may be limited to three, God, sin, and immortality, are part of the original dowry of the human soul. If it is meant that there was a special creation of the human soul, furnished from the beginning with these three intuitions, then science will resolutely refuse to admit the fact. There can be no mistake about the position held by the bulk of scientific men, and little doubt, I should think, as to its reasonableness. If there is any thing that is in ultimate analysis incomprehensible, or any fact that cannot be accounted for by natural causes, then the possibility of special creation and original intuitions must be candidly allowed, but not otherwise. There is just a chance, for instance, that the difference between the brains of the lowest man and the highest animal may ultimately be regarded as a fact inexplicable upon any theory of evolution; more, however, from a lack of evidence than from any other cause. Be this as it may, the possibility of special creation finds a distinct foothold in the acknowledged fact that the connection between thought and the brain of animals, as well as of man, is an ultimate incomprehensibility, a mystery which the law of man's intelligence prevents his ever even attempting or hoping to understand. The famous saying "*cogito ergo sum*," the foundation of all modern metaphysics, may come to be a formula under which religion, philosophy, and science, may all take shelter, and approach each other without ever actually meeting.

But the three intuitions of God, sin, and immortality, can all be accounted for by the growth of human experience, as every one knows who has at all studied the subject. At some period of the world's history, science will answer, an ape-like creature first recognized that it or he had offended against the good of some other creature and so became conscious of sin, or was created as a moral being. Thus much Mr. Darwin has affirmed, but (speaking from memory) I do not think he has called very special attention to that still greater epoch (or was it the same?) in man's history, when this ape-like creature, seeing one of its own species lying dead, recognized as a fact "I shall die." This is what we may term the creation of man as an immortal being, for in the very conflict of the two facts—one, the reflecting being, the self-conscious I; the other, death, the seeming destroyer—lie embedded all man's future spiritual cravings for eternity. And the idea of God would come in the order of Nature, before either of these, to the creature which first reflected upon the source of its own existence, and recognized a "tendency in things which it could not understand." This is, in brief, the scientific account of man's creation, and of the growth of the ideas of natural religion within his mind; and we may remark in passing that it must be a singularly uncandid and prejudiced mind which does not recognize that the book of Genesis, which, upon any theory, contains man's earliest thoughts about himself, expresses in allegorical fashion exactly the same views.

The same views are also apparently expressed by Prof. Max Müller, in a very beautiful passage in the article on Semitic Monotheism, in the same volume:

"The primitive intuition of God and the ineradicable feeling of dependence upon God could only have been the result of a primitive revelation in the truest sense of that word. Man, who owed his existence to God, and whose being centred and rested in God, saw and felt God as the only source of his own and all other existence. By the very act of the creation God had revealed Himself. Here He was, manifested in His works in all His majesty and power before the face of those to whom He had given eyes to see and ears to hear, and into whose nostrils He had breathed the breath of life, even the Spirit of God."

The first impression made by this passage may be, that, in speaking of a "revelation in the truest sense," it affords an instance of that hateful habit of using religious words in a non-natural sense. But a little deeper consideration will show that no possible definition of a revelation, accompanied and attested by miracles, can exclude the revelation made by Nature to the first man who thought. In fact, we have here a description of creation, which science, with possibly a little suspiciousness at some of the phrases, may accept, while, at the same time, natural religion is carried to its utmost and highest limits, and along with this a foundation is laid for a truer theory of the miraculous. But, while gladly admitting all this, the fact remains that these intuitions, following upon a revelation in which Nature herself was the miracle, are still plainly only the expressions of man's inward experiences, and that, however old, and venerable, and exalted, they are still only hopes, wishes, and aspirations, which may or may not be true, but which are incapable of proving the actual facts toward which they soar. It is open, therefore, to any man, accustomed to look for positive demonstration, to dismiss them as dreams of the infancy of man, or to relegate them into the prison-house of the incomprehensibilities, or to content himself with a purely natural theory of human life which rejects and dislikes the theological.

2. But when we come to inquire how far these primary intuitions have been universal, and whether they can be fairly called ineradicable, we are met by some very startling facts. The dictum *ὃ πᾶσι δόκει τοῦτό αἰναι φαμεν* is so reasonable in itself that no serious attempt would be made to question a belief that even approached to being universal, even if it could not be shown to be part of the original furniture of the mind. But the real difficulty lies in finding (apart from morals) any beliefs of which this universality can be predicated, and assuredly the immortality of the soul is not one of them. The mind of man at its lowest seems incapable of grasping the idea, and the

mind of man at its highest has striven to emancipate itself from it altogether. The evidence for this statement lies within the reach of all, but I will just adduce three names whose very juxtaposition, by the sense of incongruous oddity stirred up, may make their joint testimony the more important. I mean Moses, Buddha, and Julius Cæsar, all of whom, though widely separated in time, race, and character, representing absolutely different types of human nature, approaching the subject from widely different points of view, do, nevertheless, agree in this, that the consciousness of immortality formed no part of the furniture of their minds.

Moses lived one of the most exalted lives, whether regarded from the religious or political side, that has ever been lived on earth, and yet, as is well known, there is not a shadow of a trace to prove that he was moved by the hope of a reward after death, or that the idea of existence after death was ever consciously presented to his mind. He may be, on the whole, claimed by modern science (the miraculous element being by it excluded) as an example of those who perform the greatest practical duties, and are content to stand before the mystery of the Unknowable without inquiry and without alarm, so far as the doctrine of man's immortality is concerned. Here is another of those strange links that unite the earliest thinker and legislator with so much of the spirit of modern thought and law. Buddha, on the contrary (or his disciples, if it be true that his original teaching is lost to us), cannot be quoted as one who did not realize the possibility of life after death, nor is any scheme of philosophy that is practically Pantheistic inconsistent with immortality, if we limit the word to the bare idea of existing somehow after death. But I rather quote him as one of those who show that the very consciousness of undying personal life, the existence of a self-reflecting ego, which gives all its shape and force to the desire for life after death, may come to be regarded as a positive evil, and painless extinction be maintained as the ultimate hope and destiny of man. And the case of Julius Cæsar is, in some respects, stronger still. He is one of the world's crowning intellects, and he lived at a time when men such as he were the heirs of all the ages, the possessors of the treasures of thought in which, for generations past, the greatest men had elaborated doctrines concerning religion, duty, and life. And he represents the views of those whom the truest voice of science now repudiates as running into unscientific extremes. With him non-existence after death was a matter of practical belief. It colored his opinions upon politics, as really as Cromwell's religion affected his. He spoke against the infliction of the penalty of death upon the conspirators in Catiline's case, because death was a refuge from sorrows, because it solved all mortal miseries and left place for neither care nor joy. And Cato expressly applauded his sentiments, though with a touch of reaction from popular theology, which sounds strangely modern. To this, then, all the original intuitions of the human mind, all the glowing aspirations enshrined in Greek poetry, legend, and art, all the natural theology contained in the works of Socrates and Plato, had come at last. Will any reasonable man affirm that an age, which breathes the very air of materialism, and whose children suck in the notions of changeless law with their mother's milk, will arrive at any thing better if it has no facts upon which to rely as proofs that its hopes are not unfounded? And how can that be called a truth of human nature, or be allowed to exercise a real influence upon men's minds, which is capable of being either entirely suppressed, or earnestly striven against, or contemptuously rejected?

3. The remaining two arguments need not detain us long; indeed, I should not have mentioned them, were it not that very eminent divines have based the belief in immortality upon the existence of God or the necessities of man. Let it once be granted that we are the creatures of a personal, loving, and sustaining God, concerning whom it is possible to form adequate conceptions, and then doubts as to our immortality would be vain indeed. But the rejoinder from the scientific view is plain enough. This, it would be said, is a mere *obscurum per obscurius.* The belief in God is simply the working of the human mind striving to account for the beginning of its own existence, exactly as the belief in immortality is the result of the attempt to think about the end thereof. If the definition of God be a stream or tendency of things that we cannot otherwise account for, then it will not help us to a belief in immortality. It is surprising indeed to see how the plain conditions of the case are evaded by enthusiastic controversialists; and I am almost ashamed of being obliged to make statements that have an inevitable air of being the baldest truisms.

4. The idea that immortality is essential to the moral development of man, and that therefore it is demonstrably true, seems to receive some little countenance from Prof. Max Müller in the close of his article on Buddhism, in which he thinks it improbable that—

> "The reformer of India, the teacher of so perfect a code of morality, ... should have thrown away one of the most powerful weapons in the hands of every religious teacher, the belief in a future life, and should not have seen that, if the life was sooner or later to end in nothing, it was hardly worth the trouble which he took himself, or the sacrifices which he imposed upon his disciples."

The true bearing, in all its immense importance, of man's morality upon his belief in immortality will have to be considered hereafter; but, when used as a demonstration, it is at once seen to belong to the class of arguments from final causes which science resolutely rejects. A much more fatal answer, however, is found in a simple appeal to history, from which it will be found that, in Mr. Froude's words, no doctrine whatever, even of immortality, has a mere "mechanical effect" upon men's hearts and consciences, and that noble lives may be lived and exalted characters formed by those who are brave enough to disregard it. Nay, what is worse, immortality may be a powerful weapon for evil as for good, if it chime in with a perverted nature. The Pharaoh before whom Moses stood believed it, and we know with what results. Only that, once more will science retort, which can be proved to be true upon sufficient evidence, can be positively known to be useful.

To sum up, then, what has been said, we have seen that, however strong may be the wishes of man for immortality, however ennobling to his nature and true to his instincts the belief in it may be, there is nothing in natural religion to answer the demands of modern thought for actual proof, and nothing therefore to impugn the wisdom or refute the morality of that class of persons, representing, as they do, a growing tendency in the human mind, who take refuge in a suspense of thought and judgment upon matters which they declare are too high for them. Occasionally we may suspect that the garb of human weakness does but conceal the workings of human pride, never perhaps so subtle and so sweet as when human nature meekly resolves to be contented with its own imperfections, and to bow down before its own frailty; but denunciations of moral turpitude only harden the hearts of men who ask for the bread of evidence and receive stones in the shape of insults.

We turn next to consider the effects of modern thought upon the evidence for immortality derived from Revelation. And here the difficulty of obtaining assent to what seem to me obvious truths will be transferred from the advocates of religion to those of science. Nevertheless, I maintain an invincible conviction that it is possible to state the terms of debate in propositions which commend themselves to candid minds, and which do not, as I have said, pretend to solve the controversy, but merely to define its conditions.

Now, the first proposition is: That the Resurrection of Jesus Christ, if assumed to be true, does present actual scientific evidence for immortality. An illustration will make my meaning clear. Whether or not life can be evolved from non-living matter is a subject of debate; but it is admitted on all hands that, if a single living creature can be produced under conditions that exclude the presence of living germs, then the controversy is settled, and therefore Dr. Bastian sets himself to work with the necessary apparatus to prove his case. So, in the same way, if any man known to be dead and buried did rise again (as for the moment is assumed to be the case), and did think and act and speak in His own proper personality, then immortality (in the scientific sense of the word) is thereby proved. Accordingly, those who wish to prove their case, betake themselves to history for the required evidence, which they may or may not find, but which, such as it is, must be allowed to go to the jury. Science may refuse to listen to arguments for facts derived from men's hopes and beliefs; it ceases to be science if it refuses to listen to arguments which profess to rely upon facts also. Were there to happen now an event purporting to resemble the Resurrection, it would be necessary to examine the evidence exactly as men are commissioned to investigate any unusual occurrence, say, for instance, the supposed discovery of fertile land at the North Pole. All this is plain enough, and leads to no very important conclusions, but it is, nevertheless, necessary that it should be stated clearly, and distinctly apprehended.

Two other propositions may also be laid down as to the nature of the evidence for the Resurrection, both of them once more sufficiently obvious, but still not without their value in leading to a fair and reasonable estimation of the exact state of the case, and tending also, as we shall see presently, in one direction. It may be taken for granted, in the first place, that nothing can be alleged against the moral character of the witnesses, or against the morality which accompanied and was founded upon the preaching of the Resurrection. Mistaken they may have been, but not dishonest; enthusiasts, but not impostors. Furthermore, the deeper insight into character, which is one of the results of the modern critical spirit, enables us to see that they numbered among their ranks men of singular gifts, both moral and intellectual, who combined in a wonderful degree the faculty of receiving what was, or what they thought to be, a miraculous revelation, and the power of setting it forth in a sober and measured manner. All this is candidly admitted by the best representatives of modern thought.

Again, it may safely be asserted that, judged by the critical standards of historical science, the evidence is abundantly sufficient to prove any event not claiming to be miraculous. Let us suppose such an event as an extraordinary escape from prison related in the same way, though I admit that it requires a considerable intellectual *tour de force* to eliminate, even in imagination, the supernatural from the narrative. It is not going too far to say that no real question as to its truth would in that case ever be raised at the bar of history, even though a powerful party were interested in maintaining the contrary. A strictly scientific investigation, for instance, has brought out in our own days the absolute accuracy and consequent evidential value of the account of St. Paul's voyage to Malta. On the whole, then, we may conclude that the testimony is really evidence in the case, that it proceeds from honest and capable men, and that no one, *apart from the existence of the supernatural element*, would care to deny its truthfulness, except upon grounds that would turn all history into a mass of fables and confusion.

There remains, then, the old argument, that it is more easy to believe the witnesses to be mistaken than the fact itself to be true, and that we cannot believe a miracle unless it be more miraculous to disbelieve it. To this argument I avow my deliberate conviction, after the best thought I can give the subject, that no answer can be given regarded from a merely intellectual point of view, and subject to the conditions which modern thought not only prescribes, but is strong enough to enforce. It goes by the name of Hume, because he was the first to formulate it, but it is not so much an argument as a simple statement of common experience. All men who, from the days of St. Thomas, have disbelieved in miracles, have done so practically upon this ground. And to the "doubting" Apostle may be safely attributed the first use of the now famous formula, "It is much more likely that you, my friends, should be mistaken than that He should have risen." Now, to such a state of mind, what answer short of another miracle could be given then, or can be given now? True, you may point out the moral defects in the mind of Thomas which led him to disbelieve, but these are immediately counterbalanced by a reference to the intellectual defects of Mary Magdalene, which prompted her to accept the miracle. There is no real room for weighing the evidence on both sides, and pronouncing for that which has the greatest probability, when your opponent, by a simple assertion, reduces all the evidence on one side to zero. Once more let me ask Christian apologists to realize this, and having realized it, no matter at what cost to the fears and prejudices of theology, let us then proceed the more calmly to examine what it precisely means and to what conclusions it leads us.

We observe, first, that this argument is derived not from the first of the two ways in which, as we saw, science influences belief, namely, by altering the nature of the evidence required, but from the second, namely, by predisposing the minds of men against belief upon any attainable evidence whatever. We have seen that the evidence is that of honest men, that it is scientifically to the point, and sufficient to prove ordinary historical events. More than this cannot be demanded in the case of events which do not come under law or personal observation. But the minds of men are so predisposed by their experience of unchanging order to reject the miraculous, that, first, they demand more and more clear evidence than in other cases; and, secondly, they have recourse at once to the many considerations which weaken the force of evidence for things supernatural, and account for men's mistakes without impugning their veracity. Any one who reads Hume's essay will be struck at once with the, so to speak, subjectivity of the argument. Upon this very point he says, "When any one tells me he saw a dead man restored to life, I immediately *consider within myself*," etc., etc.. We ask then, at once, "To whom is it more likely that evidence of a miracle should be false than that the miracle should be true?" and the answer must of course be, "Those who, rightly or wrongly, are predisposed in that direction, by their experience of a changeless law, growing ever wider and more comprehensive." Nor is Paley's answer, which assumes the existence of God, at all available as against Hume, who, in his next section, puts into the mouth of an imaginary Epicurus all the arguments against such a belief. But it is a most just and reasonable remark that this predisposition does not exist in the case of those who—again rightly or wrongly—are wishing to know God and hoping to live after death. It is at this point that natural and revealed religion, weak when divided, becomes strong by combination. The Resurrection would certainly never be believed if it did not fall like a spark upon a mass of wishes and aspirations which are immediately kindled into life. Granted a man (and this is no supposition, but a fact), whose whole nature craves not to die, and whose mind is occupied by the standing miracle of its own immortality, and then the Resurrection, so far from being improbable, will be the very thing which gives life to his hopes. The more he sees that natural religion cannot give him facts as proofs, the more he will welcome Revelation which does, just because it will satisfy the rational desire which science is creating in the human mind. And just as there is no answer to Hume's argument for one predisposed as Hume was, so is there none to one predisposed as this supposed (but very actual) man is. The one is as incapable of disbelief as the other of assent. Hume and Paley do not really grapple with each other, but move in parallel lines that never meet. As Hume himself said of Berkeley, "His arguments admit of no answer and produce no conviction," so might each of the two say of the other. On the one hand, we have all the results of human experience, a severe standard of intellectual virtue, a morality which confines itself to its duties toward humanity, and the power of being able not to think about ultimate incomprehensibilities. On the other hand, we have intense longings after the infinite, which science, admitting, as it does, the existence of the Unknowable, cannot possibly deny to be legitimate in those who feel them sincerely; also a body of evidence, sufficient to prove ordinary events, for a fact that gives certainty and power to all these longings; a morality, which has reference to a Supreme Judge, and an absolute incapacity for life and duty until some sort of conclusion has been arrived at concerning the mysteries of our being and destiny. Both of these represent tendencies of human nature with which the world could at this stage very badly dispense; both may have their use and their justification; either may be true, but *both* cannot, for the Resurrection either did or did not happen.

From this account of things some very important considerations follow, a few of which I will endeavor to sum up in three heads. The scientific value of Revelation as a necessity, if there is to be any vital and practical religion at all, will, I hope, have been sufficiently indicated already:

1. The lines of a long and, perhaps, never-ending conflict between

the spirit of Religion and what, for want of a better word, I will call the spirit of Rationalism, are here defined. Neither of the two being able by mere argument to convince the other, they must rely upon gradually leavening the minds of men with prepossessions in the direction which each respectively favors. The time may come when Rationalism will have so far prevailed that a belief in the miraculous will have disappeared; the time may also come when the Christian Revelation, historically accepted, will everywhere be adopted as God's account to man of ultimate incomprehensibilities. Surely, no man who has ever fairly examined his own consciousness can deny that elements leading to either of these two conclusions exist within his own mind. He must be a very hardened believer to whom the doubt, "Is the miraculous really possible?" never suggested itself. And he must in turn be a very unscientific Rationalist who has never caught himself wondering whether, after all, the Resurrection did not take place. Nor, so far as we may at this epoch discern the probable direction of the contest, is it possible to estimate very accurately the influence which science will exercise upon it. On the one hand, it will certainly bring within the mental grasp of common men that view of law and causation which, in Hume's time, was confined to philosophers and their followers, and was attained rather by intellectual conceptions than by such common experiences of every-day life and thought as we have at present. On the other hand, it will purge religion of its more monstrous dogmas, and further, by calling attention to the necessity of proving fact by fact, and again, by clearing up the laws of evidence, will tend to deepen in the minds of religious people the value and meaning of Revelation; while, at the same time, by its frank admission of hopeless ignorance, it will concede to faith a place in the realm of fact. Every man will have his own views as to the issue of the conflict: for the present it is sufficient for him, if he can be fully satisfied in his own mind.

2. The predisposition in men's minds in favor, whether of Religion or Rationalism, will be created and sustained solely by moral means. This is the conclusion toward which I have been steadily working from the beginning of this paper to the end of it. The intellect of both Christian and Rationalist will have its part to play; but that part will consist in presenting, teaching, and enforcing each its own morality upon the minds of men. I need not say that I use the word morality as expressing in the widest sense all that is proper for and worthy of humanity, and not merely in the narrower sense of individual goodness. Rationalism will approach mankind rather upon the side of the virtues of the intellect. It will uphold the need of caution in our assent, the duty of absolute conviction, the self-sufficiency of men, the beauty of law, the glory of working for posterity, and the true humility of being content to be ignorant where knowledge is impossible. Religion will appeal to man's hopes and wishes recorded

in Nature and in history, to his yearnings for affection, to his sense of sin, to his passion for life and duty, which death cuts short. And that one of the two which is truest to humanity, which lays down the best code of duty, and creates the strongest capacity for accomplishing it, will, in the long-run, prevail; a conclusion which science, so far as it believes in man, and religion, so far as it believes in God, must adopt. Here, once more, it is well nigh impossible to discern the immediate direction of the conflict, whatever may be our views as to its ultimate decision. Science is almost creating a new class of virtues; it is laying its finger with unerring accuracy upon the faults of the old morality; it is calling into existence a passion for intellectual truth. But then Religion has always given the strongest proofs of her vitality by her power of assimilating (however slowly) new truths, and of rejecting (alas! how tardily) old falsehoods, at the demands of reason and discovery. A religious man can always say that Christians, and not Christianity, are responsible for what goes amiss. It is because religious practice never has been, and is at this moment almost less than ever, up to the standard of what religious theory exacts, that we may have confidence in gradual improvement and advance, until that standard, toward the formation of which science will have largely contributed, be attained.

3. Closely connected with the above, follows the proposition that all attempts on the part of religion to confute the "skeptic" by purely intellectual methods are worse than useless. There is no intellectual short cut to the Christian faith; it must be built up in the minds of men by setting forth a morality that satisfies their nature, consecrates humanity, and establishes society. It is not because men love the truth, but because they hate their enemies, that in things religious they desire to have what they can call an overwhelming preponderance of argument on their side of the question, the possession of which enables them to treat their opponents as knaves or fools or both. Religion may have been the first to set this pernicious example, but, judging from the tone of much modern writing, Rationalism has somewhat bettered her instructions. No doubt it is a tempting thing to mount a big pulpit, and then and there, with much intellectual pomp, to slay the absent infidel—absent no less from the preacher's argument than from his audience. Delightful it may be, but all the more dangerous, because it plunges men at once into that error, so hateful to modern thought, of affirming that intellectual mistakes are moral delinquencies. No one, least of all science, denies that men are responsible for the consequences of their belief, provided these consequences are limited to such as are capable of being recognized and foreseen, and are not extended to comprehend endless perdition in a future state—an idea which is supposed, rightly or wrongly, to lurk beneath the preacher's logical utterances, and which religion has done next to nothing to disavow. And so we come to this conclusion: to build up by precept

and example a sound and sufficient morality; to share in all the hopes and aspirations of humanity; to be foremost in practical reforms; to find what the instincts of mankind blindly search for by reference to the character of God finally revealed in Christ, and to the hope of immortality which His Resurrection brought to light; to endeavor to clear religion from the reproach of credulity, narrowness, timidity, and bitter sectarian zeal; these are, as our Master Himself assured us, the only means of engendering in the hearts of men that moral quality which we call Faith: for "HE THAT IS OF THE TRUTH HEARETH MY VOICE."

In a future paper I hope to show, by reference to the facts of man's nature, how this faith in immortality is being, and is to be, so far wrought into his mind as to form a predisposition toward a belief in the Christian doctrine of the Resurrection of Christ as a proof of that which he cannot help but desire to believe.—*Contemporary Review.*

THE SOURCE OF LABOR.

SCIENCE has taught us that the processes going on around us are but changes, not annihilations and creations. With the eye of knowledge, we see the candle slowly turning into invisible gases, nor doubt for an instant that the matter of which the candle was composed is still existing, ready to reappear in other forms. But this fact is true not only of matter itself, but also of all the influences that work on matter. We wind up the spring of a clock, and, for a whole week, the labor thus stored up is slowly expended in keeping the clock going. Or, again, we spend five minutes of hard labor in raising the hammer of a pile-driver, which, in its fall, exerts all that accumulated labor in a single instant. In these instances, we easily see that we store up labor. Now, if we put a dozen sovereigns in a purse, and none of them be lost, we can take a dozen sovereigns out again. So in labor, if no labor be lost, as science asserts—for the inertia of matter, its very deadness, so to speak, which renders it incapable of spontaneously producing work, also prevents its destroying work when involved in it—we should be able to obtain back without deduction all our invested labor when we please.

Imagine a mountain-stream turning an overshot wheel. It thus falls from a higher to a lower level. A certain amount of labor would be required to raise the water from the lower level to the higher; just this amount of labor the water gives out in its fall, and invests, as it were, in the wheel. If, however, when arrived at the lower level, the water were to demand of the wheel to be pumped up again, the slighest trial would show that it would ask more than it could obtain, though not more than it had given. The wheel, if questioned as to the cause of its inability, must reply as others have done, that it has shut up part of the labor in investments which it cannot realize. The reason, as commonly stated, is, that friction has destroyed part of the labor. The labor is not, however, destroyed. Science has shown that heat and labor are connected; labor may be turned into heat, and heat into labor. The labor absorbed by friction, is but turned into heat. If, however, we try to extract labor from the heat thus diffused through the different parts of the water-wheel, and make it available, we find ourselves quite at a loss. The heat gradually diffuses itself through surrounding bodies, and, so far as we are concerned, the labor is wasted, though it still exist, like Cleopatra's pearl dissolved in the cup of vinegar.

If no labor is lost, so neither is any created. The labor we exert is but the expenditure of labor stored up in our frames, just as the labor invested in the wound-up spring keeps the clock going. Whence, then, does all this labor originally come? We see the waste—how is compensation made? The answer is simple and easy to give. All the labor done under the sun is really done by it. The light and heat which the sun supplies are turned into labor by the organizations which exist upon the earth. These organizations may be roughly divided into two classes—the collectors and the expenders of the sun's labor. The first merely collect the sun's labor, so as to make it available for the other class; while, just as the steam-engine is the medium by which the steam gives motion, so this second class is the medium by which the sun's heat is turned into actual labor.

Still, the sun does not work only through organized labor: his mere mechanical influence is very great. With the moon—the only second post he deigns to fill—he produces the tides by his attraction on the sea. But for the friction of the earth and sea, the tides, once set in motion, would rise and fall without any further effort; but the work done in overcoming the friction is, though due to the sun and moon, not extracted from them, but by them from the earth. For it would take a vast effort to cause the earth to cease rotating. All this effort is, as it were, stored up in the revolving earth. As the tidal waters, then, rub along the bed of the sea, or the waters on which they rest and the adjacent coasts, this friction tends to make the earth move faster or slower, according to the direction in which the tidal flow is. The general effect is, however, that the friction of the tides makes the earth revolve more slowly; in other words, that part of the energy of rotation of the earth, so to speak, is consumed in rubbing against the tidal waters. All the work, therefore, that the tides do in undermining our cliffs, and washing away our beaches, is extracted by the sun and moon from the work stored up in the rotation of the earth. The diminution of rotation, indeed, is so small as scarcely to be perceived by the most refined observation, but the reality of it is now generally recognized; and this process, too, will apparently go on till the earth ceases to rotate on its axis, and presents one face constantly to the sun.

Thus we see that the destruction of the land by the sea, so interesting in a geological point of view, is partly due to the sun's action. Not only is he the source of the light and heat we enjoy, but he aids in forming the vast sedimentary beds that form so large a part of the crust of the earth, mixing the ingredients of our fields, and moulding our globe.

By heating the air, the sun produces winds, and some of the labor thus expended is made use of by man in turning his windmills, and carrying his wares across the sea. But there is another expenditure of the sun's heat more immediately useful to man. By evaporating the sea and other bodies of water, he loads the air with moisture, which, when in contact with cold mountain-peaks or cold masses of air, loses its heat, and, being condensed, falls as rain or snow. Thus the rivers are replenished, which for a long time supplied the greater part of the labor employed in manufactures, though the invention of the steam-engine is fast reducing relatively the value of this supply of labor.

But vast as the sun's power thus exerted is, and useful as it is to man, it is surpassed in importance by his labor exerted through organized beings. The above-named agents have one defect: on the whole, they are incapable of being stored up to any great degree; we must employ them as Nature gives them to us. Organized existence, however, possesses the power of storing up labor to a very high degree. The means it adopts are not mechanical, but chemical. The formation of chemical compounds is attended with the giving out of heat, which, as we have said before, is equivalent to labor, and, if of sufficient intensity, can by us be made available as labor, as in the steam-engine. Now, we take iron-ore, consisting of iron in combination with other substances. By means of great heat, the iron is set free in the smelting-furnace. The iron, then, in its change of form has, as it were, taken in all this heat. If, now, we take this iron, and, keeping it from the influence of the air, reduce it to very fine powder, and then suddenly expose it to the air, by the force of natural affinity, it will absorb the oxygen of the air, and in so doing give out the heat before required to set it free from the oxygen; and if the iron be in small enough portions, so that the process is sufficiently rapid, we may see the iron grow red-hot with the heat thus disengaged.

Now, plants and trees, by the aid of the solar light and heat, remove various substances, carbon especially, from what seem to be their more natural combinations, and in other combinations store them up in their structures. Take a young oak-tree with its first tender leaves; if deprived of the sun's light and heat, its growth would be stayed, and its life die out. But, with the aid of the sun's rays, it absorbs carbon from the gases in the air, each particle of carbon absorbed being absorbed by the power of the sun through the agency of the plant, and with each particle of carbon stored up is also, as it were, stored up the labor of the sun by which that particle was set free from its former fetters. The sap of the plant, thus enriched, returns in its course, and by some mysterious process is curdled into cells and hardened into wood. But the work by which all this was accomplished lies hid in the wood, and not only is it there, but it is there in a greatly-condensed state. To form a little ring of wood round the tree, not an eighth of an inch across it, took the sunshine of a long summer, falling on the myriad leaves of the oak.

Lemuel Gulliver, at Laputa, was astonished by seeing a philosopher aiming at extracting sunbeams from cucumbers. Had he but rightly considered the thing, he would have wondered at any one's troubling to make a science of it. The thing has always been done. From Adam and Eve in the garden of Eden eating sweet fruits, through the onion-eating builders of the pyramids, down to the flesh-eating myriads of our land, this process has always been going on. The active life of reasoning man, and his limitless powers of invention, need for their full development a vast supply of labor. By means of the vegetable kingdom, the sun's work is stored up in a number of organic substances. Man takes these into his system, and in the vessels and fibres of his body they resume their original combinations, and the labor of the sun is given out as muscular action and animal heat. To allow a larger supply of labor for man's intellect to work with, Providence created the herbivorous races. Some of these further condense the work of the sun involved in plants, by taking these plants into their systems, and storing up the work in them, in their flesh and fat, which, after some preparation, are fit to be received into the frame of man, there, as the simpler vegetable substances, to supply heat and labor. Others, extracting work from the vegetable kingdom, just as man does, and mostly from parts of the vegetable kingdom that are not suited to the organs of man, are valuable to man as sources of labor, since they have no power to invent modes of employing this labor to their own advantage. Man might have been gifted with a vaster frame, and so with greater power of labor in himself, but such a plan had been destitute of elasticity, and, while the savage would have basked in the sun in a more extended idleness, the civilized man had still lacked means to execute his plans. So that Good Providence which formed man devised a further means for supplying his wants. Instead of placing him at once on a new-formed planet, it first let the sun spend its labor for countless ages upon our world. Age by age, much of this labor was stored up in vast vegetable growths. Accumulated in the abysses of the sea, or sunk to a great depth by the collapse of supporting strata, the formation of a later age pressed and compacted this mass of organic matter. The beds thus formed were purified by water, and even by heat, and at last raised to within the reach of man by subterranean movements. From this reservoir of labor, man now draws rapidly, driving away the frost of to-day with the sunshine of a million years ago, and thrashing this year's harvest with the power that came to our earth before corn grew upon it.

Such are the processes by which the sun's power is collected and stored up by the vegetable kingdom in a form sufficiently condensed to be available for working the machinery of the bodies of men and beasts, and also to assist man in vaster expenditures of labor. It is most interesting to trace such processes, and not only interesting, but also instructive, for it shows us in what direction we are to look for our sources of labor, and will at once expose many common delusions. One hears, perhaps, that something will be found to supplant steam. Galvanism may be named; yet galvanism is generated by certain decompositions—of metal, for instance—and this metal had first to be prepared by the agency of coal, and in its decomposition can give out no more labor than the coal before invested in it. It is as if one should buy a steam-engine to pump up water to keep his mill-wheel going. The source of all labor is the sun. We cannot immediately make much use of his rays for the purposes of work; they are not intense enough; they must be condensed. The vegetable world alone at present seems capable of doing this; and its past results of coal, peat, petroleum, etc., and present results of wood and food, are ultimately all we have to look to.

To say that man will ever be dependent upon the vegetable world for all his work, may be considered bold, but there is certainly great reason to believe it. The sun's labor being supplied in such a diluted form, each small quantity continually supplied must be packed in a very small space. Now, man can only subject matter to influences in the mass. The little particle of carbon that the plant frees each instant is beyond his ken. The machinery he could make would not be fine enough: it would be like trying to tie an artery with the biggest cable on board the *Great Eastern.* Organized existence possesses machinery fine enough to effect these small results, and to avail itself of these little instalments of labor. At present, this machinery is beyond our comprehension, and possibly will ever remain so. Nature prefers that her children should keep out of the kitchen, and not pry into her pots and pans, but eat in thankfulness the meal she provides.

Some interesting results follow from what has been stated above One is, that we are consuming not only our present allowance of the sun's labor, but also a great deal more, unless the formation of coal in our age equals its consumption, which is not probable. Mother Earth will certainly, so far as we can see, some day be bankrupt. Such a consummation is pointed to, however, in other quarters. The sun's heat, unless miraculously replenished, must gradually be dissipated through space. There are reasons for thinking that the planets must ultimately fall into the sun. These things, however, possess to us no practical physical interest. Such countless ages must elapse ere they affect man's material condition upon earth, that we hardly can gravely consider them as impending. The chief interest they excite is moral. Like the man's hand that appeared to the revelling king, they write "Mene, Mene, Tekel, Upharsin" (Weighed, measured, limited, doomed) on our material world, and dimly point to some power that stands, as it were, hidden from our view behind the screen of matter, "that shall make all things new."—*Chambers's Journal.*

QUETELET ON THE SCIENCE OF MAN.[1]

By E. B. TYLOR.

TWO lines of research into the Science of Man, of the highest moment as well in theoretical Anthropology as in practical Ethics and Politics, both to be always associated with the name of Quetelet, are now discussed at large in his Social Physics and Anthropometry. The two great generalizations which the veteran Belgian astronomer has brought to bear on physiological and mental science, and which it is proposed to describe popularly here, may be briefly defined: First, he has been for many years the prime mover in introducing the doctrine that human actions, even those usually considered most arbitrary, are in fact subordinate to general laws of human nature; this doctrine, maintained in previous publications, especially in the earlier edition of the first-named work some thirty-seven years ago, is now put forth in its completest form. Second, he has succeeded in bringing the idea of a biological type or specific form, whether in bodily structure or mental faculty, to a distinct calculable conception, which is likely to impress on future arguments a definiteness not previously approached.

The doctrine of the regularity and causality of human actions was powerfully stated some fifteen years ago by Mr. Buckle in the introduction to his "History of Civilization." Buckle is here essentially the exponent of Quetelet's evidence, from which, indeed, as a speculative philosopher, he draws inferences more extreme than those of his statistical teacher. To Quetelet is due the argument from the astonishing regularity from year to year in the recurrences of murders and suicides, a regularity extending even to the means or instruments by which these violent acts are committed; his inference being broadly that "it is society which prepares the crime, the criminal being only

[1] Physique Sociale, ou Essai sur le Développement des Facultés de l'Homme. Par Ad. Quetelet. (Brussels, 1869.)

Anthropométrie, ou Mesure des différentes Facultés de l'Homme. Par Ad. Quetelet. (Brussels, 1870.)

the instrument which executes it." From various other sources Buckle brought together other pieces of evidence, especially one which is now quoted by all who discuss the subject, the regularity from year to year of letters posted, whose writers forget to direct them. It may by this time be taken as proved by such facts that each particular class of human actions may be estimated, and, to a great extent, even predicted, as a regular product of a definite social body under definite conditions. To quote another luminous instance of this regularity of action, M. Quetelet gives a table of the ages of marriage in Belgium ("Phys. Soc.," i., p. 275). Here the numbers of what may be called normal marriages, those between men under 45 with women under 30, as well as of the less usual unions where the women are between 30 and 45, show the sort of general regularity which one would expect from mere consideration of the circumstances. The astonishing feature of the table is the regularity of the unusual marriages. Disregarding decimals, and calculating the approximate whole numbers in their proportion to 10,000 marriages, the table shows, in each of five five-year periods from 1841 to 1865, 6 men aged from 30 to 45 who married women aged 60 or more, and 1 to 2 men aged 30 or less who married women aged 60 or more. M. Quetelet may well speak of this as the most curious and suggestive statistical document he has met with. These young husbands had their liberty of choice, yet their sexagenarian brides brought them up one after the other in periodical succession, as sacrifices to the occult tendencies of the social system. The statistician's comment is: "It is curious to see man, proudly entitling himself King of Nature, and fancying himself controlling all things by his free-will, yet submitting, unknown to himself, more rigorously than any other being in creation, to the laws he is under subjection to. These laws are coördinated with such wisdom that they even escape his attention."

The admission of evidence like this, however, is not always followed by the same philosophical explanation of it. Buckle finds his solution by simply discarding the idea that human action "depends on some capricious and personal principle peculiar to each man, as free-will or the like;" on the contrary, he asserts "the great truth that the actions of men, being guided by their antecedents, are in reality never inconsistent, but, however capricious they may appear, only form part of one vast scheme of universal order, of which we, in the present state of knowledge, can barely see the outline." M. Quetelet's argument from the same evidence differs remarkably from this. His expedient for accounting for the regularity of social events, without throwing over the notion of arbitrary action, is to admit the existence of free-will, but to confine its effects within very narrow bounds. He holds that arbitrary will does not act beyond the limits at which science begins, and that its effects, though apparently so great, may, if taken collectively, be reckoned as null, experience proving that individual wills are neutralized in the midst of general wills (p. 100). Free-will, though of sufficient power to prevent our predicting the actions of the individual, disappears in the collective action of large bodies of men, which results from general social laws, which can accordingly be predicted like other results regulated by natural laws. We may perhaps apprehend the meaning of Quetelet's views more clearly from another passage, where, to show how apparently isolated events may be really connected under some wide law, he compares single facts to a number of scattered points, which seem not related to one another till the observer, commanding a view of a series of them from a distance, loses sight of their little accidents of arrangement, and at the same time perceives that they are really arranged along a connecting curve. Then the writer goes on to imagine, still more suggestively, that these points might actually be tiny animated creatures, capable of free action within a very narrow range, while nevertheless their spontaneous movements would not be discernible from a distance (p. 94), where only their laws of mutual relation would appear. M. Quetelet can thus conciliate received opinions by recognizing the doctrine of arbitrary volition, while depriving it of its injurious power.[1] His defence of the existence of free-will is perhaps too much like the famous excuse of the personage who was blamed for going out shooting on the day he had received the news of his father's death, and who defended himself on the ground that he only shot very small birds. But it is evident that the statistics of social regularity have driven the popular notion of free-will into the narrow space included between Quetelet's restriction and Buckle's abolition of it. In fact, no one who studies the temper of our time will deny the increasing prevalence of the tendency of the scientific world to reject the use of the term free-will in its vulgar sense—that of unmotived spontaneous election—and even to discourage its use in any other sense as apt to mislead, while its defenders draw their weapons not so much from observation of facts as from speculative and dogmatic philosophy.

To those who accept the extreme principle that similar men under similar circumstances must necessarily do similar acts; and to those, also, who adopt the notion of free-will as a small disturbing cause which disappears in the large result of social law, the regularity of civilized life carries its own explanation. Society is roughly homogeneous from year to year. Individuals are born, pass on through stage after stage of life, and die; but at each move one drops into another's place, and the shifting of individuals only brings change into the social system, so far as those great general causes have been at work which difference one age from another—the introduction of different knowledge, different principles, different arts, different industrial materials and outlets. The modern sociologist, whatever his

[1] In regard to the relation of statistics to the doctrine of fatalism, see Dr. Farre's "Report on the Programme of the Fourth Session of the Statistical Congress."

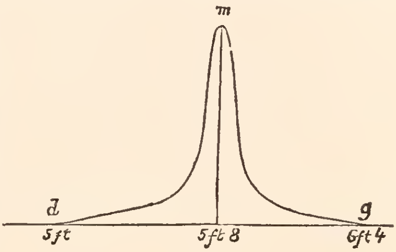
metaphysical prepossessions, looks at society as a system amenable to direct cause and effect. To a great extent his accurate reckonings serve to give more force and point to the conclusions of rough experience; to a great extent, also, they correct old ideas and introduce new aspects of social law. What gives to the statistical method its greatest scope and power is, that its evidence and proof of law applies indiscriminately to what we call physical, biological, and ethical products of society, these various effects acting and reacting on one another. A few instances may be given to show the existence of the relations in question, without attempting to show their precise nature, or to trace the operation of other determining causes.

Thus, for instance, the mode of life affects its length. Statistics show that the mortality of the very poor is about half as much again as the mortality of the very rich; while, as to the influence of professions, it appears that, in Germany, only 24 doctors reach the age of 70 as against 32 military men and 42 theologians. The propensity to theft bears a distinct relation to age; thus the French criminal statistics estimate the propensity to theft between the ages of 21 and 25 as being five-thirds as much as between the ages of 35 and 40. The amount of criminality in a country bears a relation, indirect and as yet obscure, but unmistakable, to its education, or rather to its want of education. In France, in 1828–'31, the constant percentage of accused persons was about as follows: could not read or write, 61; imperfectly, 27; well, 12. The comparison of this group of numbers with those taken lately in England shows a great change of proportion, evidently resulting from the wider diffusion of education; but the limitation of crime to the less-educated classes is even more striking: cannot read or write, 36; imperfectly, 61; well, 3. Again, for an example of connection of physical conditions with moral actions, we may notice a table showing how the hours of the day influence people who hang themselves ("Phys. Soc.," ii., 240). The maximum of such cases, 135, occurred between six and eight in the morning; the number decreased slightly till noon, and then suddenly dropped to the minimum; there being 123 cases between ten and twelve o'clock, against only 32 between twelve and two o'clock. The number rose in the afternoon to 104 cases between four and six, dropping to an average of about 70 through the night, the second minimum, 45, being between two and four o'clock in the morning. Here it is impossible to mistake the influences of the periods of the day. We can fancy we see the poor wretches rising in the morning to a life of which the misery is beyond bearing, or can only be borne till evening closes in; while the temporary relief of the midnight sleep and the mid-day meal are marked in holding back the longing to self-destruction. Madness varies with the season of the year: the maximum being in summer, and the minimum in winter (p. 187); a state of things which seems intelligible enough. Again, it is well known in current opinion that more children are born in the night than in the day; in fact, there are about five night-born against four day-born, the maximum being about midnight, the minimum a little before noon (i., p. 208). Why this is, no one yet knows; it is a case of unexplained law. But another not less curious law relating to births seems to have been at last successfully unravelled. In Europe about 106 boys are born to every 100 girls. The explanation appears to depend on the husband being older than the wife; which difference again is regulated by prudential considerations, a man not marrying till he can maintain a wife. In connection with this argument, it must be noticed that illegitimate births show a much less excess of male children (p. 168). Here, then (if this explanation may be accepted), it appears that a law, which has been supposed to be due to purely physiological causes, is traceable to an ultimate origin in political economy.

The examples brought forward by Quetelet, which thus show the intimate relation between biological and ethical phenomena, should be pondered by all who take an interest in that great movement of our time—the introduction of scientific evidence into problems over which theologians and moralists have long claimed exclusive jurisdiction. This scientific invasion consists mainly in application of exact evidence in place of inexact evidence, and of proof in place of sentiment and authority. Already the result of the introduction of statistics into inquiries of this kind appears in new adjustments of the frontier line between right and wrong, as measured under our modern social conditions. Take, for instance, the case of foundling hospitals, which provide a "tour," or other means, for the secret reception of infants abandoned by their parents. It has seemed, and still seems, to many estimable persons, an act of benevolence to found and maintain such institutions. But, when their operation comes to be studied by statisticians, they are found to produce an enormous increase in the number of exposed illegitimate children ("Phys. Soc.," i., p. 384). In fact, thus to facilitate the safe and secret abandonment of children is to set a powerful engine at work to demoralize society. Here, then, a particular class of charitable actions has been removed, by the statistical study of its effects, from the category of virtuous into that of vicious actions. An even more important transition of the same kind is taking place in the estimation of alms-giving from the ethical point of view. Until modern ages, through all the countries of higher civilization, men have been urged by their teachers of morality to give to the poor, worthy or unworthy; the state of public opinion being well exemplified by the narrowing of the word "charity" from its original sense to denote the distribution of doles. Yet, when the statistics of pauperism were collected and studied, it was shown that indiscriminate alms-giving is an action rather evil than good, its tendency being not only to maintain, but actually to produce, idle and miserable paupers. In our time a large proportion of the public and private funds, distributed among the poor, is spent in actually diminishing their industry, frugality, and self-reliance. Yet the evil of indiscriminate alms-giving is diminishing under the influence of sounder knowledge of social laws, and genuine charity is more and more directed by careful study of the means by which wealth may be spent for the distinct benefit of society. Such examples as these show clearly the imperfection and untrustworthiness of traditional, or what is called intuitive morality, in deciding on questions of right and wrong, and the necessity of appealing in all cases to the best attainable information of social science to decide what actions are really for or against the general good, and are therefore to be classed as virtuous or vicious.

Moreover, it is not too much to say that the comparatively small advance which moral science has made, since barbaric ages, has been due to the repugnance of moralists to admit, in human action, the regular causality which is the admitted principle of other parts of the action of the universe. The idea of the influence of arbitrary will in the individual man has checked and opposed the calculations which now display the paramount action of society as an organized whole. One point in M. Quetelet's doctrine of society requires a mention for its practical bearing on morals. There has seemed to some to be an immoral tendency in his principle that virtuous and vicious acts are products, not merely of the individual who does them, but of the society in which they take place, as though the tendency of this view were to weaken individual responsibility, and to discourage individual effort. Yet, when properly understood, this principle offers a more strong and definite impulse to the effort of society for good and against evil, than the theory which refers the individual's action more exclusively to himself. M. Quetelet's inference from the regular production of a certain amount of crime year by year, from a society in a certain condition, is embodied in his maxim that society prepares the crime and the criminal executes it. This should be read with a comment of the author's. "If," he says, "I were to take up the pavement before my house, should I be astonished to hear in the morning that people had fallen and hurt themselves, and could I lay the blame on the sufferers, inasmuch as they were free to go there or elsewhere?" Thus every member of society who offers a facility to the commission of crime, or does not endeavor to hinder its commission, is, in a degree, responsible for it. It is absurd to suppose that the crimes in great cities are attributable altogether to the free agency of the poor wretches who are transported or hung for them. The nation which can and does not prevent the existence of a criminal class is responsible collectively for the evil done by this class. This we can see plainly enough, although the exact distribution of the responsibility among the different members of society may be impossible to determine. Such a theory, of course, casts aside the revenge-theory of criminal law, assimilating the treatment of criminals to the operation of a surgeon healing a diseased part of the body, if possible, or, if not, rendering it harmless or removing it.

The wealthy and educated classes, whose lives seem to themselves as free from moral blame as they are from legal punishment, may at first hear with no pleasant surprise a theory which inculpates them as sharers in the crimes necessarily resulting from the state of society which they are influential in shaping. Yet this consideration is by no means one of mere hopeless regret, for coupled with it is the knowledge that it is in their power, by adopting certain educational and reformatory measures, so to alter the present moral status of society as to reduce the annual budget of crime to a fraction of its present amount. Thus the doctrine that the nation participates in and is responsible for the acts of its individual members is one which widens the range of duty to the utmost. The labors of M. Quetelet, in reducing to absolute calculation this doctrine of the solidarity of human society, entitle him to a place among those great thinkers whose efforts perceptibly raise that society to a higher intellectual and moral level. Here, as everywhere, the larger comprehension of the laws of Nature works for good and not for evil in the history of the world.



Some slight account has now to be given of M. Quetelet's doctrine of typical forms, as displayed in the "homme moyen," or "mean man," of a particular nation or race. This is no new theory; but, since the publication of the "Physique Sociale" in 1835, the author has been at work extending and systematizing it, his last results being shown in the present works. First, it must be pointed out that the term "homme moyen" is not intended to indicate what would be popularly meant by an "average man." An average or arithmetical mean of a number of objects may be a mere imaginary entity, having no real representative. Thus, an average chessman, computed as to height from the different pieces on the board, might not correspond to any one of the actual pieces. But the "homme moyen" or central type of a population really exists; more than this, the class he belongs to exceeds in number any other class, and the less nearly any other class approaches to his standard the less numerous that class is, the decrease in the number of individuals as they depart from the central type conforming to a calculable numerical law. The "mean man" (the term may probably be adopted in future researches, and when technically used its popular meaning will cease to interfere with this special one)—the "mean man" thus stands as a representative of the whole population, individuals as they differ from him being considered as forms varying from his specific type.

To realize a conception which even among anthropologists has scarcely yet become familiar, it is desirable to show by what actual observations M. Quetelet was led to the discovery of his principle. When a large number of men of a practically homogeneous population are measured, and arranged in groups accordingly, it becomes evident that the individuals are related to one another by a law of distribution A central type is represented by the most numerous group, the adjoining groups becoming less and less numerous in both directions. Thus, on classifying the measured heights of some 26,000 American soldiers of the Northern army during the late war, the proportionate number of men to each height was ascertained to be as follows ("Phys. Soc.," i., p. 131; "Anthropom.," p. 259):

Height, inches..........	60	61	62	63	64	65	66	67	68
No. of men in 1,000....	1	1	2	20	48	75	117	134	157
Height, inches..........	69	70	71	72	73	74	75	76	
No. of men in 1,000....	140	121	80	57	26	13	5	2	

Here it is seen that the mean man is a little under 5 ft. 8 in. in height, the numbers of men shorter and taller diminishing with evident regularity, down to the few representatives of the very short men of 5 ft. and under, and the very tall men of 6 ft. 4 in. and over. The law of relation of height to numerical strength is shown graphically by the binomial curve figured above, where the abscissæ (measured from an origin on the left) represent the heights of the men, and the ordinates the relative numbers of men corresponding to each height. The maximum ordinate, representing the number of mean men, is at $m =$ about 5 ft. 8 in., the ordinates on both sides diminishing almost to nothing as they reach the dwarfish and gigantic limits d and g, and vanishing beyond.

Again, measurement around the chest, applied to the soldiers of the Potomac Army, shows a similar law of grouping ("Phys. Soc.," ii., 59; "Anthropom.," p. 289):

Round chest, inches..........	28	29	30	31	32	33	34	35
No. of men in 1,000..........	1	3	11	36	67	119	160	204
Round chest, inches..........	36	37	38	39	40	41	42	
No. of men in 1,000..........	166	119	68	28	13	4	1	

Here the mean man measures about 35 in. round the chest, the numbers diminishing both ways till we reach the few extremely narrow-chested men of 28 in., and the few extremely broad-chested men of 42 in. These two examples may represent the more symmetrical cases of distribution of individuals on both sides of a central type, as worked out by M. Quetelet from various physical measurements applied to large numbers of individuals. Here the tendency to vary is approximately equal in both directions. Where the tendency to vary is perceptibly different in the two directions, the curve loses its symmetry, as in the figures representing the weights of women at different ages ("Anthropom.," p. 349), and the number of marriages of men and women at different ages ("Phys. Soc.," i., 272). The actual series of numbers given by observation are placed beside series computed according to the law of the expanded binomial, the same which is applied in the theory of probabilities to such calculations as that of the proportionate distribution of less probable events on each side of a most probable maximum term, the distribution of errors of observation of a single object, and of accidental variations in general. It is the closeness of approximation between the observed and calculated series of variations, computed not only as to the dimensions, but the actions of man, which gives to M. Quetelet's theory its remarkable definiteness and precision.

The diagram of statures here figured, which may be looked upon as representing a nation measured in one particular way, at once impresses on the mind a conception of a race-type materially differing from the vague notions hitherto current. It is seen that individual men of different statures are required to constitute a nation, but they are required in less and less proportion as they depart in excess or defect from the central type. The nation is not even complete without its dwarfs and giants. In fact, if all the monstrously short and tall men of a particular country were put out of sight, and the census of the population taken according to stature, the national formula thence deduced would enable a statistician to reckon with considerable accuracy how many dwarfs and giants of each size had been removed.

M. Quetelet's investigations further prove, or tend to prove, that similar laws of variation from the central type govern the distribution of individuals classed according to other bodily dimensions, and also according to physical qualities such as weight and strength, it being borne in mind that the particular expressions with their descriptive curves differ for the various qualities or faculties of man, being also in some cases much less symmetrical than in others. An absolute coincidence of the series of observed facts with the numerical law chosen to express them would be too much to expect; it is a great deal to obtain even a rough coincidence. For instance, when the strength of a number of men is estimated by a dynamometer, the maximum number showed 140 to 150 degrees on the scale, the number of weaker and stronger men being both fewer from this point, groups following approximately the proportions of the coefficients of a binomial of the sixth order; the numbers are reduced as follows from the table ("Anthropom.," p. 365):

Renal force, degrees.........	90	100–110	120–130	140–150	160–170
No. of men in 64.............	1	8	14	20	15
Binom. coeff.................	1	6	15	20	15

Renal force, degrees...	180–190	200
No. of men in 64......	6	1
Binom. coeff..........	6	1

In the various numerical examples here given, the element of age is not introduced, the ages of the individuals being calculated or taken as uniform. The problem of variation of numerical distribution of a population at different ages is treated by M. Quetelet in a comparatively simple case, that of the stature-curve. Here a curve approximating to a parabola is laid down, the ages of man from birth onward being measured along its axis; each double ordinate of this curve forms the base on which a binomial curve is erected perpendicularly, the vertices of these curves forming a curve of mean stature, of the nature of a curve of mortality ("Anthropom.," p. 264). How far M. Quetelet may succeed in his contemplated purpose of carrying his method from the physical into the intellectual and moral nature of man, it is premature to judge.

Without entering into the more intricate and difficult problems opened by this theory of central types, it is evident that the bearing of its main conception on the problems of anthropology and biology in general is highly important. Some able anthropologists have accepted the theory of the mean, or central standard, as a basis for the comparison of races, but this line of research is still in its infancy. In M. Quetelet's last volume, a principle is worked out which serves as a bridge between the old and new methods. His experience is that, in a well-marked population, no extraordinary number of observations is required for the determination of the mean man. In former ages, one result of the national type being so preponderant in number and so easily recognizable was, that the bodily measurements of any man of ordinary stature and proportions could be trusted to give, with reasonable accuracy, the standard measures of the nation, such as the foot, cubit, fathom, etc. In the same manner M. Quetelet finds a small number of selected individuals sufficient for ascertaining the standard national proportions of the human body, male and female, from year to year of growth; his tables, founded for the most part on Belgian models, are given in an appendix. This method is applicable to the purposes of general anthropology. Thus a traveller, studying some African or American race, has to select by mere inspection a moderate number of typical men and women, by comparison of whose accurately admeasured proportions he may approximate very closely to a central race-type.[1] It is not necessary to dwell on the obvious difficulties

[1] Thus General Lefroy's measurements of thirty-three Chippewa Indians ("Journal of the Ethnological Society," vol. ii., p. 44, 1870) are sufficient to determine the stature of the mean man as about 5 ft. 7 in., the number of individuals in this maximum group being 8. It is even possible to guess from this small number of measurements the numerical law of variation in the tribe, the series of groups from five ft. 3 in. to 5 ft. 11 in being as follows: 1, 1½, 2½, 6, 8, 4½, 4½, 3, 1.

of connecting the standard types of mixed nations with the races composing them. The stature-curve of England differs visibly in proportions from that of Italy, the measurements of Scotch and American soldiers show very different mean and extreme terms, and the problems of race underlying these differences are of a most complex character, the more so when the consideration is introduced of the race-type varying within itself from century to century. M. Quetelet is naturally apt, when expressing his views in an exordium or a peroration, to draw a good deal on the anticipated future results of his admirable method; but in judging of the value of his doctrine of central types, the best criterion is his actual success in reducing the observed facts of Nature to numerical calculation. The future must show how far it will be possible to apply to the theory of species the definition of central specific forms, from which varieties calculably diminish in numbers as they depart in type.—*Nature.*

DISINFECTION AND DISINFECTANTS.

By WILLIAM EASSIE, C. E.

THERE are certain rules to be promulgated respecting the protection of human life from contagion, or from the injurious effects of decomposing organic matters, which may be gleaned from the experience of ages, and which as yet have never been laid down with sufficient clearness.

A writer in a medical journal, the other day, pointed out, from the "Odyssey" of Homer, the great solicitude of Ulysses for the purification of his house with sulphur, and the history of purgation could go still farther back, and bring to light many other interesting *memorabilia.* This, however, hardly comes within the scope of these short papers; neither, as I said before, would any attempt to explain the cause of disease, for it would only be a repetition of wise things said before. Happily, too, the grim dwellers of the threshold are now watched with eye of lynx and nerve of steel, and their newer thrusts at poor mankind met or parried. Names like those of Drs. Parkes and Sanderson, in this respect, are fast becoming household words. For the purposes of this chapter, however, I cannot forbear from condensing the remarks of Dr. Angus Smith, with respect to disease generally. According to this authority, the classes of disease may be caused—firstly, by gases easily diffused in air, such as carbonic acid, nitrogen, marsh-gas, and others; secondly, by vapors falling in cold air and taken up in fogs, volatile bodies in fact, that concentrate in cool temperatures, and not to be classed with gases; thirdly, by putrid or decomposing substances, that include, with the hurtful gases named under the first head, many organic forms which, transferred to a suitable soil, are capable of working havoc with life and health; and, fourthly, by those more organized bodies in various stages and ferments that have a definite existence, and that multiply the diseases to which they are most allied, whenever they meet with suitable fields for propagation.

Disinfection is practised by fits and starts. With us it has been mainly a summer practice, when our nostrils encounter the smell off offensive matters. Contagion seizes a house, or a town, and for a time the sanitary inspectors, and the awakened people themselves, distribute even the most noxious disinfectants without system, and with the inevitable result of expending the most money with the least possible good result. The destruction of valuable property, a senseless panic, and a relapse into the indulgence of time-honored abuses, are the common results of outbreaks of typhus or typhoid fevers, of small-pox, cholera, or any other of the many diseases by which we are punished for grave derelictions of duty. We cannot neglect with impunity the maintenance of personal and household cleanliness—ventilation, and an abundant supply of pure water. Soap and soda are the simplest expedients at our disposal for cleansing purposes. Experience teaches us that ancient cities, and even modern human dwellings, are admirably suited to act as reservoirs of contagion, and are constantly polluted by the excreta of the healthy as well as of the sick. We have, therefore, been compelled to resort to disinfection. But such has been our shortsightedness in the matter, that the employment of any agent to destroy infection is too often evaded, and has usually been rendered most distasteful and even painful. A nauseous coating has been put upon this very simple pill. A poor woman is sent to the oil-shop for a little chloride of lime; a foul room is thereby rendered unbearable, the place has to be thrown open, disinfection is not attained, and the *maximum* of discomfort is attended with a *minimum* of benefit.

Some medical men are, I fear, blamable for not estimating with greater precision the real benefits derived from the use of volatile disinfectants. They are all irritating and of bad odor, and a popular belief has arisen that, unless they are foul and caustic, they can do no good service. A distinguished chemist, Mr. J. A. Wanklyn, has very recently shown that the constitution of a poisoned atmosphere cannot be modified even in a small dwelling by an expenditure of material that would be certainly beyond the means of a wealthy person. To diminish the evils of a malign atmosphere, he says, "ventilate," and, while admitting the correctness of this, I shall humbly attempt to show that means may be employed for fixing the poisonous particles floating in a fever-chamber without rendering the air of that chamber irrespirable, or without killing a patient by draughts of cold air.

Disinfectants are employed as deodorizers and as contagion-destroyers. Such agents as carbolic acid prevent the decomposition of organic matter, and therefore favor a state of atmospheric purity; but carbolic acid is not a deodorizer. It makes, but it does not absorb or destroy, fetid vapors: and it is for this reason that M. Lemaire and others have recommended the use of carbolic acid in conjunction with sulphate of zinc, salts of iron, chloride of lime, and so on.

There is indisputable similarity between the working of putrid germs and of the seeds of the most virulent plagues. Fevers were classed of old as putrid diseases, and any one who has witnessed the prompt decomposition and the foul emanations of fever-stricken beings, whether human or brute, can readily understand that it was no very India-rubber-like stretch of the imagination that led our forefathers to confound contagion with putrescence.

It is, however, necessary to learn that, in practising Disinfection, we have to neutralize the products of, or check the decay of healthy matter separated from living plants or animals, and that we have likewise to destroy specific elements of contagion, elements which differ in the various maladies that are known to be transmissible from the sick to the healthy. In order to illustrate this, let us take the case of sewage. The excreta of healthy human beings decompose, and the sewer-gases belong to the class of irrespirable gases which cannot be absorbed into the system without producing serious ill effects, and even symptoms such as characterize a putrid fever—vomiting—faintness followed by prolonged stupor—fetid diarrhœa, and even death. The results are apparently undistinguishable from typhus fever. The line of demarcation, between a malignant fever produced under such circumstances and fevers due to a specific virus, has not yet been satisfactorily established.

The foregoing symptoms result also from decomposing matters passing into the blood otherwise than by the lungs, and whole hecatombs of slain, through the instrumentality of hospital gangrene, pyæmia, puerperal fever, and allied diseases, testify to the great dangers arising from the diffusion of solid or fluid matters in a state of decomposition. In dealing with the excreta of the sick, it is not the volatile elements and simple gases that we have to fear, but the materials that adhere to any thing and every thing on and around the sick, and, if ever we allow them to pass from the sick-room, it is quite impossible to control them. If we even let them pass in any quantity from room to room or house to house in atmospheric currents, we cannot trace them until they have victimized fresh subjects susceptible to their pernicious influences.

For our purpose it may be accepted as proved that successful disinfection must aim at preventing decomposition in simple putrescible matters, or must aim at attacking fever-germs as soon as discharged by the patient. It is desirable that a disinfectant should be an anti septic—viz., an agent that arrests chemical change in animal or vegetable matters, and it must be a deodorizer, or capable of fixing the most noxious gases evolved. It has been erroneously believed that sulphuretted hydrogen is the principal deleterious gas which disinfectants have to encounter—the worst kind of vermin to ferret out. Prof. Way, however, asserts that the gaseous elements that are usually foul smelling and hurtful are ammoniacal.

The best disinfectant to deal with sulphuretted hydrogen, such as is evolved in the emptying of a foul ash-pit, would be salts of iron or chloride of zinc. Salts of iron and copper are antiseptics and very active deodorizers, and would have been used even more extensively than they have been, had they been harmless. But the iron-salts stain all they come into contact with, and copper salts are injurious to life. Zinc-salts are also inimical in this latter way. A disinfectant, to be available in the homes I am endeavoring to depict, must necessarily be harmless, and until quite recently it was not easy to find such an agent. The alkaline permanganates have been extolled as disinfectants. They are in many instances admirable deodorizers, but the fact that permanganates are sparingly soluble in water renders their employment very difficult, except in dealing with small accumulations of putrid matter. The use is too limited to enable us to rely on them for systematic disinfection.

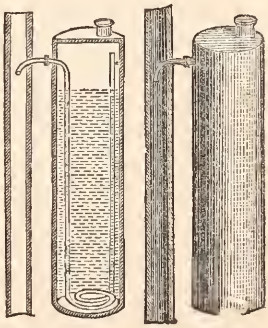
There is one volatile deodorizer and disinfectant that has been recommended very strongly in some cases by Dr. B. W. Richardson and Mr. Spencer Wells, and that is iodine. In some virulent diseases attended with fetid discharges, a little iodine placed in a box, with a little muslin to confine it, is sufficient to render the room tolerable to the attendants upon the sick. For similar purposes, peat, sea-weed, wood, or animal charcoal, have been recommended, owing to the avidity with which they condense the gases of decomposition within their pores. For some years, Prof. Gamgee has used charcoal charged with sulphurous acid as an active antiseptic, and he now suggests the use of charcoal mixed with chloride of aluminium, or, as he popularly calls it, chloralum. The sulphurous acid renders air irrespirable, but chloralum, which is a deliquescent chloride of aluminium, attracts and neutralizes the noxious elements of a poisoned atmosphere.

Having attempted to show that disinfection must be an every-day practice in the household, and that disinfectants must necessarily be harmless antiseptic deodorizers, it is not difficult to establish a code of rules of almost universal application. There is a caution that should be given at all times in a household: Servants cannot be expected to understand the use of disinfectants any more than they can be trusted to carry out a system of ventilation. Disinfection and ventilation, therefore, should, to a large extent, be automatic processes and, happily, such things are to be found.

A fusion of the two processes of disinfection and ventilation has been tried, of late, in the following manner: The space occupied by a top pane of glass is fitted up with a piece of metal which slants from the bottom upward, and the top is rounded in shape and perforated.

Inside this wedge-shaped ventilator are two shelves, pierced with holes, the top one being made to carry a box of charcoal and the bottom one a piece of sponge. By this double contrivance the inventor and patentee, Dr. Howard, of St. John's, Canada, claims not only to absorb the watery vapor of the incoming air by the sponge, and disinfect any foul air that may seek entrance by means of the charcoal, but also to warm the cold air by the amount of friction it has to undergo in its ingress through the body of a ventilator which is already somewhat heated by the warmth of the room. If the wind blows too strongly upon the outside mouth of the ventilator, Dr. Howard proposes a sliding valve to work up and down inside the pane occupied by the apparatus. I cannot but regard such a contrivance as a clumsy one. It may be said to stand in the same relationship to either perfect ventilation or perfect disinfection that spurious freemasonry does to what is called the pure craft masonry, or certain litharges to good white lead. There is no necessity, either, to filter the air of a room in such a manner.

There can, however, be a strong case made out why the water-closet pans of a house should be disinfected, and I am able to point out an apparatus which fulfils every requirement for that purpose. It is exhibited in the diagram, both in section and elevation, and is known as Brown's patent self-acting disinfector. The object is to deliver at every upheaval of the handle a certain portion of a fluid disinfectant; formerly it was exclusively Condy's fluid, now it is chloralum. The construction is the essence of simplicity. In a metal, glass, or earthenware vessel, holding a gallon of disinfecting fluid, a metal siphon is fixed, and the bottom is coiled and has a small inlet as shown, by which means the siphon fills itself. When the closet-handle is raised, the water rushing down the supply-pipe to flush the basin causes a vacuum in the disinfecting siphon, and its contents are blended with the water. By this means a portion of the deodorizing fluid is retained in the trap or basin where it has no sinecure of work to perform. The siphon refills in a few seconds, and, as only a *certain* quantity is discharged, a pint of disinfecting fluid, costing one shilling, mixed with sufficient water to make up the gallon, will serve about 140 distinct actions of the closet. The cost of the apparatus is about ten shillings, and it can be fixed in an hour to any patterned water-closet whatever. The vessel containing the fluid is usually fixed upon a bracket in a corner above the seat. This kind of apparatus can be fixed to a tap in the stable, or anywhere else, and water containing a percentage of the medicated fluid drawn off into buckets, or run off



into the pavement-drains. They can be obtained at the depot, 58 The Exchange, Southwark.

Such disinfectors are not new, but the above is the simplest. A patent automatic apparatus of a similar kind was introduced some little time ago by Mr. Spencer. It is also worked by the handle of the closet, and fixed on the wall above the seat, but it is too dependent upon a complicated action of wires and cranks—its cost is, moreover, thirty shillings. Similar contrivances are sold, adaptable for the earth-closets now in use. Whether it be true or not that the partisans of the earth-closet first drew attention to the disinfection of the excreta, I do not know, but at all events they were not far behind. I have already given an example of these as applied to the earth or ash closet. As a matter of course, they are chiefly powdered disinfectants. Mr. Bannehr, in his improved ash-closet, uses a simple carbonaceous powder, chiefly as an absorbing medium.

Nothing could be more wearisome than wading through the history of disinfectants, and yet an occasional smile would be sure to light up the way. Who would propose to burn incense to the God of Stinks at various times throughout the day, in the shape of patent pastils, composed chiefly of charcoal, sulphur, and nitrate of potass? Or who could be brought to look, Hindoo-fashion, on his patrimonial open drain or sewer as a river Ganges, and with religious punctuality set adrift upon the water there a sacred vessel which would admit a certain portion of such water, and also containing a phosphuret which would decompose in contact with the water, the gas and flame thus evolved being understood to neutralize the evaporating poison of Siva, the destroyer? And yet men have paid for leave to rivet such absurdities upon us, and the cry is, "Still they come." Since the time of M Legras, who, in 1849, claimed to discover and patented not less than twelve disinfectants (three liquids and nine powders), what have householders not had to endure?

Apart from the many simpler disinfectants, such as earth, ashes, charcoal, peat, salt, sulphur, gypsum, alum, vinegar, and tar-water, etc., suitable for the coarser purposes of a farm, the disinfectants for the house now in commerce may be reckoned on the fingers of one hand. I have already given a general indication of the action of each, and will only add that these useful agents have now been brought to such a state of perfection, that the person who chooses to make up his own mixtures, puts himself in the position of an ague-patient, who, ignoring the labors of chemistry, prefers the powdered Peruvian bark to the sulphate of quinine.

The disinfectant used in a household ought certainly to be a non-poisonous one. Fortunately, or unfortunately, there is not any choice, for the only one of this description is chloralum, now adopted by the Board of Trade. This is the popular name bestowed upon it by its inventor, Prof. Gamgee. It contains 1,500 grains of hydrated chloride of aluminium to the pint, or about 75 grains to the ounce, and is sold in a fluid and solid state. Slightly diluted, the former will disinfect secretions in the utensils of a sick-room; and, exposed in a saucer in its concentrated form, I have found it to remove even the smell which is given off by a newly-painted room. In its powdered state it may be sprinkled in cellars, larders, dust-bins, ash-pits, stables, piggeries, poultry-houses, and wherever a smell is continually arising. In the deodorization of sewage, while being pumped over the garden, one gallon of the fluid, or three pounds of the powder, will suffice for 150 gallons of sewage.

As regards the disinfection of clothing in the laundry, Mrs. Meredith, the patroness of the Discharged Female Prisoners' Aid Society, lately wrote to the *Standard* newspaper as under:

> "The articles taken in for the wash are fairly sprinkled with chloralum-powder; they are then packed in sacks, in which they remain for about two hours, when they arrive at the wash-house. They are then unpacked and shaken singly. After this they are put in a large tank, where a great quantity of water flows over and through them. In this way they rest for at least twelve hours. They are then wrung out, and undergo the ordinary process of washing. It is highly satisfactory to add that not the least deterioration of texture or color results."

At the wash-houses referred to by this lady, a great number of women are employed, and nothing but the washing of the sick is carried on.

THE NATURAL HISTORY OF MAN.

A COURSE OF LECTURES AT THE IMPERIAL ASYLUM OF VINCENNES.

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TRANSLATED BY ELIZA A. YOUMANS.

I.—The Unity of the Human Species.

GENTLEMEN: Each of my fellow-laborers in science comes here to lecture to you; they each select the subject which habitually occupies them. Some tell you of the heavens, the earth, the waters; from others you get the history of vegetables and animals. As I am Professor of the Natural History of Man at the Museum, I ask myself why I should not speak to you of man.

There is evidently as much interest for us in our own species as in the history of animals, even of those most useful to us. Indeed, at this time, the mind is drawn toward this study by an irresistible movement. Formerly, Anthropology, the natural history of man, was not represented in philosophical bodies, nor by the periodical press. Now, in Paris alone there are two Philosophical Societies occupied exclusively with this science, and two large publications equally devoted to it. At the Museum the teaching of anthropology is older. It is there aided by a collection which is still the best in the world.

I do not hesitate to say that it is one of the glories of France to have given by these methods an example to the entire world—an example followed to-day in America as well as in Europe. And I wish to make you take a part in this movement, by giving you some serious notion of the *ensemble* of the human family.

This, gentlemen, is much more difficult for me than for my associates. In all these lectures we are to speak of only a single being, man. Consequently, there will be an intimate union between them, so much so that any person who should miss a lecture would find difficulty in thoroughly understanding those that follow. To remove this difficulty, I mean to shape my teaching so that each lecture will form as definite a whole as possible. Then, at the commencement of each lecture, I shall endeavor to give, in a few words, a *résumé* of the preceding. In this way I hope to carry you to the end without ceasing to be understood.

Each lecture, then, will be a sort of chapter of what we might call *Popular Anthropology.*

By-and-by I hope that these lectures will be collected into a volume, and I shall be very proud if one day they merit the adjective I have employed—if, in reality, they become popular among you.

Let us enter, then, upon our first chapter. Since man is the subject of our discourse, we must first ask what he is. But, before answering, I ought to enter into some explanation.

This question has been often asked, but generally by theologians or by philosophers. Theologians have answered in the name of dogma and religion; philosophers in the name of metaphysics and abstraction. Let it be well understood between us that I shall take neither of these grounds, but shall avoid, with great care, both that of theology and that of philosophy. Before I became professor at the Museum, I was occupied with the study of animals—I was a naturalist. It is as a naturalist that I have taken my chair at the Institute. At the Museum I remain what I was, and nothing else. I shall continue the same at Vincennes, leaving to theologians theology, to philosophers philosophy, limiting myself in the name of science, and, above all, in the name of natural science.

Let us now return to the question I was about to put: What is man?

It is evidently useless to insist that man is neither a mineral nor a vegetable—that he is neither a stone nor a plant. But is he an animal?

No, indeed, especially *when we take into account all which exists in him.* And I am sure that in this respect you all agree with me.

Certainly none of you would wish to be compared with cattle that ruminate, with hogs that wallow in the mire. Nor would you wish to be classed with the dog, notwithstanding all the qualities which make him the friend and companion of man; nor with the horse, though it should be with Gladiator.

Man is not an animal. He is widely distinguished from animals by numerous and important characters of different sorts. I shall here only refer to his *intellectual superiority*, to which belongs articulate speech, so that each people has its special language; *writing*, which permits the reproduction of this language; *the fine arts*, by the aid of which he conveys, and, in some sort, materializes the conceptions of his imagination. But he is distinguished from all animals by two fundamental characters which pertain only to him. Man is the only one among organized and living beings who has the *abstract sentiment of good and evil;* in him alone, consequently, exists *moral sense.*

He is also alone in the belief that there will be *something after this life*, and in the recognition of a *Supreme Being*, who can influence his life for good or for evil. It is upon this double idea that the great fact of *religion* rests.

By-and-by these two questions of *morals* and *religion* will turn up again. We shall, I repeat, examine them, *not as theologians*, but simply as *naturalists.* I will only say for the present that man, everywhere, however savage he may be, shows some signs of *morality* and of *religion* that we never find among animals.

Hence man is a being apart, separated from animals by two great characters, which, I repeat, distinguish him yet more than his incontestable intellectual superiority.

But here the differences end. *So far as the body is concerned*, man is an animal, *nothing more, nothing less.* Except some differences of form and disposition, he is the equal, only the equal, of the superior animals that surround him.

If we take, for terms of comparison, the species that approach us nearest in general form, *anatomy* shows us that our organs are exactly the same as theirs. We can trace in them, almost muscle by muscle and nerve by nerve, those which we find in man himself.

Physiology, in its turn, shows us, in the body of man, the organs, muscles, nerves, performing exactly the same functions as in the animal. This is a capital fact which daily profits us, both from a purely scientific and from a practical point of view. We cannot experiment upon man—we can upon animals. *Human physiology* has employed this means to discover the functions of our organs. *Physicians* go further still; they bring to the sick-bed the fruit of experiments made upon animals. *Anthropology* also, as we have just seen, applies to these inferior creatures for very important instruction.

But Anthropology should descend much lower than the animals when it would enlighten us completely. Vegetables are not animals, any more than animals are man. But men, animals, and vegetables, are all *organized and living beings.* They are distinguished from minerals, which are neither the one nor the other, by certain general facts common to all.

All organized beings have a limited duration; all are born small and feeble; during part of their existence, all grow and strengthen, then decrease in energy and vitality, sometimes also in size; finally all die. Throughout life, all organized and living beings need nourishment. Before death, all reproduce their kind by a seed or an egg (we speak here of species, not of individuals), and this is true even of those which seem to come directly from a bud, from a layer, from a graft, etc.; for from bud to bud, from layer to layer, from graft to graft, we can rise to the seed and to the egg. Finally, then, all organized and living beings have had a father and a mother.

These grand phenomena, common to all living beings, and consequently to man, imply general laws which control them, and which must therefore govern man as well as the plant.

Science every day confirms this conclusion, which might have been reached by reason alone, but which may now be regarded as a fact of *experience.* And I believe I need not dwell here, to make you understand the magnificence of this result.

As for me, I find it admirable that man and the lowest insect, that the king of the earth and the lowliest of the mosses, are so linked together that the entire living world forms but one whole where all harmonizes in the closest mutual dependence.

From this community in certain phenomena, from this subjection to certain laws equally common, results a consequence of the highest importance. Whatever questions concerning man you may have to examine, if they touch upon any of these properties, of these phenomena common to all organized and living beings, you must interrogate not only animals, but vegetables also, if you would reach the truth.

When one of these questions is put and answered, to make the answer good, to make it true, you must bring man under all the general laws which rule other organized and living beings.

If the solution tends to make man an exception to general laws, you may affirm that it is bad and false.

But also, when you have resolved the question so as to include man in these great general laws, you may be certain that the solution is good, that it is true, and really scientific.

With these data, and these alone, we will now consider the second question of Anthropology, and here it is:

Are there several species of men, or is there but one, including several races?

To be understood, this question requires some explanation.

Look at the drawings I have hung at the bottom of the hall. These figures are part of those I employ in the course at the Jardin des Plantes.

I have brought but a small number, but they suffice to give an idea of the principal varieties which the human type presents. You have here individuals taken from nearly every part of the world; and this I regard as a very important point. You see that they differ considerably from each other in color, often also in hair, sometimes in proportions, sometimes in features.

Well, our question is, whether the differences presented by the human groups from which these designs were taken are differences of *species*, or if they indicate only differences among *races* that belong to one and the same species.

To answer this question, we must begin by getting a clear idea of what is meant by the words *species* and *race*. In fact, the whole discussion turns on these two words.

Unhappily, they have been often taken one for the other, or else they have been badly defined. The discussions which have hence arisen would very quickly cease, if we would study them a little more closely.

Let us see if we cannot get precise ideas without going into details impossible here.

Certainly none of you would ever confound an ass with a horse: not even when a horse is small, and there are horses no larger than a Newfoundland dog; nor when an ass attains the size of an ordinary horse, as, for example, our large asses of Poitou. You say immediately, they are different species: here is a big ass and a little horse. And you say the same on seeing, side by side, a dog and a wolf.

On the other hand, all of you here would give the single name of *dog* to animals which differ from each other, as do the bull-dog and water-spaniel, the greyhound and the lapdog, the Newfoundland dog and the King-Charles; and you are right.

However, judging by sight alone, even after detailed observation, you see, between the dogs I have just named, differences of size, of proportion, of color, much greater than those which separate the horse from the ass. An ass and a horse of the same size certainly resemble each other much more than the types of dog I have just named.

Further, if you place side by side a black and a white water-spaniel, you will not designate them by different names. You will call them both water-spaniels, although one is black and the other white.

In the case of vegetables you do exactly the same thing. A red rose and a white rose are equally roses; a pear is always a pear, whether you buy two for a sous in the street, or pay three francs at Chevet.

Well, without doubt, your decision is exactly like that of the naturalists. You have answered, just as they do, the question of species and race—a question that at first appears very complicated, because of the confusion before referred to. Here, then, is one more example to prove that, under many circumstances, popular observation and good sense go straight to the mark, as well as the labors of science.

Indeed, let us translate into general scientific language what I have just said of your views, and I am very sure not to be mistaken with regard to them.

The meaning of this judgment is, that an animal or a vegetable may vary within certain limits. The dog remains a dog, whatever its general form, its size, its hair; the pear remains a pear, whatever its size, its savor, the color of its skin.

From these facts, which I simply allude to, it results that these variations may be transmitted by way of generation. You all know that the union of two water-spaniels will produce water-spaniels; that the union of two bull-dogs gives bull-dogs.

It results, finally, in a more general way, that individuals of the same species may cease to resemble each other in an absolute manner, may sometimes even take very different characters, without becoming isolated and forming different species. As we have just said, *the dog remains a dog*, whatever its modifications.

Well, these groups, formed by individuals which have departed from the primitive type, and have formed distinct secondary groups, are precisely the ones that naturalists call races.

You understand why we constantly speak of races of cattle, horses, etc. There is, in fact, but one species of domestic cattle, which has given birth to the *race bretonne*, as well as to the great cattle of Uri, with their savage aspect, and to the peaceful Durham. We have, again, but one species of domestic horse, and this species has given birth to the little Shetland pony, of which I spoke just now, and to those enormous brewers' horses that we see in the streets of London. Finally, the various races of sheep, goats, etc., have arisen from one and the same species.

We must give more precision to our ideas on this point, because the least vagueness here will make very serious inconvenience. I will cite some further examples taken from vegetables and animals, being careful to choose such as are entirely familiar.

You all know the seed of the coffee-tree. Permit me to give its history. You will see that it is instructive.

The coffee-tree came originally from Africa, where from time immemorial it has been cultivated on the declivities of Abyssinia that slope toward the Red Sea. About the fifteenth century, something like four hundred years ago, the coffee-tree crossed this sea and penetrated into Arabia, where it has since been cultivated, and whence especially we get the famous coffee of Mocha.

The use of coffee spread very early and with great rapidity in the East. It penetrated Europe much more slowly, and it was first taken in France at Marseilles.

Coffee was first drunk in Paris in 1667. The seeds which furnished it were brought in small quantity by a French traveller named Thevenot. Two years afterward, in 1669, Soliman Aga, ambassador of the Sublime Porte in the time of Louis XIV., induced the courtesans of that great king to taste it, and they found it very agreeable. However, its use did not spread for a long time. It was not until the eighteenth century that it began to be generally used.

You see that coffee has not been very long in circulation. In fact, it is scarcely a century and a half since it became an article of general consumption by the people of Europe.

Well, during many years Europe remained tributary to Arabia for this commodity. All the coffee consumed in Europe came from Arabia, and particularly from Mocha. Toward the commencement of the eighteenth century the Dutch attempted to import it into Batavia, one of their colonies in the Indian Archipelago. They succeeded very well. From Batavia some stalks were taken to Holland and put in a hot-house, where they succeeded equally well. One of these stalks was brought to France toward 1710, and was placed in the conservatory of the Jardin des Plantes, and there also it prospered and gave birth to a certain number of sprouts.

In 1720 or 1725 (I have not been able to find the precise date), an officer of the French Navy, Captain Desclieux, thought that, since Holland had cultivated coffee at Batavia, he might also acclimate it in our colonies of the Gulf of Mexico. When embarking for Martinique, he took from the Jardin des Plantes three stalks of coffee, and carried them with him. The voyage was long and difficult, by reason of contrary winds. The supply of water proving insufficient, it was necessary to put the crew on rations. Captain Desclieux, like the others, had but a small quantity of water to drink each day. He divided it with his coffee-plants. Notwithstanding all his care, two died on the passage; only one arrived safe and sound at Martinique. Put at once into the earth, it prospered so much and so well that from it have descended all the coffee-trees now spread over the Antilles and tropical America. Twenty years after, our Western colonies exported millions of pounds of coffee.

You see the coffee-tree, starting from Africa, has reached the extremity of Asia on the east and America on the west. Hence, it has nearly travelled round the world. Now, in this long voyage, coffee has become modified.

Passing by the tree, of which we know little, let us consider the seed. We need not be grocers to know the different qualities of coffees and their different production. Nobody would confound Mocha with Bourbon, Rio Janeiro with Martinique. Each of these seeds carries in its form, in its proportions, in its aroma, the certificate, so to say, of its birth.

Whence came these changes? We cannot know with certainty and explain the why and the how, and follow rigorously the filiation of cause and effect; but, considering the phenomena as a whole, it becomes evident that it is to differences of temperature, of climate, of culture, that all these modifications are due.

This example, taken from vegetables, shows that if we transport to considerable distances different specimens of the same vegetable, placing them in different conditions of cultivation, we obtain different races. Tea transported some years ago into tropical America would present us with like facts.

Take, now, an example from animals. You all know the turkey but, perhaps, some of you do not know that it came from America. Its introduction into Europe is quite recent.

In America the turkey is wild; and there, in its natural conditions of existence, it presents many characters which distinguish it from our domesticated individuals. The wild-turkey is a very beautiful bird, of a deep-brown color, very iridescent, presenting reflections of blue, copper, and gold, which make it truly ornamental. It was because of its fine plumage that it was first introduced into France. In the beginning no one thought of the turkey as food; and the first turkey served at table in France was in 1570, at the wedding of Charles IX., two hundred and ninety-seven years ago.

As soon as one has tasted the turkey, one finds that he is too good to be merely looked at. He passes from the park to the poultry-yard, from the poultry-yard to the farm, and from one farm to another, east, west, north, and south. At present, in almost all France, turkeys are raised and are a considerable object of commerce.

But, in going from farm to farm, in travelling all over our country, this bird has encountered different conditions of existence, differences of nourishment and temperature, and never the primitive conditions that it had naturally in America. As a consequence of all this, the turkey has also varied, and, to-day, not a turkey in France resembles the wild stock. Generally, it has become much smaller; when it has preserved its deep plumage it has become darker and duller; but some have become fawn-colored, others are more or less white, and others again are spotted with white, gray, or fawn-color.

In a word, almost all the localities to which the turkey has become addicted have given birth to new varieties which have been transformed into *races*.

Now, in spite of these changes, and although they do not resemble their first parents in America, and do not resemble each other, are our French turkeys less the children of the wild-turkey of America? Or if you like that better, are they less brothers and sisters? Have they ceased to be part of the same species? Evidently not.

What I have just said of the turkey might also be said of the rabbit. The wild-rabbit lives all around us—in our downs, in our woods—and he does not resemble, or resembles but little, our domestic rabbit. These, you know, are both great and small, with short hair, and with silky hair; that they are black and white, yellow and gray, spotted and of uniform color. In a word, this species comprehends a great number of different races, all constituting one and the same species with the wild stock which still lives around us.

From these facts, that could be multiplied, we have to draw an important consequence, to which I call your attention:

A pair of rabbits, left in a plain where they would encounter no enemies, in a few years would fill it with their descendants, and, in a little while, all France would be easily peopled. We have just seen that a single stalk of coffee gave birth to all the coffee-trees now found in America.

The wild-turkeys and their domestic offspring, the wild-rabbits and their captive descendants, may then be considered by the naturalist as equally arising from a primitive pair.

Gentlemen, this is the stamp of a species. Whenever you see a greater or less number of individuals, or groups of animals, or vegetables, if, for one reason or another, you can look upon them as descendants of a single primitive pair, you may say you have before you *a species;* if from group to group there are differences, you say these are *the races of that species.*

Observe carefully, gentlemen, that, in thus expressing myself, I have not stated for certain the existence of this primitive pair of the stock of rabbits or of the stock of turkeys. I affirm no such thing, because neither experiment nor observation—the two guides we should always follow in science—can aid us on this point. I only say to you, every thing is as if they had been derived from a single pair.

You see, after all, the question of *species* and of *race* is not very difficult to comprehend, nor even very difficult to settle when we know the wild type, when we have the historic data which enable us to connect with this type the more or less different groups which domestication has detached. But when we do not know the wild type, when the historic data are lost, the question, on the contrary, becomes extremely difficult at the first step, because differences that we encounter from individual to individual, and, above all, from group to group, might be considered as specific differences.

Happily, Physiology comes now to our relief. We encounter here one of those great and beautiful general laws upon which the established order depends, and which we admire more the more we study. This is the law of cross-breeding—a law which governs animals as well as vegetables, and is, of course, applicable to man himself.

You know what is meant by the word crossing. We mean by it all marriage occurring between animals that belong either to two different species or to two different races. Well, the results of these marriages obey the following laws, which are:

When this union takes place between two animals belonging to *different species*—that is, when we attempt *hybridization*—in the immense majority of cases the marriage is *sterile.* Thus, for example, it has been tried thousands of times and in all the world, to unite *rabbits* and *hares.* It is said that they have succeeded twice. But these two quoted facts are much more doubtful than the results of experiments recently made by a man of true talent, skilled in the art of experimenting, and who believes in the possibility of these unions, who has completely failed. Although he furnished the best conditions for success, he was not more fortunate in his results than Buffon, and the two Geoffroy Saint-Hilaires before him.

So the rabbit and the hare are of such a nature that, although presenting in appearance a great conformity, they cannot reproduce together.

Such is the general result of crossing two different *species.*

In many cases, the union of two individuals of different species is fertile, but the offspring cannot reproduce. For example, I refer you to the union of the ass and horse. This union produces the mule. All the mules in the world are offspring of the jackass and the mare. Now, these animals are numerous, for in Spain and in tropical America they are much preferred for work to horses, because of their resistance to fatigue. The *hinny*, less in demand, because less robust than the mule, is the result of an inverse cross; it is the offspring of the horse and the ass. The hinny, like the mule, cannot reproduce its kind. When we wish for either, we must have recourse to the two *species.*

Finally, in extremely rare exceptions, the fertility persists in the offspring, but it is much diminished. It diminishes still more in the grandchildren, and it is extinguished in the third or fourth generation at the most. This is the case when we unite the canary-bird with the goldfinch.

I might here accumulate a mass of analogous facts and details. But over them all would appear a great general fact including them, which is the expression of a law; and here is this fact: notwithstanding observations reaching back for thousands of years, and made on hundreds of species, we do not yet know a single example of intermediate species obtained by the crossing of animals *belonging to different species.*

This general fact explains how order is maintained in the present living creation. If it had been otherwise, the animal world and the vegetable world would be filled with intermediate groups, passing into each other by insensible shades, and, in the midst of this confusion, it would be impossible for even naturalists to discriminate.

The general conclusion from all this is, that *infertility is the law when animals of different species unite* (Hybridization).

When, on the contrary, individuals which are only of *different races*, but of the same species, are brought together, that is to say, when we produce a *mongrel*, is the result the same? No, it is exactly contrary.

These crossings are always fertile, and sometimes more so than the union of animals of the same race. But especially the children and grandchildren are also as fertile as the parents and grandparents; so much so that they propagate their kind indefinitely. The difficulty here is not to procure *mixed races;* the difficulty is, when we have pure races that we desire to preserve, to keep strange blood from modifying them.

Races thrive by crossing—that is, by the union of different races of the same species, they multiply abundantly around us; such are our street-dogs, our roof-cats, our coach-horses, all our animals where the race is indistinct; because of cross-breeding in all directions, the differential characters becoming confounded.

So far from experiencing difficulty in obtaining offspring from races, the men who are occupied with cattle, with sheep, with horses, amateurs in dogs, in pigeons, know with what watchful care they must protect their favorite race.

Here, then, is a general fact, and from this fact it results that *fertility is the law of union between animals belonging to different races* (MIXED BREEDING).

Here, gentlemen, you see the great distinction, the fundamental distinction, between *species* and *race.* And, it is all the more important to recognize and record this distinction, as it facilitates experiment. When you have two different vegetables, or two different animals, and wish to know whether they belong to two *distinct species*, or only to *two races of the same species*, marry them. If the union proves immediately fertile, if the fertility is propagated and persists, you may affirm that, notwithstanding the differences which separate them, these vegetables and these animals are only *races of the same species.* If, on the contrary, you see the fertility disappear completely or diminish notably at the first union, if you see it decreasing, and go on diminishing, to disappear at the end of a few generations, you may without hesitation affirm that these vegetables and these animals belong to *distinct species.*

Gentlemen, I have discoursed at length of vegetables and animals, of the coffee-tree, of the turkey, of the rabbit, of the dog, of the cat, of cattle, etc., and you may think that I am forgetting man. On the contrary, I have not ceased to think of him.

What is our question concerning man? Distinctly this.

Look once more at these designs. They show you differences, marked enough, between the human groups, although less considerable than at first appears.

Now, we do not know the type or the primitive types of these human groups.

Even when we encounter one or several men, presenting the characters of these types, we cannot identify them, for lack of historical documents upon the subject. Consequently, if we judge by the looks, if we take account only of the men themselves, we cannot decide whether the differences they present are *differences of race or differences of species;* whether man is to be considered as arising from a single primitive stock, or whether we ought to suppose several primitive stocks.

But we have already said, and we again repeat, that *man is an organized and living being;* and, as such, he obeys all the general laws which govern all organized and living beings: he consequently obeys the laws of crossing. These, then, we must interrogate, to find out whether there *is one or several species of men.*

Take, for example, the two most distinct types, those which, more than any others, seem separated by profound differences—the white man and the negro.

If these types really constitute *distinct species*, their union ought to bear the stamp we have found to characterize the unions between animals and vegetables of different species. In the great majority of cases they should be infertile; in all the remainder, slightly fertile; the fertility should soon disappear, and they should not be able to form intermediate groups between the negro and the white. If these two men are only *races of one and the same species*, their union, on the contrary, should be very fertile; the fertility should be kept up by their descendants, and intermediate races ought to be formed.

Well, gentlemen, the facts here are decisive, and admit of no hesitation. It is scarcely three centuries since the white man *par excellence*—the European—made, so to say, the conquest of the world; he has gone everywhere, and everywhere he has found local races, human groups that do not resemble him; everywhere he has crossed with them, and the unions have been very fertile, sometimes very sensibly more fertile than those of the indigenous people themselves.

And further, in consequence of a detestable institution, which happily has never sullied the soil of France, in consequence of slavery, the white has taken the negro everywhere, everywhere he has crossed with his slaves, and everywhere a mulatto population has been formed. Everywhere, also, the negro has crossed with the local groups, and everywhere there have sprung up intermediate races, which, by their characters, proclaim this double origin. The white, finally, has crossed with these mixed breeds, and hence has resulted in certain parts of the globe, and notably in America, an inextricable mass of mixed peoples, perfectly comparable with our street-dogs and roof-cats.

The rapidity with which these mixed races cross and multiply is truly remarkable. It is hardly three centuries, about twelve generations, since the European spread over all parts of the world. Well, we estimate that already one-seventieth of the total population of the globe are mixtures, resulting from the cross of the whites with indige nous peoples.

In certain states of South America where the mixture began earlier where the European arrived in the first days of discovery, a quarter of the population is composed of cross-breeds, and in some regions the proportion is more than half.

You see, our experience is to-day as complete as possible. Unless we deny all modern science, unless we would make man a solitary exception in the midst of organic and living beings, we must admit that all men form only one and the same species, composed of a certain number of different races; we must, therefore, admit that all men may be considered as descended from a single primitive pair.

You see, gentlemen, we have reached this conclusion, outside of all species of dogmatic or theological consideration, outside of all species of philosophical or metaphysical consideration. Observation and experiment alone, applied to the animal and vegetable kingdom, science, in a word, leads us logically to this conclusion: *there exists but one species of men.*

This result, I do not fear to say, is of great and serious importance, for it gives to the thought of universal brotherhood the only foundation that many people now recognize, that of science and reason.

I hope, gentlemen, that my demonstration has convinced you. However, I am not unaware of the fact, and you doubtless also know, that all anthropologists are not agreed. There are among my fellow-laborers a certain number of men, even of great men, who believe in the plurality of the human species. Perhaps you may have come in contact with them. Well, listen, then, with attention to the reasons they bring in support of their view. You easily see that all these reasons may be summed up in this: There is too much difference between the negro and the white man to permit them to belong to the same species.

Then you reply: Between the white or black water-spaniel and the greyhound, between the bull-dog and the lapdog, there is much more difference than between the European and the inhabitant of Africa, and yet the greyhound and the water-spaniel, the bull-dog and the lap-dog, are equally dogs.

They will perhaps add: How could the same primitive man, whatever his characters might be, give birth to the white man and the negro?

You will answer: How has the wild-turkey, of which we know the origin, of which we know the grandparents, how has the wild-rabbit, which we find still among us, how have they been able to give birth to all our domestic races?

We cannot, I repeat, explain rigorously the how and the why; but this we know, the fact exists, and we find its general explanation in the conditions of existence, in the conditions of the environment.

Now, man, who has progressed upon the earth a much longer time than the turkey or the rabbit, who has been upon the globe for thousands of years, living under the most diverse, the most opposite conditions, multiplying further the causes of modification by his manners, his habits, his kind of life, by the more or less care he takes of himself —man, I say, is certainly found in conditions of variation much more marked than those which have been encountered by the animals we have cited. It is not, then, surprising that men, from one group to another, present differences of which we here see the specimens. If there is any thing in them to astonish us, it is that these differences are not more considerable.

In your turn you ask of the polygenesists—for this is the name given to the philosophers who believe in the multiplicity of the human species—how is it that when the white man comes to any country whatever, at the antipodes, in America, in Polynesia—how is it, I say, that everywhere he crosses with human groups that differ most completely from him; that these unions are always fertile, and that everywhere he has left traces of his passage in producing a mixed population?

If you press your interlocutor a little, he will quite often deny the reality of species; he will thus put himself in contradiction with all naturalists without exception, botanists or zoologists—with all the eminent minds who, following Buffon, Tournefort, Jussieu, Cuvier, Geoffroy Saint-Hilaire, have studied vegetables and animals, outside of all discussion, and without thought of man.

In thus dealing with the question, the polygenesist falls into disagreement with the best-established science.

Sometimes, also, you will hear him declare that man is an exception, that he has his particular laws, that the arguments taken from plants and animals are not applicable to him. Answer him, then, in the name of physiology, in the name of all the natural sciences, that he is certainly mistaken.

It is quite as impossible that an organized and living body should escape the laws of organization and life as that material substances should escape the laws that govern inorganic matter. Therefore, man, an organized and living being, obeys, as such, all general laws, and those of crossing like the rest. The conclusion we have drawn is then legitimate, and the nature of the arguments employed to combat it is a further proof in its favor.

Gentlemen, the subject of this lecture, which has occupied about an hour, at the Museum took up an entire course. The exposition has necessarily been brief. But I hope you have seen reasons strong enough to make you accept my view.

If doubts remain, try to come to my lectures. Some of you will be able, perhaps. I sometimes see working-men on the seats of my lecture-room, and I can testify to the attention of some among them. I own I was happy to see the attention they gave to these exalted questions. It would give me great pleasure to see at the Jardin des Plantes some of my audience at Vincennes.

THE CAUSES OF DYSPEPSIA.

By ARTHUR LEARED, M.D.

THE digestive power may be compared to the physical strength. Every individual can without inconvenience carry a certain weight, while any addition to it is accompanied by a proportionate sense of oppression. In the same way, what is called indigestion is often simply a result of excess. The amount of food which each man is capable of digesting with ease has always a limit. This limit bears relation to his age, constitution, state of health, and habits.

For undisturbed digestion two conditions are essential: a proper relation of the aliment to the digestive organs, and a healthy state of the organs themselves. The first is generally within direct control; but, obviously, with the second, this is not the case; and when, as frequently happens, both conditions are imperfectly fulfilled in the same person, more or less dyspepsia ensues.

Bearing in mind these general views, let us examine the influence of particular causes; and first, as regards age. Appetite, or the natural feeling that food is wanted, indicates that the waste of the body requires to be replenished—that the outlay begins to exceed the income. From birth to the moment of dissolution, waste and supply are in active operation. The infant, in consequence of its rapid growth, requires food at short intervals, and the energy of the wasting process is shown by the activity of his excreting organs. So long as growth continues, the same conditions may be observed, but in a lessening degree. When the stature and form of the body are matured, the demands for nutrition are less urgent, and, after middle age, are diminished still more. The practical inference is, that the man of advanced years does not require, and should not take, as much food as the young man.

How this was recognized by a profound thinker, may be read in Cicero's "Essay on Old Age." He expresses himself gratefully that, while advancing years increased his desire for conversation, they had diminished the necessity for food and drink. But such reflections are seldom made, and still more rarely acted upon. At all stages of adult life, but particularly during its decline, the appetite is over-stimulated by condiments, and tempted to excess by culinary refinements.[1] Dyspepsia is not the worst result of this. Gout, and still more serious maladies connected with an impure state of blood, closely follow.

Infringements of the laws of digestion are constantly and in many instances unconsciously committed. One man digests with ease an amount of food which would be fatal to the comfort of another. Animal food is easily digested by some persons twice, or even three times daily; while, if taken by others more than once, it is sure to induce suffering. Nevertheless, the diet of persons associated together is apt to be the same, and a sufficient individuality in matters of eating and drinking is seldom observed.

When the general health is impaired from any cause, digestion infallibly suffers. In many instances it is sought to prop up the one by overtaxing the powers of the other, and dyspepsia is often thus permanently added to the old disorder. The proverb, "Custom is second nature," applies to the human constitution. Health may be maintained, by gradual usage, under circumstances which would be disastrous to the novice. In this country, great faults are committed in the relative amount and distribution of meals. Breakfast frequently consists of tea or coffee, with a small proportion of plain bread or toast. This allays the appetite, but is insufficient for the supply of bodily waste during the long interval between breakfast and a late dinner; during which, in many instances, no luncheon is taken. It also often happens that no solid food is taken from dinner-time until the following morning, which is an additional reason for a more substantial breakfast.

Experience shows that the delicate stomach suffers severely from these causes. In some instances, the long-unemployed organ secretes an excess of mucus, which greatly interferes with digestion. A sufficient amount of food at breakfast has a direct influence on the digestion of dinner; in which process, large quantities of gastric juice—a fluid charged with nitrogenous and other materials—must be suddenly extracted from the blood. No argument is needed to prove that the blood will be better fitted for these demands upon it, if replenished by the absorption of a substantial breakfast. If gastric juice, insufficient in quantity or of bad quality, be supplied, the appetite for dinner exceeds the digestive power, and another material cause of dyspepsia arises. Long abstinence thus causes the amount of food taken at dinner to be relatively, as well as absolutely, in excess. When a sufficient quantity of nutriment has been taken in the morning, less will be requisite at a later period, and less will be desired.

The distribution of meals in point of time is by many regarded as quite unimportant. Dinner, as has been said, comes late, quickly followed by tea, and sometimes by supper also. This approximation

[1] Abernethy, in his peculiar style, insists that civilized man "eats and drinks an enormous deal more than is necessary for his wants or welfare. He fills his stomach and bowels with food which actually putrefies in those organs."

of meals is pernicious, for the human stomach was unquestionably intended to have intervals of rest. The organ should be allowed to act on its contents *en masse;* to eat constantly like a ruminant animal is altogether unnatural. The health of any individual would speedily break down, were even the proper amount of food taken in equally divided portions at very short intervals.

Continual alteration of the time of meals is another great mistake. Every hour of the day for dinner, from one to eight, will sometimes be ranged through in the course of a single week. Such irregularities may long be endured by the robust stomach, but are very injurious to the weakened organ. In relation to time, all our functions are singularly influenced by habit. Digestion, therefore, will be best performed at the period when the stomach, from habit, expects employment. The kind and quality of food are essential considerations; and these subjects will be considered elsewhere. Adulteration of food is without doubt a cause of dyspepsia. Inferior articles of diet, such as tough meat or coarse fish, may, in those unaccustomed to them, produce serious inconvenience; and the impurities of water are well known to disorder digestion.

Man inhabits every part of the globe where external influences can be successfully resisted, and, in effecting this, food is an important element. The colder the climate the more animal food and oily substances are requisite; the warmer, the more vegetable diet is suitable. Whale-blubber to the warmly-clothed Esquimaux, and rice to the naked Negro, are not more necessities of locality than they would be matters of choice. The same indications exist even within European limits. Thus, diet in England and in Italy is essentially different.

The effects of universal communication are nowhere more obvious than on the luxurious table. To furnish the refined *cuisine*, all climates, both sea and land, are laid under contribution; and the stomach is expected to digest every thing that is put into it. Huddling together such various products, and neglect of the relation between climate and food, are active causes of dyspepsia. The substantial dishes of this country accord badly with the thermometer at ninety degrees; thus, among the English in India, inflexibility in regulating the kind and quantity of food taken is the cause of much ill health.

Under the head of the relation of food to the organs may be placed the effects of insufficient mastication. It is a fruitful source of dyspepsia, and is more frequently caused by haste or carelessness, than inevitable from the want of teeth. The great prevalence of dyspepsia in the United States has been attributed to the rapid and characteristic manner in which meals are there dispatched. In some employments the insufficient time allowed for meals is, for the same reason, a cause of disturbed digestion, and too often gives rise to permanent disease. Besides actual loss, soreness of the teeth or of the gums, sometimes attended by fetid secretions, greatly interferes with mastication. It is most important that solid food should be duly prepared, by chewing, for the action of the stomach; and it is also important that the starchy elements of food be sufficiently submitted to the action of pure saliva.

There are numerous other causes which affect the digestive organs less directly, but no less injuriously. It has been assumed by some writers that the conditions of civilization are incompatible with the highest degree of health. But there is every reason to believe that dyspepsia affects all races. The Laplander is especially subject to water-brash; the Maories of New Zealand suffer much from dyspepsia; and the use of bitter substances to promote digestion is known to many savage tribes. The extremes of abstinence and repletion common with savages, their precarious mode of existence, their fits of complete indolence, followed by exhausting fatigue, must cause them a full share of digestive trouble.

The relative superiority in physical strength of civilized over savage nations has been sufficiently proved. Refined and settled habits are not *necessarily* attended by any physical disadvantages. But it is observable that those who live in towns are most affected by dyspepsia. There it is that the mental powers are most overtasked; and the relation between mind and body, as well as their mutual reactions, disregarded or forgotten. Too large a share of the nervous energy, so necessary for digestion, is expended in mental toil or business anxieties. In many cases, attention to the commonest physical wants is neglected in monotonous pursuits; the appetite for food is disregarded until it no longer exists; exercise is either not taken at all, or is fitful and unseasonable; ventilation is neglected, and a close and polluted atmosphere is breathed. Such is no overdrawn picture of the town life of vast numbers who suffer, more or less, from dyspepsia.

Two habits, smoking and taking snuff, require special notice as causes of dyspepsia. Excessive smoking produces a depressed condition of the system, and a great waste of saliva if the habit of spitting is encouraged. I have met some severe cases of dyspepsia clearly resulting from these causes. Some individuals are unable to acquire the habit of smoking even moderately. Deadly paleness, nausea, vomiting, intermittency of pulse, with great depression of the circulation, come on whenever it is attempted. But this incapacity is exceptional, and so universal is the desire for tobacco, that it seems as if some want of the system is supplied by its use. Smoking has been attacked and defended with much zeal. Its adversaries have strongly urged that the practice is a potent cause of dyspepsia. The late Sir Benjamin Brodie was a great enemy to tobacco. But, as one of his biographers has observed, he appeared in this instance to have departed from the rule by which he was generally guided, to weigh impartially all the facts bearing on an argument. Other names of eminence might be cited in the ranks of those who are strong opponents of smoking. On the other hand, tobacco stands in no want of facts or of able advocates in its favor.

It has been proved, beyond question, that, where men have been exposed to the combined influences of cold and want of food, those who smoked displayed most endurance. Dr. Hammond states that smoking in moderation, if the food be at the same time sufficient, increases the weight of the body.[1] The author of a clever work on physiology states that a cigar after dinner notably assists his digestion.[2] I am often told by patients that the sense of oppression felt after meals is relieved by smoking. The explanation depends on the strong sympathy which exists between the stomach and the salivary glands. One proof of this dependence is that sickness of stomach is commonly attended by salivation. This makes it probable that, when the salivary glands are stimulated by smoking, the gastric glands, in obedience to a sympathetic action, pour out their secretion more freely. But, if a depressing effect on the nervous system is induced by smoking too much, digestion is certain to be impeded. On the whole, smoking is the cause of more harm than good to digestion. That kind of chronic nervous depression which belongs to hard and inveterate smokers is always accompanied by dyspepsia.

The effects of taking snuff are more insidious, as no warning is given by immediate bad consequences. Great snuff-takers are often sufferers in the stomach. In addition to the specific effects of tobacco, the continued stimulating and mechanical action of snuff on the mucous membrane of the nose is injurious. Irritation is directly transmitted from the nasal surface to that of the stomach, with which it is continuous. Dry snuffs are more hurtful than moist, as they penetrate farther.

The difficulty of breaking off or even moderating this habit is well known, and the following plan, practised with success by an inveterate snuff-taker, is worth mention: Instead of pure snuff, he kept in his box a mixture in equal parts of snuff and powdered valerian-root. His theory was, that the valerian repaired the ravages of the snuff upon his nerves, but the more probable explanation of the benefit is, that he consumed much less of the disagreeable compound than he did of pure snuff.

Persons engaged in offices are exposed to a directly-exciting cause of indigestion. The stooping posture in which they write, mechanically interferes with the stomach's action. I have even traced well-marked dyspepsia to sitting immediately after dinner in a low arm-chair, so that the body was curved forward and the stomach compressed. In some trades, the pressure of certain implements upon the pit of the stomach, as in the case of curriers, bootmakers, and weavers, produces severe dyspepsia. Many bad cases, attended with water-brash, occur among the weavers of Spitalfields.

[1] "Physiological Memoirs." By W. Hammond, M.D. Philadelphia, 1863.
[2] "The Physiology of Common Life." By G. H. Lewes, M.D.

Self-indulgent, luxurious habits, are highly injurious to healthy digestion; but on this threadbare subject it would be mere waste of time to enlarge. Idleness, and the want of a definite pursuit in life, must also rank high in this class of causes. To preserve the general health, occupation is as necessary for the active mind as exercise is for the vigorous body.

The importance in the system of the reproductive functions is such that their exhaustion must, sooner or later, react on the functions of nutrition. Lamentable instances of the results of sexual excess are occasionally met, and dyspepsia is almost invariably one of these. But the injurious effects of a free indulgence of the sexual instincts have been highly colored. Unprincipled men, who prey on the young and the inexperienced, magnify and distort the significance of certain ailments, the treatment of which, in too many instances, passes out of the hands of the regular practitioner.

In youth, the sensations are quickest, and the impressions most fresh and vivid; so that it might be supposed life would be always then most keenly enjoyed. But its earlier years are frequently clouded. An aching desire for change and excitement often destroys present happiness; and, when the desired excitement is unattainable, *ennui* and a hopeless indolence ensue. Experience convinces me that this condition of mind is but a frequent result of a feeble state of health. This can be often traced to an overstrain of the mental powers—a strain daily increased among men by a spirit of emulation, fostered and rewarded by the competitive system to an extent formerly unknown. Accomplishments also among girls are made objects of relentless perseverance. In both sexes, at a time when growth is incomplete, and new functions are springing into existence, the mental are developed at the expense of the bodily powers. Nutrition suffers because appetite and digestion are impaired, and the power of the mind itself is weakened. Over-exertion of mind fatigues equally with that of the body. No reasonable doubt can therefore be entertained that *thinking* is the result of a physical action in the brain. In what may be for convenience termed secretion of thought, demands are made on nutrition just as in bodily exercise. It has been often observed that great *thinkers*, if healthy, are usually large *eaters*.

The state of the air we breathe is highly important in relation to dyspepsia. We live at the bottom of an elastic medium, presenting everywhere the same general composition, and exactly adapted to the exigencies of animal life. Any accidental impurity of the atmosphere tends to disturb the balance of health. Oxygenation of blood is the object of respiration; and its replenishment is the object of digestion. On the other hand, the digestive secretions, as well as the nervous energy by which they are governed, depend for their perfection upon the perfect state of the blood. For this reason ill-ventilated workshops and crowded sleeping-rooms among the poor, and the overheated and impure atmosphere of assemblies and public places of amusement among the better classes, are constantly-acting causes of dyspepsia.

Many invalids are affected by changes of weather, especially if these changes occur suddenly. Even in the healthy a general feeling of discomfort is caused by easterly winds; and various disorders are greatly aggravated by them. Rheumatic patients are especially susceptible of bad effects from damp or cold winds, and many dyspeptics are hardly less so; an unusually dry atmosphere is equally injurious to others.

As in the case of a change of climate, the quantity and kind of food required are much influenced by season and temperature, and the agency of these in causing dyspepsia is, therefore, not to be wondered at. Some dyspeptics are always better in summer than in autumn or winter, others the reverse; while a great many tell us they suffer more in spring than at any other season.

Our bodies are at all times pervaded by electricity, the condition of which often completely changes. The clear, serene atmosphere is usually charged with positive electricity, and this, by induction, causes our bodies, as well as the earth itself, to be negative. In wet or stormy weather the opposite of this state of things is usual; the atmosphere is negative while our bodies are positive. We are unable in health to detect these electrical changes; but we might reasonably look for their effects when disease had rendered the body less capable of resisting external impressions. The probable effects of electricity, when the health is susceptible, will be again referred to.

We have still to consider instances in which, although the food may be suitable, and the digestive organs healthy, dyspepsia may be induced by an immediate and accidental effect upon the organs, through the influence of the nerves. There are certain sensations, of which nausea is a remarkable instance, not obviously assignable to any of the five senses; and all these sensations seem capable of being excited by mental influence. We are all conscious that the stomach is a region of sympathy; and here Van Helmont places the seat of the soul itself. With the stomach, or with the bowels, easily confounded with it, various passions—as joy, sorrow, compassion, and indignation—have been in all times associated.

It is universally known that bad news received at or preceding a meal will spoil the best appetite. A disagreeable mental impression sometimes even produces severe dyspepsia, with epigastric pain and sense of oppression, nausea, or vomiting. The intimate nervous connection between the stomach and the brain leaves us at no loss to explain this; and probably an arrest of the secretion of gastric juice is the immediate cause; for in the same way the mouth will become dry from a diminished secretion of saliva. Dyspepsia is also produced or aggravated by severe mental exertion immediately after meals, because of the untimely expenditure of nervous power.

Violent bodily exercise when the stomach is full is a well-known cause of disturbed digestion; and in this case the disturbance seems mechanical. The motions of the stomach cannot be favorably carried on while its contents are tossed about by rapid movements of the body; for we know it is essential to the due solution of food that it should be all in turn brought into contact with the stomach's surface

A cold bath after a full meal will frequently disturb digestion; and a hot bath either of water or air will do so with still more certainty. Dyspepsia from warm and cold bathing occurs, in each case, on the same principle, but for opposite reasons. It has been proved, from observations on Alexis St. Martin, that congestion of the stomach is most unfavorable to the secretion of gastric juice. Now, the shock of cold bathing produces congestion, by driving the blood from the surface of the body to the viscera; on the other hand, a certain flow of blood to the stomach is equally indispensable, and *that* would be interfered with by the hot bath, because it draws the blood from the viscera to the surface. Free bloodletting soon after a meal is commonly succeeded by vomiting, and this affords another example of the effect of sudden withdrawal of blood from the digestive organs.

Dyspepsia has the widest range of all diseases because it forms a part of almost every other; and some, as pulmonary consumption, are in many instances preceded by it. In such cases, early attention to the defects of nutrition would often avert a fatal issue. The gravest forms of dyspepsia accompany organic changes in the alimentary tube itself, as cancer and ulcer of the stomach. It cannot be affirmed that simple dyspepsia does not sometimes shorten life, by producing another disease, or even prove fatal of itself; yet it is certain that digestion may be performed with difficulty for many years without more serious results than proverbial suffering and discomfort.—*Causes and Treatment of Imperfect Digestion, new edition.*

WOMAN AND POLITICAL POWER.

By LUKE OWEN PIKE, M. A.,

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IT is not improbable that the present remarkable phase in woman's history may have made its appearance, partly at least, through reaction against the very common opinion that the male is the superior sex. This idea, offensive as it is to all feminine sentiment, receives its best illustration in the old fable, according to which, various parts of the body, each being necessary to the rest, put in a claim, each, to superiority. The truth is that in the sexes, as in the members, there is neither superiority nor inferiority; but it does not therefore follow, as has been hastily assumed, that there is equality. No two things can be pronounced equal or unequal, superior or inferior, unless there is some common standard by which they can be measured. The color *blue* is not equal nor inferior, nor superior to the color *yellow;* and the *green*, which is produced by the mixture of the two, owes no more to one than to the other. In the same way, humanity is perpetuated by the coexistence of male and female; and, if the functions of either one sex or other were radically changed or perverted, humanity itself would cease to exist.

The most vital point in my present argument is that woman must be regarded as woman, not as a nondescript animal, with a greater or less capacity for assimilation to man. The question, regarded from a scientific point of view, is not how far the female intellect can be trained to imitate the male; but what it may be shown to be from observation, or inferred to be from correlations of physical structure. The argument, from observation, which would be considered sufficient by most men of science, is controverted on the ground that human laws have been stronger than the laws of Nature. It is said that man has oppressed woman by his superior muscular power, and has impeded the natural development of her intellect. If this be true, and if mere strength of body can thus get the better of mind, it is certainly strange that horses and elephants have not become the masters of men; and hardly less strange that the stalwart Negro should long have been the slave of the more intellectual, but not more muscular, white man. But, as it is useless to prove the relations which have existed, to those who preach of relations which ought to exist, between the two sexes, it becomes necessary to investigate the matter from the point of view of physical structure and its correlated functions.

Among other and better-known features distinguishing the female sex from the male, are the smallness of the brain-case, the width of the pelvis, and the tendency to deposit adipose tissue, rather than muscular fibre. To the rule, of course, there are exceptions; there are masculine women just as there are effeminate men, and those exceptions I propose to consider before concluding, but they ought not to affect the broad general treatment of the subject. To these and other differences of structure, correspond numerous differences of function. Both the capacity and the desire for muscular exertion are less in the female than in the male; the strength of the system develops itself in another direction. So also the desire, if not the capacity, for the prolonged study of abstruse subjects, is less in the female than in the male; and mental activity pursues another course. It does not follow that, because a man can lift a greater weight on the average than a woman, he is therefore her superior, any more than that he is her inferior because she can bear children and he cannot. Nor is woman man's inferior because she has never devised a system of philosophy, any more than she is his superior because he lacks all her wealth of maternal tenderness, and some of her ready powers of expression.

Much has been said of the difference of weight in the male and female brain; and it has been argued that the female intellect must, for that reason, be necessarily inferior to the male. But apart, from the difficulty of finding a common measure for the two, there is great uncertainty concerning the relation of mental activity to the contents of the skull. The average stature of women is less than that of men; and therefore the absolute difference of weight cannot be a fact of any value, unless the various mental functions are localized. He would be a very bold man who ventured to pronounce that the brain has no influence over the muscles of voluntary motion, or even over those which are beyond the control of volition. And when inferior stature is found in combination with less development of the muscular system, who can say how far these conditions may be the correlates of some condition of the brain? It may be, and probably is, true that the brain is intimately connected with intellectual and emotional manifestations; but it is probably no less true that the brain is connected with all manifestations of volition; and, until we have determined the relative position and the quantity of cerebral matter necessary for combined muscular movements, we have no means of determining the quantity or the position of that which is necessary for thought and feeling. I am aware that many attempts to localize the various functions have already been made; but the mere fact, that the various inquirers and experimenters have arrived at various and contradictory conclusions, is in itself enough to prove that the contents of the skull have not yet been correctly mapped.

Women of all nations are, I believe, generally considered to possess not only more emotional characters, but greater powers of observation than men. If this be true, it follows, I think, that their senses must be more strongly developed than those of the male sex, and that their memories must be equally if not more retentive. It matters little that the objects which they observe are not the objects observed by men. It is as great an effort for the eyes and mind to see and remember all the colors and all the forms in a room full of human beings, as to define the position of the earth's strata, and assign every fossil to its place. But women, on the average, prefer millinery to geology, and men, on the average, applaud the preference. The matters with which attention is occupied must, to a great extent, depend upon the bodily capabilities of each individual. The man who has lost his limbs cannot scale mountains, and the blind man cannot paint; but the energies of either may flow in a direction suitable to his circumstances, and each may distinguish himself in some field of thought.

And so, although woman may be more at home in the drawing-room or the nursery, than in the field of battle or the seventh heaven of metaphysics, her walk in life may exhibit qualities as high, and energies as well directed, as those of the chemist, the engineer, the philologist, or even the philosopher. Nothing can be more ungenerous than to flout her with her domestic cares, or to depreciate her efforts to please. If her form is more susceptible of adornment than man's, it is but natural that she should be more anxious to adorn it. If it is a privilege of her organization that she can become a mother, the wish to deprive her of it is not consistent with the teachings of science, with manliness of character, or with common-sense. If her maternity forces upon her the consideration of minute details which are unobserved by men, or have no interest for them, the tendencies of her mind are not a fit subject for detraction, unless that detraction be intended, as it commonly is, for maternity itself.

The *elements* of the female mind (to regard the mind alone, for a moment) are probably, as the champions of women's rights assert, identical with those of the male; and the inference which some persons would draw is that the *mind itself* ought not to be different. No one would seriously deny that woman possesses emotions, will, senses, and intellect; or that man's mind is susceptible of precisely the same division. It does not, however, require even a knowledge of chemistry to discover that combinations of the same elements, in different proportions, will produce compounds of different qualities. But chemistry, perhaps, illustrates the subject better than any other science. Not only may the same elements, mingled in different quantities, produce substances of different properties; but the same elements, even in the same proportions, may, under different circumstances, yield dissimilar products. Not only do the ethers differ from the alcohols, and each alcohol and each ether from its namesake, though all are compounded of carbon, hydrogen, and oxygen, in different proportions; but alanine and sarcosine — which are both compounded of carbon, hydrogen, nitrogen, and oxygen, in exactly the same proportions—have properties entirely different from each other. If, therefore, it could be shown that the male and female minds are, in the language of chemistry, isomeric, it would not follow, according to any natural law, that they should be identical in character; still less if they merely possess the same elements without being isomeric. And it would surely be not more unscientific to preach the conversion of all ether into alcohol, and all sarcosine into alanine, than to insist that the feminine mind should undertake all the functions of the male.

While the senses, and the faculty of retaining impressions, are as strong in women as in men, and perhaps stronger, it will hardly be denied that in all ages and in all climates women are and have been more prone to the display of emotion than of pure reason. Rachel weeping for her children, Sappho burning with desire, Iphigenia grieving, not to die, but to die unwedded, Aspasia brilliant with wit and cruel in hate, the girl who, as Horace says, lied gloriously to save her lover, the woman prodigal of her ointment upon the Saviour's head, Cleopatra, too proud to live when she could not captivate her conqueror, are immortal types of what is good and what may be bad in feminine nature. It is not out of such qualities that statesmanship can be developed or science advanced; but science and statesmanship are not the only good things in the world, and the world may enjoy enough of them without calling in the assistance of women. If man's highest prerogative is to think, woman's noblest function is to love; and this assertion is not a metaphysical dogma, nor even a generalization from the history of mankind, but is an inference from the relative position of the sexes throughout the whole of that class of animals to which mankind belongs. The maternal instinct, as it is commonly called, is shared by the females of all the mammalia, from the tigress to the gorilla, and is not, as might be inferred from certain teachings, the sad consequence of iniquitous legislation.

The skull of the female gorilla differs from the skull of the male, just as the skull of the woman differs from the skull of the man. And this difference has not been caused by centuries of oppression; it merely gives evidence of the healthy operation of that natural law by which structure corresponds more or less to function. In some respects the skull of the female gorilla is more human in its form than that of the male; and so, also, in some respects the skull of the woman exhibits, in a more striking manner, the attributes of humanity than that of the man. Nor are these skull differences restricted to a few species; they extend throughout almost the whole of the vertebrate family; they are accompanied by differences of muscular development, which are no less constant; and the whole of these physical differences are correlated with a psychical difference which is indisputable—the greater pugnacity of the male as compared with the female. Considered, then, apart from individual peculiarities, the diversities of male and female capacities may be seen to have arisen from the widespread action of natural laws, and are not to be annihilated by a merely human decree. It is not the fault of the male human being that he possesses more, than the female, of that combativeness which is necessary, not only in political life, but even in the ordinary struggles for existence. It is his privilege to protect, and hers to be protected.

It may be suspected that the advocates of a sexual revolution have been unfortunate in their experience of the sex opposed to their own. There is no doubt that, century after century, women have shown a preference for men possessing the qualities which seemed to them distinctively masculine; and that men have wished their wives to possess the virtues which are considered distinctively feminine. In other words, the intellect of either sex has found pleasure in association with something dissimilar to itself, not because one is better or worse than the other, but simply because the two are different. There is no more reason for the assertion that a woman's brain is an undeveloped man's which requires cultivation, than for the assertion that a man's pelvis is an undeveloped woman's which requires to be expanded, or that some of his muscles should be converted into fat. To him it is not, as a rule, given to express himself so rapidly as a woman; to her it is not, as a rule, given to think so deeply as a man. But she often sees what is lost to him during a fit of abstraction; and he is often indebted to her for the materials upon which his reflection may work. Genius, it has often been said, is of both sexes at once; and the saying well indicates the true relation of the male and female intellects. Each has powers and beauties of its own; each may profit by contact with the other, and it is not until some resemblance to a combination of the two has been effected that men recognize that highest mental development to which they give the name of genius.

There are few subjects interesting to man in which clever women do not sometimes also take an interest; and from this fact it has been hastily inferred that women might, with profit, devote the same attention as men to any and every branch of study. Such an inference leaves out of sight the fact that women rarely look at any subject from the same point of view as men; their opinions often have the value which is to be found in the observations of an intelligent spectator when persons, whose whole attention is absorbed in any pursuit, fail to perceive what most concerns them. The best critic is not always a good author or composer; and excellent suggestions are frequently made by those who are not fitted by Nature to carry their own ideas into operation. This is especially the case with women, who, if they were to devote their whole energies to science or to politics, would do violence to their physical organization. The prolonged effort which is necessary in order to work out any great scheme, to make any great discovery, to colligate any vast mass of materials by a great generalization, is a heavier strain on the vital powers than any merely physical exertion. It is, like military service, inconsistent with that bodily constitution which is adapted to maternity, and all that maternity implies; nor does it seem possible that by any process of selection, either natural or human, this difficulty can be overcome. The change in woman's nature must (if effected at all) be effected either in one generation or more; if in one, humanity must immediately cease to exist; if in more, humanity would only be extinguished by degrees; but the diversion of woman's vital powers, from the course which they take by nature, is neither more nor less than the abolition of motherhood. And this, either wholly or in part, either directly or indirectly, is what some earnest men are preaching in the name of sexual equality.

The modern attempts to deprive woman of her womanliness belong to the metaphysical school of thought, as much as any dogma of a mediæval schoolman. They start from the assumption that living women either conform, or should be forced to conform, to some *a priori* definition of woman, evolved from the inner consciousness of a human being. They ignore all the ascertained facts of anatomy and physiology. They are directed not toward the perfection of womanhood in all its functions, but toward the transformation of woman into something different. They suggest not the study of natural laws, nor the observation of facts in Nature, but the worthlessness of all facts, and all laws, in comparison with a *dictum* issued from the study. It is not wonderful that ignorant enthusiasts should have placed woman in a false position through their inability to comprehend their own religion, but it is perhaps the strangest feature of the nineteenth century that thousands of persons advocate a still more unnatural revolution of the sexes in blind obedience to a purely metaphysical proposition.

The stages into which Auguste Comte divided the progress of human thought are admirably illustrated by modern attempts to alter the position of woman. Seventeen hundred years ago she was a stumbling-block in the way of the religious enthusiasts; to the metaphysicians of to-day she is no more than an abstraction. The early fathers of the Christian Church regarded her physically as a temptation to sin; some modern philanthropists regard her intellectually as the equal of man. It is possible that there may be truth in both opinions, but it is certain that the whole truth is not to be found in either. The religious doctrine is intelligible enough at first sight, but the metaphysical doctrine takes us back to the middle ages, to the conflict between the realists and the nominalists, to the verbal quibbling in which great minds, for want of better occupation, frequently expended all their energies. The woman for whom a vote is demanded is not, when carefully inspected, a woman of flesh and blood, but an abstract or archetypal idea for which the realists of the nineteenth century claim a positive existence.

The process by which such ideas were arrived at in former times, and by which, in all probability, they are arrived at now, is of the following character: Men and women possess certain attributes, or a certain attribute, in common, and to this attribute, or to these attributes collectively, may be given the name of humanity. All points of difference are by the very nature of the process disregarded, or drawn off, or in technical language *abstracted;* or rather the point of resemblance is *abstracted* from the point of difference. Now, when humanity and similar abstract terms had been thus invented by men who perceived their value as a species of mental short-hand, they were invested with a substantial existence by Plato and many of his mediæval followers. The "humanity" which is reached by this mental operation is, of course, divested of sex along with all other differences. If the human beings who are actually born into the world could in reality, or even in imagination, be made to conform to this sexless archetype, there could be no objection to voters on the score of sex. Thus much may be safely admitted; but it would then be in the power of any human being to coin such a word as "mammality," or "animality," or to make use of the old word "entity," to assert the existence of a substance corresponding to each word, and so to destroy not only the distinction between man and brute, but between organic and inorganic matter. In short, the very same argument which would introduce woman to man's occupations on the ground of her humanity, would introduce whales on the ground of their mammality, or stocks and stones on the ground of their entity.

I trust that I shall not be considered guilty of any disrespect in reducing some well-known arguments of some justly influential thinkers *ad absurdum*. I no more mean to show disrespect by my treatment of the subject, than to deny the sincere philanthropy of many who advocate woman's rights, when I say that it savors not a little of priestcraft. Just as the metaphysical stage of thought bears a great resemblance to the religious, so the attempt to carry a philosophical doctrine into execution is by no means unlike the attempt to impose a creed. Every ideal form of government which has hitherto been conceived has had innumerable elements in common with the Church of the middle ages. From the time of Plato to our own, philosophers have always presented themselves upon the domestic hearth to dictate the relations between husband and wife; all who are acquainted with the early books of penance will remember that the priest took upon himself the same office, even to the minutest details. In all the mediæval works which touch upon science it will be found that the final authority upon every controverted point is not the evidence which may be discovered, but the doctrine of the Church; so neither Plato nor Malthus, nor the followers of either, appeal fairly to physiological facts or laws, but would repress the very instincts of human nature wherever they are opposed to the philosophical idea.

The apostles of all religious and all metaphysical doctrines have commonly been not only energetic but thoroughly honest men. They would direct all thought and all action into the groove worn by their own minds, not from an innate love of tyranny, but from an enthusiasm which cannot admit the possibility that persons of a different opinion may be in the right. In the apostle there is always much to admire, but it happens only too often that his priestly successor inherits his faults without his virtues. The present may be called the apostolic age of the doctrine of equal humanity; and many followers will be won through respect for the character of the apostles, rather than from conviction after sober consideration. But, to the student who desires something positive in science, and who would use that science for the benefit of mankind, there is sad discouragement in the spectacle of a new intellectual crusade for an idea. To this there are only two possible issues—on the one hand, complete failure; on the other hand, government by a metaphysical priesthood which will not even spare sex in its efforts to crush out all individual preëminence.

It may, perhaps, be thought that the Anthropologist who endeavors to assign woman her true position according to the laws of Nature is practically not less tyrannical toward her than the reformer who would have her modelled according to rules of his own. There are, however, two most important distinctions to be borne in mind: In the first place, the man of science knows from observation and experience that when structure is healthily developed, and function of every kind unimpeded, there results the nearest approach to happiness of which any individual is capable. But the Utopian of the *a priori* school gives no pledge for happiness except a general proposition, or a series of general propositions, well enough suited to the days of Plato, but wholly without value in the days of Darwin. In the second place, the propounders of new schemes make no provision for exceptional cases, but would reduce all mankind to one dead level, while variation is admitted, and the efforts of remarkable individuals are watched with interest by the observers of Nature. The latter, conscious that they are not yet masters of the universe, would allow fair play to all alike, in the hope of learning something new; the former, tacitly assuming that the apex of knowledge is reached, would issue edicts, from their metaphysical Olympus, for the reconstruction of humanity.

There cannot be a doubt that human beings exist who, though not of the male sex, have more masculine intellects than many men, and others whose muscular development and power of enduring fatigue are far superior to those of many a conscript. Had conquerors possessed Utopian minds, they would long ago have declared the fitness of women for military service, for which they are adapted just as well as for political life. But it is only in such a work as the "Republic of Plato" that we find a plea for the application of the same physical training to both sexes. In that treatise[1] an objector is made to suggest that the spectators would begin to laugh if men and women were seen struggling together in the same arena. The philosopher, whose ideal republic would have possessed an hermaphroditic army, could not see the point of the joke, and expressed a profound contempt for the sneers of the unphilosophic. It is, however, worthy of remark that, although he would gladly have seen women converted into wrestlers, boxers, and soldiers, and even thought of giving them a share in the government of the state, he declared them to be in all things weaker than man. The idea of absolute equality is of quite modern growth, and has probably been suggested by the undeniable success of the female intellect in many fields of literature.

To write ingenious novels, and even successful dramas, to paint

[1] Book v., cc. iii. to vi.; see, also, the "Laws," book vi., c. xxiii.

from Nature, to interpret the works of the greatest musical composers, to act with taste and discrimination—all these, and a thousand similar accomplishments, each requiring an effort of intellect, are now within the range of women who are no more exceptional than the front rank of men in every generation. Such distinctions may be attained by women who lose none of the charms of womanhood; and even a knowledge of the latest discoveries in science is in no way incompatible with any of the feminine graces. But a little consideration will lead to the conclusion that all this mental activity is but the evidence of human progress in general, and that its root, as well as its most perfect development, is to be found in the domestic life. Long before the invention of printing, mothers amused their children with nursery-tales, lulled them to sleep with songs, and imparted to them the rudiments of such knowledge as the world possessed; maidens and wives could act well enough to deceive husbands or attract lovers in the days of Homer or even of the patriarchs. And many of those beautiful poetical stories which constitute the mythology of all imperfectly civilized nations bear the stamp of woman's imagination, and have often been narrated to excite or to soothe the terrors of the young.

Women, however, with intellects truly masculine, are, and have always been, even more rare than women with a masculine development of muscles. There are few, if any, distinctively masculine pursuits in which any women have ever succeeded; there is no great law of Nature, no great mechanical invention, no great legal code, nor even any great metaphysical system, of which any woman can say, "Of this the world owes the knowledge to me." A reason for this fact is to be discovered not in the inferior quality of the feminine mind, but in the character of the objects to which woman's physical organization naturally directs her attention. The practice of medicine, which is now becoming recognized as a feminine occupation in America, suggests at once that instinct for nursing, which every one admits to be the special gift of woman, and which is, in fact, a correlate of her power to become a mother. In short, if there be any truth in science, the intellect of woman not only has, but must have, a certain relation to her structure; and, if it could be shown that there exists no difference between the male and female minds, there would be an end of anthropology. But the directions in which clever women have developed their mental activity afford the best possible illustrations of the scientific view of woman's position, and show how the long-inherited instinct matures itself according to the truly feminine type. All the different lines, when traced back, converge through the nurse upon the mother.

It should not, however, be forgotten that there may be individual peculiarities of structure, caused by circumstances either antecedent or subsequent to birth, that the constitution of society may impede the natural development of function, and that there may be a number of women in every age whose case demands special consideration. Though the births of males are slightly in excess of the births of females, the females in the prime of life exceed the males in number, and it follows, therefore, that, even could every male afford to marry, there would still be some women husbandless. The difficulty which here meets us is only one among many of those which appear irremediable not only to statesmen, but to men of science; it is no more probable that the body social will ever be so constituted as to secure the happiness of every individual, than that the human frame will cease to be subject to disease. There is, indeed, no doubt that the science of health and the science of politics are closely allied, and that each must be imperfect without the other. The end of both is the extinction of mental and bodily pain, but that end seems to be unattainable. Anatomists and physiologists know only too well that, had freedom from disorder been the object with which our organs are constructed, the means would have been lamentably ill adapted to the end, that every malady is easily induced, and with difficulty checked, and that the greater part of mankind start in the career of life with some inherited weakness. It is true that much has been done toward the mitigation of epidemic diseases, and it is possible that something may be done toward the alleviation of social grievances; but the success which has been achieved in one case affords a very instructive lesson toward the mode of proceeding in the other. Epidemics have been deprived of their worst sting, not by any political theories, nor by a statement of human rights, nor by a definition of man or woman, nor by a refusal to consider our physical organization, nor by any attempt to alter it, but by a careful study of the facts of Nature, and by placing humanity, such as it is, in a more favorable condition toward the outer world, such as it is.

How the woman who cannot marry may be most favorably placed is a problem which can hardly be solved in general terms, and which must be answered according to the exigencies of each particular case. But it may be safely asserted that the gift of votes to the whole female sex would not in any way improve the condition of old maids; wherever keenness of observation and a retentive memory are of service, there is a good prospect of success for a cultivated female intellect In proportion as the instincts of sex are suppressed, the range of acquisition may be widened. Woman naturally loves to teach the young, and, when she is without husband, home, or children, she may well succeed in teaching more than children can learn. She naturally loves to tend the sick of her family, and, when she is without family ties, she may, perhaps with advantage, add a knowledge of medicine to her other gifts, and bring comfort to the bedside of strangers. In short, she may exercise her feminine capacities in a more extended field of action than that of her own house; but, should she ever enter fairly into competition with men in all professions, she will have ceased to be woman, though she will not have become man. The experiment, could it really be made on a small scale, would not be without its interest to the students of science, though, from the conditions of the problem, it could never be made to illustrate any theory of the origin of species. To the unwomanly woman it is a virtue to be childless.

A state with an hermaphroditic form of government, if even it could exist for a generation, is by Nature doomed to extinction; it may, however, be worth while to consider what kind of being a woman would become who should take an active part in the election of a representative. As an energetic member of his committee she would have to fight the battle, foot by foot, with his opponents of either sex; she could not always sit at home and restrict herself to the use of a voting-paper, because she would then tacitly admit her unfitness for political life with all its hard work and its turmoil of speech-making; she would be like a foreigner giving a vote from a distance, without a knowledge of the qualities requisite for success in Parliament. It would be necessary for her to be thoroughly prepared for the fray—breeched instead of petticoated, with a voice hoarse from shouting, with her hair cropped close to her head, with her deltoid muscles developed at the expense of her bust, prepared with syllogisms instead of smiles, and more ready to plant a blow than to shed a tear. She hurries from her husbandless, childless hearth to make a speech on the hustings; with hard biceps and harder elbows she forces her way through the election mob; her powerful intellect fully appreciates all the ribald jests and obscene gestures of the British "rough;" she knows the art of conciliating rude natures, and can exchange "chaff" with a foul-mouthed costermonger; or, if necessary, she can defend herself, and blacken the eye of a drunken bargee. She has learned all the catechism of politics, and when she mounts the platform she can glibly recite her duty to the world according to the side she has chosen. Experience has taught her the value of invectives, and she denounces her opponents with a choice selection of the strongest epithets; at first she speaks loud in a tone of contentment and self-satisfaction; she ends by losing her temper and bawling at the top of her voice. The crowd, never very indulgent, has no mind to respect a sex which makes no claim and has forfeited all right to forbearance. The hardened lines of her face are battered with apples, brick-bats, and rotten eggs—the recognized weapons of political warfare. Perhaps the very place where she stands is the mark of a storming-party; and, after enjoying the glory of an encounter with a prize-fighter (it may be of her own sex), she is at last brought to the ground by superior skill and strength. Then probably she retires to her home; but I, for one, had rather not follow her thither, or into that House of Parliament of which she is destined one day to become an ornament.

Such a description, I am aware, could only be applied to an electioneering woman in modern Britain, and not to an inhabitant of Utopia. In that, or some other republic of the future, not only is woman to be different, but man also; the sexes are to lose their characteristic distinctions not simply by the conversion of woman into man, but by the partial conversion of man into woman. As soon as this sexual compromise has been effected, by means not clearly described, the world will enjoy what enthusiastic heathens used to call the golden age, and what modern enthusiasts of another school now call the millennium. Envy, hatred, malice, and all uncharitableness, will disappear, there will be neither wars nor rumors of wars, and an angelic population will know its own place and limit itself to its own number. Mankind will then have developed itself into a species of gigantic trade-union, in which women and their accomplices will infallibly be "rattened" if they create too much competition among men.

A state of society in which humanity shall no longer be human, in which not only sex, but intellect and emotion, shall have been remodelled, and the aspect of the outer world changed by a new and metaphysical cosmogony, is, like the doctrine of abstract right, beyond the grasp of the humble Anthropologist. His occupation will be gone as soon as that era shall commence. But, until then, until murder, theft, and villany of every kind, shall have been extinguished, until that struggle for existence, which pervades all Nature and constitutes the only healthy check upon population, shall have been abolished, until every evil passion shall have been rooted out, he may perhaps be permitted to raise his feeble protest against innovations which would not only subvert man's civilized customs but contradict Nature's first lessons. If statesmanship can amend the laws which press hard upon some unfortunate and exceptional women, if ingenuity can devise harmless occupations for mothers whom prosperity or adversity has deprived of their maternal cares, in short, if any grievance can be met with a remedy which is not opposed to the teachings of science, every human being will have cause for gratitude. If men have met with women who prefer political to domestic life, and despise all conceptions but those which are purely mental, let them in the name of liberty cultivate their acquaintances; but let them also, in the name of liberty and in the name of Nature, permit other men and other women to choose for themselves. If they have but little liking for women who are womanly, if they care nothing for the conversation and the tone of thought which are most in accordance with woman's voice, and mouth, and brain, if they are unable to realize that pleasure which either sex may derive from the sense of intellectual difference, let them by all means endeavor to gratify themselves, according to their own constitution, but let them not, Vandal-like, attempt to destroy those beauties which they do not appreciate.—*Anthropological Review*

THE EARLY SUPERSTITIONS OF MEDICINE.

By W. B. CHEADLE, M.D.

IN the earlier ages of mankind, when the knowledge of Nature was small, and confined to priests and sages, their explanations were received with a simple childlike faith by the people, who cared not, or, if they cared, dared not to question or inquire further. These explanations were, for the most part, mere fanciful and arbitrary guesses, founded, not upon ascertained facts, but on the simplest conceptions arising from the consciousness of some supreme power or powers, which governed the universe, and accommodated to the religious theories of the time. All the mysteries of Nature were solved by the supposition of innumerable supernatural agents, according to whose caprice mankind were injured or benefited, punished or rewarded. Medicine was consequently intimately associated with religion; among the more barbarous nations, the priest and the medicine-man were identical; and, among the more civilized, the recognized practice of it was confined to the sacerdotal orders until the thirteenth or fourteenth century. Neither the priests nor the people of the superstitious age could understand invariable laws.

If a solar eclipse took place, a dragon was supposed to have swallowed up the sun; if an earthquake occurred, or a volcano burst forth, some subterraneous demon was presumed to be at work. When a pestilence raged, the invisible arrows of an offended deity struck down the victims. A man who lost speech or hearing had a dumb devil or a deaf one. We see the same condition of mind exemplified now in the fetichism of barbarous nations, and the belief in charms and sorcery which still obtains among the vulgar, even in this country. But at no period was it more conspicuous than in the middle ages, when the belief in magic and witchcraft gave rise to the terrible atrocities which were perpetrated in the punishment of those who were supposed to plot evil against their fellows by direct compact with and assistance from the devil. If a man suffered from pain in the region of the heart, or in the head, a witch inflicted these tortures by secretly sticking pins into the corresponding portion of a wax image representing the sufferer, and thousands of unfortunates were burnt for causing disease and death by their unholy incantations. The dancing mania, which arose in Flanders and Germany during the fourteenth century, was regarded as a display of satanic power, and the popular reason assigned was that the boots with pointed toes, which had been lately introduced, were peculiarly offensive to the Almighty!

With the belief in witchcraft and sorcery, prevailed also the belief in astrology, and that so universally, even among the more highly-educated, that, although occasionally some daring minds raised their voices against the delusion, the storm of obloquy and contempt which was showered on them served to show the strength and popularity of the superstition. The heavens were divided, by the most educated men of the time, into houses of life and of death, of riches, marriage, or religion, and the particular planet which chanced to be in any one house at the time, was denominated the lord of the house, in power over the destinies of mankind, unless a greater than he reigned elsewhere.

While this firm belief in magic, and this disposition to refer all diseases to the direct interposition of supernatural agencies, continued to prevail, the science of medicine necessarily remained almost stationary, or rather could hardly come into existence. Few ever thought of trying to find out *how* sorcerers, demons, and planets did their work—and the Church terribly punished all who dared to attempt the investigation. As magic—a mysterious power which man could not understand, but thoroughly believed in—caused diseases, so a kind of magic was trusted to cure them. The efficacy of relics and charms was universally acknowledged. The efforts of physicians were directed to the invention of nostrums and counter-charms—not to the investigation of the causes of disease, the careful observation of their phenomena, or the mode of action of the remedies prescribed for them. Galen had, indeed, made important discoveries in anatomy in the second century, and Mondino and others had added to them; but their knowledge was rude and imperfect, and their deductions vitiated by the most absurd physiological dogmas. When they had discovered a few broad and simple facts in anatomy, they rested from their labors, well content; and founded theories, supported by unfounded assumptions, but which became articles of faith, received without question by their successors in the study. Galen, for example, assumed that the arteries carried the purest blood from the left ventricle of the heart, to the higher and more refined organs, the brain and lungs; while the veins conveyed that of inferior quality from the right ventricle to the grosser organs, the liver and spleen. He chose, moreover, to affirm that the venous blood was not fit for its office, unless some portion of the essence or spirit, and of the arterial blood contained in the left ventricle, were infused into it. Now, these two chambers of the heart, each containing the different quality of blood above mentioned, are separated by a partition, through which there is no aperture whatever. Holes of communication were, however, required by Galen to support his theory, and, therefore, in the true spirit of the time, holes were accordingly seen by him. He squared his facts to suit his theory. And, stranger still, although the heart was frequently examined afterward, so paramount was the authority of Galen, that these imaginary holes were seen by a succession of anatomists for fourteen hundred years, until, at last, Vesalius dared to declare that he could not find them.

This profound reverence for authority, this belief in supernatural agencies, and this stagnation of true science, was the condition which prevailed at the beginning of the sixteenth century. But education gradually spread, and at this time thinkers arose, who, dissatisfied with mere assumptions, or the baseless dicta of previous authorities, commenced working at the rudiments of the science which had hitherto rested on such imperfect foundations.

Protestantism broke forth, marking the commencement of the age of free inquiry, the spirit of which had so often been quenched in blood to burst forth again irrepressibly, and henceforth to continue and spread abroad with little interruption. The Italians—and more especially the republican Venetians—appear to have been peculiarly free from the prejudice against the dissection of human bodies which generally prevailed; the study of anatomy was warmly encouraged at Padua and Bologna; and, owing to this liberal spirit, Mondino, in the fourteenth century, was enabled to demonstrate human anatomy by actual dissection. But he was so trammelled by tradition and the authority of Galen, that he perpetuated numberless errors, which would have been patent enough to an unprejudiced mind. So powerful were these influences, even two hundred years later, that Berenger, who boasted of having dissected one hundred subjects at Bologna, and who added largely to anatomical knowledge, ventured to dispute or correct but few of the propositions of his predecessors in the study. To Vesalius belongs the credit of daring to expose the errors of the Galenian system. A Fleming by birth, he early migrated to Venetia, and lectured with immense success at Padua, and afterward at Bologna and Pisa. So prominently does his simple adherence to facts and disregard of tradition and prejudice, exhibit him as superior to the more servile workers in the science of medicine before his time, who were in reality mere commentators on Hippocrates and Galen, that he has been called the father of human anatomy. He elaborated a comprehensive system, which, although necessarily incomplete, contained few mistakes, and he exposed and corrected a vast number of errors, which, up to that time, had been received without question.

The beginning of the sixteenth century, when Luther nailed his ninety-five propositions to the gates of Wittenberg, marked the commencement of a new era in science, as well as in religion. The spirit of Protestantism influenced the study of medicine, and Vesalius did not stand alone. Linacre, who had studied at Padua before the time of Vesalius, had just established the College of Physicians in London, thus emancipating medicine to a great extent from priestly influence. Hitherto the power of approving and licensing practitioners had been committed to the bishops in their several dioceses, and the practice of physic was accordingly engrossed by illiterate monks and other ignorant empirics, who, as the charter of the college expresses it, "boldly and accustomably took upon them great cures, to the high displeasure of God, the great infamy of the faculty, and the grievous hurt of his Majesty's liege people." Physicians had gradually become distinct from the sacerdotal order on the Continent, and as early as the beginning of the fourteenth century we find that monks were expelled from the hospitals by the University of Vienna for their "insatiate avidity, and flagrant incompetency," and the care of the sick poor given into the hands of the laity. The monks revenged themselves by procuring an order from the Pope, prohibiting physicians from visiting their patients a second time, without summoning a priest to attend also!

From the Protestant era, original investigation and the accumulation of facts from accurate observation proceeded with a rapidity and certainty beyond all previous experience. Their progress was, nevertheless, impeded, and the value of the results produced depreciated by several opposing influences.

The Romish Church, ever intolerant of novelties which did not emanate from herself, viewed with apprehension and hatred all scientific discoveries, since they were subversive of dogmas which infallibility had sanctioned and approved. Roger Bacon was persecuted by a priesthood said to be so ignorant that they knew no property of the circle, except that of keeping out the devil—and the cry of sorcery or heresy was raised against succeeding explorers of Nature to the time of Galileo. It is terrible to think how many great lights must have been extinguished, how many great discoveries nipped in the bud, by the rigorous stamping out of heresy and unholy pursuits, carried on by the Inquisition. And Protestantism, which had its origin in a similar spirit of inquiry, deprecated with almost equal bigotry, though with less power, every conclusion which seemed contrary to her own interpretation of the word of God. God had afflicted Job with horrible diseases, and the history of the demoniacs proved that devils could derange bodily functions; therefore to doubt these causes was to impugn the veracity of the Bible.

As late as the year 1699, the Royal Society was attacked by theologians soon after its foundation, on the ground that the society neglected the wiser and more discerning ancient philosophers, and depended too much on their own unassisted powers—that, by admitting men of all religions and all countries, they endangered the stability of the Established Church—and, more than all, that a philosophy, founded on experiment, was likely to lead to the overthrow of the Christian religion, and even to a formal denial of the existence of God. And about this time, the orthodox and devout Willis, who gave all his Sunday fees in charity, who procured a special early service daily at a church in St. Martin's Lane, in order that he might be able to attend before he visited his patients, and dedicated his treatise, "De Animâ Brutorum," to the Archbishop of Canterbury, was condemned by the theologians of the day as tainted with heresy, because he ventured on some speculations not sanctioned by the verdict of antiquity.

The Humoral Pathology had been established as a simple explanation of ordinary diseases, which the more educated people had begun to think might be owing to natural causes; but the pestilences which ravaged nations, and indeed any strange and unaccountable malady, were still unhesitatingly referred to some unpropitious conjunction of the planets, or the machinations of the devil. This Humoral Pathology assumed the existence of four humors in the body, viz., blood, melancholy, choler, and phlegm. Blood was supposed to be formed by the liver, melancholy by the spleen, choler by the gall-bladder, and phlegm by the stomach. The temperament of each individual was termed sanguine, melancholy, choleric, or phlegmatic, according to the humor naturally predominant in his constitution, and one fluid prevailing with abnormal excess over the others gave rise to morbid conditions. The faculty still held to the doctrine of "signatures," as it was called, as the basis of therapeutics; which doctrine assumed certain remedies to be potent in certain diseases, because there was some external resemblance or fanciful connection between the two. Thus, scarlet bed-curtains were a cure for scarlet fever, measles, or any disease with a red eruption on the skin, and the grandfather of Maria Theresa died of small-pox, wrapped, by order of his physicians, in twenty yards of scarlet broadcloth! The yellow powder turmeric was a remedy for jaundice, the lung of the long-winded fox a cure for asthma and shortness of breath; the heart of a nightingale was prescribed for loss of memory; the royal touch was a specific for scrofula or king's evil; and we find John Brown, chirurgeon-in-ordinary to Charles II., writing a treatise on the "Royal Gift of Healing Strumæs by Imposition of Hands," with a description of the proper and efficacious manner of conducting the ceremony. This delusion actually held its ground until the eighteenth century, when the great Dr. Johnson was touched by Queen Anne.

As late as 1623, Sir Kenelm Digby, the Admirable Crichton of his time, produced a sympathetic powder which was to cure wounds even when the patient was out of sight. This powder had extraordinary success, and its efficacy was almost universally acknowledged.

The more advanced minds were, in truth, not yet in the condition most favorable to the development of the sciences. Men of the most daring and original minds were tainted with superstition and credulity. Luther believed that the devil tormented him with earache; he emphatically enforced the duty of burning witches, and earnestly recommended some anxious parents to destroy their son, whom he declared to be possessed by an evil spirit! The belief in witchcraft was still universal, and the last witch was not burnt until 1722. Bishops, judges, magistrates, and learned men, all agreed in crediting the reality of sorcery and the efficacy of astrology.

Men wasted their time and energies in discussing whether a spirit could live in a vacuum, and whether, in that case, the vacuum would be complete; and whether Adam and Eve, not being born in the natural manner, possessed the umbilical mark. They theorized concerning the nature or essence of vital principles and other mysterious entities, and heaped hypothesis on hypothesis, careless of their foundations. Van Helmont, who is immortalized by the discovery of the gases, adopted as an established fact a theory which he founded on the hypothetical "archæus" or entity of Paracelsus. The archæus being an immaterial force or spiritual agent, Van Helmont believed that each member of the body had its own particular archæus, subordinate to the central or principal archæus, which he localized in the stomach; and, as he found that nauseating medicines impaired mental vigor, he assigned to the stomach the seat of the intellect also. Thus, although he made great discoveries in chemistry, his physiology was wildly imaginary and unwarrantably assumptive, and detracts from the fame which his valuable researches in chemistry conferred upon him.

The matter-of-fact Vesalius, too, who had dared to fail in seeing the openings through the septum of the heart, which Galen had declared to exist, did not dream of disputing the theory of that authority concerning the distribution of the blood, which required that the blood from the two ventricles should intermingle, and therefore imagined that it distilled through the pores of the unbroken and impermeable partition; and, contrary to what seems to have been his general temper, he steadily denied the existence of valves in the veins, which had been observed by others, although he might have verified their statements had he been in this instance open to conviction. Servetus, also, the victim of Calvin, who burnt him and his works together at Geneva, when he had discovered the pulmonary circulation, and almost grasped the great secret afterward found out by Harvey—the complete circulation of the blood—instead of proceeding with the investigation, assumed all other errors except the one he had disproved, and describes how the air passes from the nose into the ventricles of the brain, and speculates how the devil takes the same route to the soul. The spirit of the age continued eminently unpractical, and men took interest in facts only as they could be bent to the support of preconceived theories, "spinning," as Lord Bacon says, "like the spider, the thread of speculative doctrine from within themselves," and regarding the perfection and symmetry of their production, rather than its truth and certainty.—*Abstract from Fortnightly Review.*

PREHISTORIC TIMES.[1]

By Dr. T. M. COAN.

Ethnology is passing at present through a phase from which older sciences have safely emerged. The new views with reference to the antiquity of man are still looked upon by some persons with distrust and apprehension. Yet, says the distinguished author, of whose researches we are about to give some account, these new views "will, I doubt not, in a few years, be regarded with as little disquietude as are now those discoveries in astronomy and geology which at one time excited even greater opposition." It is now pretty generally admitted that the first appearance of Man in Europe dates from a period so remote, that neither history, nor even tradition, can throw any light on his origin, or mode of life. Under these circumstances, some have supposed that the past is hidden from the present by a veil, which time will probably thicken, but never can remove. Thus our prehistoric antiquities have been valued as monuments of ancient skill and perseverance, not regarded as pages of ancient history; recognized as interesting vignettes, not as historical pictures. Some writers have assured us that, in the words of Palgrave, "we must give it up, that speechless past; whether fact or chronology, doctrine or mythology; whether in Europe, Asia, Africa, or America; at Thebes or Palenque, on Lycian shore or Salisbury Plain: lost is lost; gone is gone forever."

Of late years, however, a new Science has been born among us which deals with times and events far more ancient than any which have yet fallen within the province of the archæologist. The geologist reckons not by days or by years; the whole six thousand years, which were until lately looked on as the sum of the world's existence, are to him but one unit of measurement in the long succession of past ages.

Our knowledge of geology is, of course, very incomplete; on some questions we shall, no doubt, see reason to change our opinion, but, on the whole, the conclusions to which it points are as definite as those of zoology, chemistry, or any of the kindred sciences. Nor does there appear to be any reason why those methods of examination which have proved so successful in geology, should not also be used to throw light on the history of man in prehistoric times. Archæology forms, in fact, the link between geology and history. But, while other animals leave only teeth and bones behind them, the men of the earliest ages are to be studied principally by their works; they have left

[1] "Prehistoric Times as illustrated by Ancient Remains, and the Manners and Customs of Modern Savages By Sir John Lubbock, Bart., M. P., Vice-President of the Royal Society," etc., etc. 8vo, pp. 640. New York: D. Appleton & Co.

behind them houses, tombs, fortifications, temples, implements for use, and ornaments for decoration.

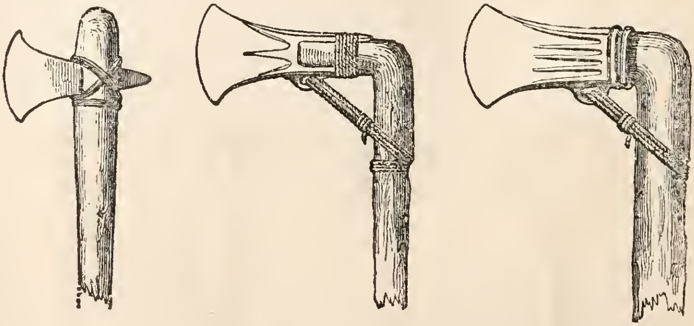
From the careful study of these remains, it would appear that prehistoric archæology may be divided into four great epochs:

1. That of the Drift; where man shared the possession of Europe with the Mammoth, the Cave bear, the woolly-haired rhinoceros, and other extinct animals. This we may call the "Palæolithic" period.

2. The later or polished Stone Age; a period characterized by beautiful weapons and instruments made of flint and other kinds of stone; in which, however, we find no trace of the knowledge of any metal, excepting gold, which seems to have been sometimes used for ornaments. This we may call the "Neolithic" period.

3. The Bronze Age, in which bronze was used for arms and cutting instruments of all kinds.

4. The Iron Age, in which that metal had superseded bronze for arms, axes, knives, etc.; bronze, however, still being in common use for ornaments, and frequently also for the *handles* or swords and other arms, though never for the blades.



The three different types of Celts, and the manner in which they are supposed to have been handled.

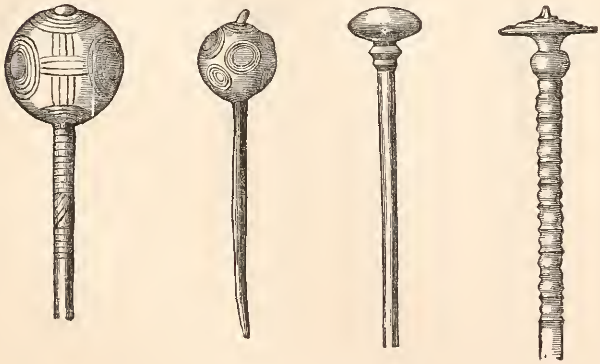
Without attempting a laborious classification of the records of these epochs, we will speak first of some of the records of the "Bronze Age." The commonest and, perhaps, the most characteristic objects belonging to this age are the so-called "celts," which were probably used for chisels, hoes, war-axes, and a variety of other purposes.

Bronze celts are generally plain, but sometimes ornamented with ridges, dots, or lines, as in the accompanying figures. More than two thousand specimens of them are known to exist in the different Irish collections, of which the great Museum belonging to the Royal Irish Academy at Dublin contained in the year 1860 no less than six hundred and eighty-eight, no two of which were cast in the same mould. They vary in size from an inch to a foot in length. That they were made in the countries where they are found, is proved by the presence of moulds. It is difficult to understand why the celt-makers never cast their axes as we do ours, with a transverse hole, through which the handle might pass. No bronze implements of this description have been yet found in Great Britain, though a few have occurred in Denmark, where they are of great beauty and highly decorated.

The swords of the Bronze Age are always more or less leaf-like in shape, double-edged, sharp-pointed, and intended for stabbing and thrusting, rather than for cutting.

Fish-hooks, knives, bracelets, pins, and rings, of the same era, are also discovered in great numbers in various parts of Europe. They

Bracelets.—Switzerland.



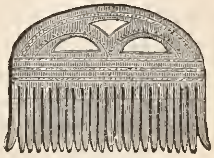
Bronze Hair-pins.—Switzerland.

are well cast, and show considerable skill in metallurgy; and the beauty of their form and ornamentation indicates no little development of the artistic faculties.

We should hardly have hoped to ascertain much of the manner in which the people of the Bronze Age were dressed. Considering how perishable are the materials out of which clothes are formed, it is wonderful that any fragments of them should have remained to the present day; yet, in addition to traces of linen tissue, and of the skins of animals used in this period, we possess the whole dress of a chief belonging to the Bronze Age.

On a farm occupied by M. Dahls, near Ribe in Jutland, are four tumuli, known as Great Kongehoi, Little Kongehoi, Guldhoi, and Treenhoi. This last was examined in 1861. Near its centre were found

Woollen Caps, from Tumulus.



Comb.

three wooden coffins, two of full size, and one evidently intended for a child. The contents of the larger were partially preserved, and very interesting: caps, a comb, two woollen shawls, traces of leather, some black hair, and the brain, remained, when all of the bones had changed into a kind of blue powder. Implements of bronze accompanied these remains, and there seems no doubt that they dated from a prehistoric antiquity.

Many of the dwellings in use during the Bronze Age were no doubt subterranean or semi-subterranean. On almost all large tracts of uncultivated land, ancient villages of this character may still be traced. A pit was dug, and the earth which was thrown out formed a circular wall, the whole being then probably covered over with boughs. The "Penpits," near Gillingham, in Wiltshire, are of this character, and indicate a populous settlement. In Anglesea, similar hut-circles exist. On Dartmoor and elsewhere, where large blocks of stone abounded, the natives saved themselves the trouble of excavating, and simply built up circular walls of stone. In other cases, probably when concealment was an object, the dwellings were entirely subterranean. Such ancient dwellings are in Scotland known as "weems," from "Uamha," a cave. In one of these at Monzie, in Perthshire, a bronze sword was discovered. Such underground chambers, however, appear to have been used in Scotland as dwellings, or at least as places of concealment, down to the time of the Romans; for a weem described by Lord Rosehill was constructed partly of stones showing the diagonal and diamond markings peculiar to Roman workmanship. Sir John Lubbock believes that Stonehenge also belongs to the Bronze Age.

From the independent statements of Homer and in the book of Kings (where the word is mistranslated *brass*) we find that bronze was abundant in the East no less than three thousand years ago. Bronze is composed of about nine parts of copper to one of tin: and copper is found in so many countries that we cannot as yet tell whence the

Phœnicians obtained it. But, unless the ancients had some source of tin with which we are unacquainted, it seems to be well established that the Phœnician tin was mainly derived from Cornwall, and consequently that even at this early period a considerable commerce had been organized, and very distant countries brought into connection with one another. We are justified in concluding that, between B. C. 1500 and B. C. 1200, the Phœnicians were already acquainted with the mineral fields of Spain and of Britain.

Of the still earlier Age of Stone no less than 30,000 relics, mainly in the shape of implements, are preserved in the Danish museums alone. There is enough evidence to justify us in believing that there was a period when society was in so barbarous a state that sticks or stones (to which we must add horns and bones) were the only implements with which men knew how to furnish themselves.

Our knowledge of this ancient period is derived principally from four sources: namely, the tumuli, or ancient burial-mounds; the Lake habitations of Switzerland; shell-mounds of Denmark; and the Bone-caves. There are, indeed, many other remains of great interest, such, for example, as the ancient fortifications, the "castles" and "camps" which crown so many English hill-tops, and the great lines of embankment; there are the so-called Druidical circles and the vestiges of ancient habitations. The majority of these belong, however, in all probability, to a later period; and at any rate, in the present state of our knowledge, we cannot say which, or how many of them, are referable to the Stone Age.

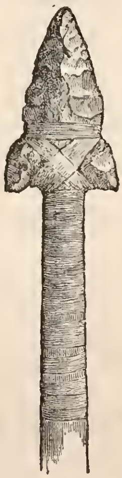
Flint appears to have been the stone most frequently used in Europe, and it has had a much more important influence on our civilization than is generally supposed. Savages value it on account of its hardness and mode of fracture, which is such that, with practice, a good sound block can be chipped into almost any form that may be required.

In many cases block and pebbles of flint, picked up on the surface of the ground, were used in the manufacture of implements; but in other cases much labor was spent to obtain flint of good quality. A good illustration of this is afforded by the so-called Grime's Graves, near Brandon, one of which has recently been explored by Mr. Greenwell. These turned out to be excavations made for the purpose of obtaining flint. The end of an ancient gallery was exposed to view. The flint had been hollowed out in three places, and in front of two of these recesses, pointing toward the half-excavated stone, were two deer-horn picks, lying just as they had been left, still coated with chalk-dust, on which was in one place plainly visible the print of the workman's hand. They had evidently been left at the close of a day's work; during the night the gallery had fallen in, and they had never been recovered.

The flint knives, or "flakes," simple as their forms appear, are always the work of man. To make one, the flint must be held firmly, and then a considerable force must be applied, either by pressure or by blows, repeated three or four times, but at least three, and given in certain slightly different directions, with a certain definite force; these conditions could scarcely occur by accident, so that, simple as it may seem to the untrained eye, a flint flake is to the antiquary as sure a trace of man as the footprint in the sand was to Robinson Crusoe.

To us, accustomed as we are to the use of metals, it seems difficult to believe that such things were ever made use of; we know, however, that many savages of the present day have no better tools. Yet, with axes such as these, and generally with the assistance of fire, they will cut down large trees, and hollow them out into canoes. The piles used in the Swiss Stone Age Lake habitations were evidently, from the marks of the cuts on them, prepared with the help of stone axes. The great similarity of arrow-heads, even from the most distant localities, may be seen in the accompanying figures, which represent specimens from France, North America, and Tierra del Fuego, respectively.

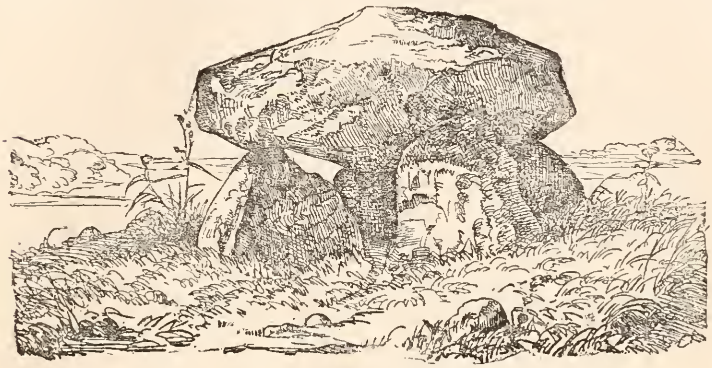
France.



North America.

Tierra del Fuego.

Of monuments and tumuli belonging to this epoch, there is no lack; throughout the world, they are scattered—camps, dikes, fortifications, cromlechs, or stone circles. In the Orkneys, more than 2,000 of the smaller tumuli still remain. In Denmark, they are still more abundant. They are found all over Europe, from the shores of the Atlantic to the Ural Mountains; in Asia, they are scattered over the great steppes, from the borders of Russia to the Pacific Ocean, and from the plains of Siberia to those of Hindostan; the entire plain of Jelalabad, says Masson, "is literally covered with tumuli and mounds." In America, they are to be numbered by thousands and tens of thousands; nor are they wanting in Africa, where the Pyramids themselves exhibit the most magnificent development of the same idea; indeed, the whole world is studded with the burial-places of the dead. Tumuli or barrows are much more numerous and more widely distributed than stone circles. No doubt the great majority of them are burial-mounds, but some also were erected as memorials, like the "heap of witness"



Danish Dolmen.

erected by Laban and Jacob, or the mound heaped up by the ten thousand in their celebrated retreat, when they obtained their first view of the sea.

One of the most curious habits of the prehistoric European was that of constructing his dwellings upon piles above the surface of the

Sepulchral Stone Circle.

water. The vestiges of many Swiss buildings of this sort are not unlike those of the Pæonians, described by Herodotus.

"Their dwellings," he says, "are contrived after this manner planks fitted on lofty piles are placed in the middle of the lake, with a narrow entrance from the main-land by a single bridge. These piles, that support the planks, all the citizens anciently placed there at the public charge; but afterward they established a law to the following effect: whenever a man marries, for each wife he sinks three piles, bringing wood from a mountain called Orbelus: but every man has several wives. They live in the following manner: on the planks every man has a hut, in which he dwells, with a trap-door closely fitted in the planks, and leading down to the lake. They tie the young children with a cord round the foot, fearing lest they should fall into the lake beneath. To their horses and beasts of burden they give fish for fodder; of which there is such an abundance, that, when a man has opened his trap-door, he lets down an empty basket by a cord into the lake, and, after waiting a short time, draws it up full of fish."

And certain savage or semi-savage tribes live in the same manner, even at the present day. The fishermen of Lake Prasias still inhabit wooden cottages built over the water, as in the time of Herodotus. In most of the large Swiss lakes these habitations have been discovered, numbering over 200 at the present date. M. Troyon has endeavored to make a retrospective census of those early times. The settlement at Morges, which is one of the largest in the Lake of Geneva, is 1,200 feet long and 150 broad, giving a surface of 180,000 square feet. Allowing the huts to have been fifteen feet in diameter, and supposing that they occupied half the surface, leaving the rest for gangways, he estimates the number of cabins at 311; and supposing again that, on an average, each was inhabited by four persons, he obtains for the whole a population of 1,244. Sixty-eight villages belonging to the Bronze Age are supposed to have contained 42,500 persons; while for the preceding epoch, by the same process of reasoning, he estimates the population at 31,875.

Abundant animal remains are found in these lake-dwellings, no less, indeed, than 70 species, of which 10 are fishes, four reptiles, 26 birds, and the remainder quadrupeds. The dog, pig, horse, goat, and sheep, are recognized, and at least two varieties of oxen. Remains of the horse are extremely rare. Three varieties of wheat were cultivated by the lake-dwellers, who also possessed two kinds of barley, and two of millet. Of these the most ancient and most important were the small six-rowed barley and small "lake-dwellers'" wheat. The discovery of Egyptian wheat at Wangen and Robenhausen is particularly interesting. Oats were cultivated during the Bronze Age, but are absent from all the Stone Age villages. Rye also was unknown. Altogether 115 species of plants have been determined. It is evident that the nourishment of the dwellers in the pile-works consisted of corn and wild fruits, of fish, and the flesh of wild and domestic animals. Doubtless, also, milk was an important article of their diet.

Much as still remains to be made out, respecting the men of the Stone period, the facts already ascertained, like a few strokes by a clever draughtsman, supply us with the elements of an outline sketch. Carrying our imagination back into the past, we see before us, on the low shores of the Danish Archipelago, a race of small men, with heavy, overhanging brows, round heads, and faces probably much like those of the present Laplanders. As they must evidently have had some protection from the weather, it is most probable that they lived in tents made of skins. The total absence of metal indicates that they had not yet any weapons except those made of wood, stone, horn, and bone. Their principal food must have consisted of shell-fish, but they were able to catch fish, and often varied their diet by game caught in hunting. It is, perhaps, not uncharitable to conclude that, when their hunters were unusually successful, the whole community gorged itself with food, as is the case with many savage races at the present time. It is evident that marrow was considered a great delicacy, for every single bone which contained any was split open in the manner best adapted to extract the precious morsel. As to the date, however, of this remote savage life, it is as yet impossible to speak with confidence, except to say that it was, in all probability, thousands of years earlier than any historic record.

Our knowledge of North American archæology is derived mainly from the researches of Messrs. Atwater, Squier, Davis, Lapham, and Haven. These remains differ less in kind than in degree from others concerning which history has not been entirely silent. They are more numerous, more concentrated, and in some particulars on a larger scale of labor, than the works which approach them on their several borders, and with whose various characters they are blended. Their great numbers may be the result of frequent changes of residence by a comparatively limited population, in accordance with a superstitious trait of the Indian nature, leading to the abandonment of places where any great calamity has been suffered. The contents of the Indian mounds are very various and interesting. They show that the art of pottery had been brought to a considerable degree of perfection. Various ornamental articles abound in the tumuli, such as beads, shells, necklaces, bracelets, etc. Earthworks for defence are also numerous, especially in the central parts of the States, and the remains of ancient mud-huts have occasionally been found.

The so-called "Sacrificial Mounds" are a class of ancient monuments altogether peculiar to the New World, and highly illustrative of the rites and customs of the ancient races of the mounds. These remarkable mounds have been very carefully explored. Their most noticeable characteristics are, their almost invariable occurrence within enclosures; their regular construction in uniform layers of gravel, earth, and sand, disposed alternately in strata, conformable to the shape of the mound; and their covering, a symmetrical altar of burnt clay or stone, on which are deposited numerous relics, in all instances exhibiting traces, more or less abundant, of their having been exposed to the action of fire. The so-called "altar" is a basin, or table of burnt clay, carefully moulded into a symmetrical form, but varying much both in shape and size. Some are round, some elliptical, and others squares or parallelograms, while in size they vary from 2 feet to

50 feet, by 12 or 15. The usual dimensions, however, are from 5 to 8 feet.

Not the least remarkable of the American antiquities are the *Animal Mounds*, which are principally, though not exclusively, found in Wisconsin. In this district thousands of examples occur of gigantic *basso-rilievos* of men, beasts, birds, and reptiles, all wrought with persevering labor on the surface of the soil, while enclosures and works of defence are almost entirely wanting, the ancient city of Aztalan being, as is supposed, the only example of the former class.

One remarkable group in Dale County, close to the Great Indian War-path, consists of a man with extended arms, seven more or less elongated mounds, one tumulus, and six quadrupeds. The length of the human figure is 125 feet, and it is 140 feet from the extremity of one arm to that of the other. The quadrupeds vary from 90 to 126 feet in length.

"But," says Mr. Lapham, "the most remarkable collection of lizards and turtles yet discovered is on the school section about a mile and a half southeast from the village of Pewaukee. This consists of seven turtles, two lizards, four oblong mounds, and one of the remark able excavations before alluded to. One of the turtle-mounds, partially obliterated by the road, has a length of 450 feet, being nearly double the usual dimensions. Three of them are remarkable for their curved tails, a feature here first observed."

When, why, or by whom these remarkable works were erected, as yet we know not. The present Indians, though they look upon them with reverence, can throw no light upon their origin. Nor do the contents of the mounds themselves assist us in this inquiry. Several of them have been opened, and, in making the streets of Milwaukee, many of the mounds have been entirely removed; but the only result has been to show that they are not sepulchral, and that, excepting by accident, they contain no implements or ornaments.

Many computations have been made in respect to the actual antiquity of the various prehistoric remains that we have described. Sir Charles Lyell, one of the most cautious of geologists, thinks that 100,000 years is a moderate estimate of the time that has been required to form the alluvial delta of the Mississippi; and he considers that the alluvium of the Somme, containing flint implements and the remains of the mammoth and hyena, is no less ancient.

Many astronomical and climatic proofs are found of the extreme antiquity of the globe; and all geologists, indeed, are now prepared to admit that man has existed on our earth for a much longer period than was until recently supposed to have been the case.

But it may be doubted whether even geologists yet realize the great antiquity of our race. Sir Charles Lyell himself thinks that we may expect to find the remains of man in the pliocene strata, but there he draws the line, and says that in miocene time, "had some other rational being, representing man, then flourished, some signs of his existence could hardly have escaped unnoticed, in the shape of implements of stone or metal, more frequent and more durable than the osseous remains of any of the mammalia."

It is true that few of our existing species, or even genera, have as yet been found in miocene strata; but if man constitutes a separate family of mammalia, as he does in the opinion of the highest authorities, then, according to all paleontological analogies, he must have had representatives in miocene times. We need not, however, expect to find the proofs in Europe; our nearest relatives in the animal kingdom are confined to hot, almost to tropical climates, and it is in such countries that we are most likely to find the earliest traces of the human race.

M. Morlot has made some interesting calculations respecting the age of geological formations in Switzerland. The torrent of the Tinière, at the point where it falls into the Lake of Geneva, near Villeneuve, has gradually built up a cone of gravel and alluvium. In the formation of the railway this cone has been bisected for a length of 1,000 feet, and to a depth, in the central part, of about 32 feet 6 inches above the level of the railway. The section of the cone thus obtained shows a very regular structure, which proves that its formation was gradual. It is composed of the same materials (sand, gravel, and large blocks) as those which are even now brought down by the stream. The amount of detritus does, indeed, differ considerably from year to year, but in the long-run the differences compensate for one another, so that, when considering long periods, and the structure of the whole mass, the influences of the temporary variations, which arise from meteorological causes, altogether disappear, and need not, therefore, be taken into account. M. Morlot's estimates assign about 6,000 years for the formation of the lower layer of vegetable soil, and 10,000 years for that of the whole existing cone. But above this cone is another, which was formed when the lake stood at a higher level than at present, and which M. Morlot refers to the period of the river-drift gravels. This drift-age cone is about twelve times as large as that now forming, and would appear, therefore, on the same data, to indicate an antiquity of more than 100,000 years.

Again, it will be remembered that, side by side with the remains of Arctic animals, have been found others indicating a warm climate, such for instance as the hippopotamus. This fact, which has always hitherto been felt as a difficulty, is at once explained by the suggestion of a change every 10,000 or 11,000 years, from a high to a low temperature, and *vice versa*. But a period of 10,000 years, long as it may appear to us, is very little from a geological point of view. We can thus understand how the remains of the hippopotamus and the bones of the musk-ox come to be found together in England and in France. The very same geological conditions which fitted our valleys for the one, would, at an interval of 10,000 years, render them suitable for the other. That man existed in Europe during the period of the mammoth, no longer, apparently, admits of a doubt. "When speculations on the long series of events which occurred in the glacial and post-glacial periods are indulged in," says Sir C. Lyell, "the imagination is apt to take alarm at the immensity of the time required to interpret the monuments of these ages, all referable to the era of existing species. In order to abridge the number of centuries which would otherwise be indispensable, a disposition is shown by many to magnify the rate of change in prehistoric times, by investing the causes which have modified the animate and the inanimate world with extraordinary and excessive energy. . . . We of the living generation, when called upon to make grants of thousands of centuries in order to explain the events of what is called the modern period, shrink naturally at first from making what seems so lavish an expenditure of past time."

To the geologist, however, these large figures have no appearance of improbability. All the facts of geology tend to indicate an antiquity of which we are but begining to form a dim idea. Take, for instance, one single formation—our well-known chalk. This consists entirely of shells and fragments of shells deposited at the bottom of an ancient sea, far away from any continent. Such a progress as this must be very slow: probably we should be much above the mark if we were to assume a rate of deposition of ten inches in a century. Now the chalk is more than a thousand feet in thickness, and would have required, therefore, more than 120,000 years for its formation. The fossiliferous beds of Great Britain, as a whole, are more than 70,000 feet in thickness, and many which there measure only a few inches, on the Continent expand into strata of immense depth; while others, of great importance elsewhere, are wholly wanting there, for it is evident that, during all the different periods in which Great Britain has been dry land, strata have been forming (as is, for example, the case now) elsewhere, and not with us. Moreover, we must remember that many of the strata now existing have been formed at the expense of older ones; thus, all the flint-gravels in the southeast of England have been produced by the destruction of chalk. This, again, is a very slow process. It has been estimated that a cliff 500 feet high will be worn away at the rate of an inch in a century. This may seem a low rate, but we must bear in mind that along any line of coast there are comparatively few points which are suffering at one time, and that even on those, when a fall of cliff has taken place, the fragments serve as a protection to the coast, until they have been gradually removed by the waves The Wealden Valley is 22 miles in breadth, and on these data it has been calculated that the denudation of the Weald must have required more than 150,000,000 of years.

EDITOR'S TABLE.

PURPOSE AND PLAN OF OUR ENTERPRISE.

THE POPULAR SCIENCE MONTHLY has been started to help on the work of sound public education, by supplying instructive articles on the leading subjects of scientific inquiry. It will contain papers, original and selected, on a wide range of subjects, from the ablest scientific men of different countries, explaining their views to non-scientific people. A magazine is needed here, which shall be devoted to this purpose, for, although much is done by the general press in scattering light articles and shreds of information, yet many scientific discussions of merit and moment are passed by. It is, therefore, thought best to bring this class of contributions together for the benefit of all who are interested in the advance of ideas and the diffusion of valuable knowledge.

The increasing interest in science, in its facts and principles, its practical applications, and its bearings upon opinion, is undeniable; and, with this augmenting interest, there is growing up a new and enlarged meaning of the term which it is important for us to notice. By science is now meant the most accurate knowledge that can be obtained of the order of the universe by which man is surrounded, and of which he is a part. This order was at first perceived in simple physical things, and the tracing of it out in these gave origin to the physical sciences. In its earlier development, therefore, science pertained to certain branches of knowledge, and to many the term science still implies *physical* science.

But this is an erroneous conception of its real scope. The growth of science involves a widening as well as a progression. The ascertainable order of things proves to be much more extensive than was at first suspected; and the inquiry into it has led to sphere after sphere of new investigation, until science is now regarded as not applying to this or that class of objects, but to the whole of Nature—as being, in fact, a method of the mind, a quality or character of knowledge upon all subjects of which we can think or know.

What some call the progress of science, and others call its encroachments, is undoubtedly the great fact of modern thought, and it implies a more critical method of inquiry applied to subjects not before dealt with in so strict a manner. The effect has been, that many subjects, formerly widely separated from the recognized sciences, have been brought nearer to them, and have passed more or less completely under the influence of the scientific method of investigation. Whatever subjects involve accessible and observable phenomena, one causing another, or in any way related to another, belong properly to science for investigation. Intellect, feeling, human action, language, education, history, morals, religion, law, commerce, and all social relations and activities, answer to this condition; each has its basis of fact, which is the legitimate subject-matter of scientific inquiry. Those, therefore, who consider that observatory-watching, laboratory-work, or the dredging of the sea for specimens to be classified, is all there is to science, make a serious mistake. Science truly means continuous intelligent observation of the characters of men, as well as of the characters of insects. It means the analysis of mind as well as that of chemical substances It means the scrutiny of evidence, in regard to political theories, as inexorable as that applied to theories of comets. It means the tracing of cause and effect in the sequences of human conduct as well as in the sequences of atmospheric change. It means strict inductive inquiry as to how society has come to be what it is, as well as how the rocky systems have come to be what they are. In short, science is not the mystery of a class, but the common interest of rational beings, in whom thinking determines action, and whose highest concern it is that thought shall be brought into the exactest harmony with things—and this is the supreme purpose of education.

If, in this statement of the scope and work of science, we have not laid stress upon those great achievements by which it has given man power over the material world, it is not because we undervalue them. They are noble results, but they are abundantly eulogized, and their very splendor has operated to dim the view of other conquests, less conspicuous, but even more important. Telegraphs, steam-engines, and the thousand devices to which science has led, are great things; but what, after all, is their value compared with the emancipation of the human spirit from the thraldom of ignorance, which the world owes to this agency? Rightly to appreciate what science has accomplished for humanity, we must remember not only that it has raised men to the understanding and enjoyment of the beautiful order of Nature, but that it has put an end to the baneful superstitions by which, for ages, men's lives were darkened, to the sufferings of witchcraft, and the terrors of the untaught imagination which filled the world with malignant agencies.

It is this immense extension of the conception of science, in which all the higher subjects of human interest are now included, that gives it an ever-increasing claim on the attention of the public. Besides its indispensable use in all avocations, and its constant application in the sphere of daily life, it is also profoundly affecting the whole circle of questions, speculative and practical, which have agitated the minds of men for generations. Whoever cares to know whither inquiry is tending, or how opinion is changing, what old ideas are perishing, and what new ones are rising into acceptance — briefly, whoever desires to be intelligent as to contemporary movements in the world of thought — must give attention to the course of scientific inquiry. Believing that there are many such in this country, and that they are certain to become more numerous in future, THE POPULAR SCIENCE MONTHLY has been commenced with the intention of meeting their wants more perfectly than any other periodical they can get.

The work of *creating* science has been organized for centuries. Royal societies and scientific academies are hundreds of years old. Men of science have their journals, in all departments, in which they report to each the results of original work, describe their processes, engage in mutual criticism, and cultivate a special literature in the interests of scientific advancement.

The work of *diffusing* science is, however, as yet, but very imperfectly organized, although it is clearly the next great task of civilization. The signs, however, are promising. Schools of science are springing up in all enlightened countries, and old educational establishments are yielding to the reformatory spirit, modifying and modernizing their systems of study. There is, besides, a growing sympathy, on the part of men of science of the highest character, with the work of popular teaching, and an increasing readiness to coöperate in undertakings that shall promote it. There is, in fact, growing up a valuable literature of popular science —not the trash that caters to public ignorance, wonder, and prejudice, but able and instructive essays and lectures from men who are authorities upon the subjects which they treat. But the task of systematically disseminating these valuable productions is as yet but imperfectly executed, and we propose to contribute what we can to it in the present publication.

The Popular Science Monthly will make its appeal, not to the illiterate, but to the generally-educated classes. The universities, colleges, academies, and high-schools of this country are numbered by hundreds, and their graduates by hundreds of thousands. Their culture is generally literary, with but a small portion of elementary science; but they are active-minded, and competent to follow connected thought in untechnical English, even if it be sometimes a little close. Our pages will be adapted to the wants of these, and will enable them to carry on the work of self-instruction in science.

The present undertaking is experimental. We propose to give it a fair trial; but it will be for the public to decide whether the publication shall be continued. All who are in sympathy with its aims are invited to do what they can to extend its circulation.

THE WORK OF PROF. MORSE.

Prof. Morse has completed his career, and taken his place in the past. He belongs now to memory and to fame, and his name and work will help to save our age from oblivion in the distant future. After a few thousand years, when the inferior races of men shall have disappeared from the earth, except perhaps a few samples preserved as antiquarian specimens; when civilization has overspread the world, and the telegraph system has become so universal and perfected that any individual will be able to put himself into instantaneous communication with any other individual upon the globe, then will the name of Morse, one of the great founders of the system, be more eminent than any upon whom we now look back as the illustrious of ancient times.

Prof. Morse illustrated the law of the hereditary descent of talent, being the son of the Rev. Jedediah Morse, the first American geographer. He was born in Massachusetts, in 1791, and graduated at Yale College in 1810. The American inventor of the telegraph, like the inventor of the steamboat, was at first an artist, and distinguished himself both in painting and sculpture. He studied abroad, and received the gold medal from the Adelphi Society of Arts for his first attempt in sculpture. Returning to this country, he was engaged, by the corporation of New York City, to paint the portrait of Lafayette; he assisted in founding the National Academy of Design, was its first president, and gave the first course of lectures ever delivered on art in this country.

In college, young Morse had paid some attention to chemistry and physics, but did not afterward specially pursue them. He took up the subject of electricity much as Franklin did, through the influence of others, and with reference to utilitarian ends. The invention of the Leyden jar, in 1746, set all Europe to experimenting, and the next year Peter Collinson, of London, sent a box of glass tubes, and other things for experimenting, to his friend Franklin, at Philadelphia, who took the electric fever and went enthusiastically to work, giving the world the lightning-rod in five years after he began to investigate. So, while Morse was lecturing on the fine arts, his friend Prof. G. F. Dana was lecturing in the same institution on electro-magnetism, and his attention was thus drawn to the subject. This was in 1826–'27, when much was said of the many and brilliant discoveries in these sciences.

The conception of the telegraph in Prof. Morse's mind dates from 1832, when he was forty-one years old—exactly the age of Franklin when he received his instruments from Collinson, and entered upon the study of electricity. It was in a conversation on electro-magnetism on board the packet-ship

Sully that the idea of instantaneous communication of intelligence by means of an insulated wire occurred to him, "and, before the completion of the voyage, he had not only worked out in his own mind, but had committed to paper, the general plan of the invention with which his name is indissolubly connected. His main object was to effect a communication, by means of the electro-magnet, that would leave a permanent record by signs answering for an alphabet, and which, though carried to any distance, would communicate with any place through which the line might pass. His first idea was to use a strip of paper, saturated with some chemical preparation that would be decomposed when brought in connection with the wire, along which the electric current was passing, and thus by a series of chemical marks, varying in width and number for the different letters of the alphabet, record the message without separating the wire at each point of communication."

Three years were now consumed in experimenting, and in 1835 he had so far perfected his instrument as to be able to show it to his friends, and send by it a message to the distance of half a mile; but, at this time, he could not receive an answer through the same wire. Two years later, his plan was so matured that he could telegraph to a distance, and receive replies; and he then exhibited it to hundreds of people in the University of New York, where soon after the first photograph of a human countenance was taken by Dr. J. W. Draper.

It is interesting to note the equality of the rhythms of mental movement in the development of electrical science. If we start with Du Fay, the greatest electrician of the last century, and who first introduced the conception of the two kinds of electricity, vitreous and resinous—afterward positive and negative—we may assume that he first laid its secure foundation as a science, and his researches were published in the proceedings of the French Academy in 1737. The next fifteen years was the most productive period in the development of frictional electricity, and ended with the invention of the lightning-rod in 1752. In 1790, a new form of electricity was discovered by Galvani, and then came a period of seventeen years in which the phenomena were rapidly developed, ending with Davy's grand experiments in electrical decomposition with the galvanic battery in 1807. In 1820, Oersted announced electro-magnetism, and then followed a brilliant course of discoveries again, for seventeen years, terminating in the patenting of the electro-magnetic telegraph by Morse in 1837—exactly a century from the publication of the memoirs of Du Fay.

It is not to be forgotten, however, that the time had come for the electric telegraph, and other men were working at the problem as well as Morse. He sailed for Europe in 1838, to get assistance in carrying out his project, and to obtain patents in foreign countries. In this he failed, because of rival contrivances already in the field. Cooke and Wheatstone in England, and Steinheil in Munich, had been at work for several years on the same problem. The latter had patented an electric telegraph in 1836, and the former in 1837.

Of Prof. Morse's difficulties in carrying out his great and beneficent invention, the lack of sympathy and appreciation on the part of the public, the faithlessness of capitalists, and the stupidity of the American Congress, little need be said, as it is but the old story over again. Yet he triumphed over all these obstacles, and lived to a ripe old age, to enjoy in munificent measure the rewards and the applause of his generation.

THE SCIENCE OF SOCIETY.

The first article of our first number is the first instalment of a series of essays on the study of society in a methodical way, or sociology. But few can now be found who will question that the author of these articles is the highest authority of our age upon the subject. To deal with any thing so vast and complex as society, by an original method, so as to bring out the natural laws of its constitution, requires rare powers and attainments on the part of him who undertakes it. He must have an accurate and extensive acquaintance with the higher sciences of life and mind, as well as the various states and phases of man's social condition. To encyclopædic knowledge, there must be added originality, independence, and a broad grasp of principles and details. That Mr. Spencer possesses these in an eminent degree, we are assured by authorities who are both competent to judge and cautious in the expression of their judgment—such men as Mill, Hooker, Lewes, Darwin, Morell, Wallace, Huxley, Masson, McCosh. In the last number of the *Contemporary Review* is an article by the acute essayist, "Henry Holbeach," referring to what Mr. Spencer has already written on public and social questions, in which he is spoken of as "holding the unique and very eminent place as a great thinker, which he does, in fact, hold," and these writings are referred to as containing "an arsenal of argument and illustration never surpassed for range and force, if ever equalled in the history of philosophy."

Mr. Spencer has now been engaged twelve years on his life-work, a system of Synthetic Philosophy, based on the doctrine of evolution. Five volumes of this work will be completed next autumn, in which the foundations are deeply laid in the sciences of life and mind for the third great discussion—the Principles of Sociology, in three volumes, treating of the development of society in all its elements in accordance with the theory of evolution.

Before entering upon this part of his undertaking, the author has thought it expedient to make some observations concerning it, which will be outside of the philosophical system, and independent of it. Those who have familiarized themselves with the former parts of his system, are not as the stars of heaven in number; nor are those who understand the nature and claims of sociological science as the sands of the sea. The term social science has indeed come into vogue, and large associations have assumed it; but, as thus applied, it fails to connote any distinctive or coherent body of principles such as are necessary to constitute a science.

In this state of things, and before proceeding to the systematic work of developing the science itself, Mr. Spencer will consider its claims as an object of study, its subject matter, its method of investigation, scope, and limits. The article which is now published presents the need of the study, and the next will answer the question, "Is there a social science?" The paper we now publish tells its own story, and the subsequent ones will not fall below it in interest and instructiveness.

LITERARY NOTICES.

Instinct: its Office in the Animal Kingdom, and its Relation to the Higher Powers in Man. By P. A. Chadbourne, LL. D. George P. Putnam & Sons.

This is a very interesting volume on a fascinating subject. Dr. Chadbourne is well known as an able student of natural history, which he has long cultivated both by independent observation and in a philosophic spirit, and in this little book he gives the results of much study of instinctive action as displayed in the lower animals, and of much reflection on its bearings upon the mental and moral nature of man. Conceding fully man's close relation to the forms of life below him, Dr. Chadbourne recognizes the scientific necessity of investigating the lower to get a true interpretation of the higher; or of tracing out the workings of instinctive impulse in the simpler creatures, in order to understand the springs of movement in our own more complex mental nature. The volume is full of fresh and suggestive facts, and the author discusses the doctrines put forth by some of the recent biologists in the most liberal temper. Natural selection is recognized as a true principle of Nature, producing real effects; but it is held insufficient to account for much that is attributed to it. We cordially indorse his claim for greater breadth of culture as indispensable to a true understanding of the science of human nature: "It is with a deep conviction of the need of the hearty coöperation of the cultivators of different fields of science, especially of Naturalists and Mental Philosophers, in the full study of man, that these Lectures are presented to the public. Broad culture as a foundation for scientific attainments, respect for other sciences than our own, and intercourse with those who view the same subjects from other stand-points than our own, are absolutely essential for safe generalizations in those complex sciences that relate to animal and rational life."

The To-morrow of Death; or, the Future Life according to Science. By Louis Figuier. Roberts Brothers.

In this little book the great French compiler turns religious romancer, as he has a perfect right to do if it suits him. But the pretence that his childish vagaries are "according to science" is in the last degree absurd. A great deal of talk about science is mixed up with the most preposterous speculations concerning the supernatural, until the reader is puzzled to decide whether the writer is wag, fanatic, or fool. If honest, it is a case of emotion upsetting intellect. The author begins by propounding to the reader the safe induction that he must die. He then says that he lost a beloved son, and, falling into great grief, he at once began to speculate about the future life and the spiritual world, and came to the conclusions that light and heat are emanations of soul-substance; that some human souls migrate into the bodies of new-born children; and that the sun is the home of human souls after death. The book is not worth reading, and would not be worth mentioning, but that the writer has a sort of reputation which may mislead many as to the character of his performance.

A Dictionary of English Etymology, by Hensleigh Wedgewood. Macmillan & Co.

This is a painstaking and exhaustive work on the derivation of English words from other languages, and the origin and history of their meanings. It has passed to a second edition, and the author has had the assistance of Mr. George P. Marsh in making its thorough revision. We took it up in utter innocence, supposing it to be sound and safe, and never for a moment dreaming of any thing wrong or dangerous between its honest-looking lids. But what was our astonishment to find that the pestilent doctrine of "Darwinism," that is thrusting itself into every place where it is not welcome, and taking away the peace of so many worthy people, had got in here also. Darwinism, rank and outright, in an arid etymological dictionary! It seems that the author could not escape it. Etymology opens the question of the origin of words and language. It goes back to beginnings, and is fundamentally concerned to know by what law or method language has been formed. As language is an attribute of man, it links itself at once to the question of the origin of man. Were man and language created perfect at first, and has their onward course been a movement of degeneracy; or did they begin low and imperfect, and has the movement been a gradual unfolding—an evolution? This is more than a mere speculative question; it involves the interpretation that shall be given to the facts before us. If man and language have come to be what they are through a principle of slow and gradual evolution, our mode of regarding them will be very different from that which must be adopted if they came by an opposite method. And so the author prefixes to the second edition of his volume an elaborate essay on the origin of language, in which he rejects the old and still current view, and declares for the doctrine of evolution. We extract a portion of his statement: "If man can anyhow have stumbled into speech under the guidance of his ordinary intelligence, it will be absurd to suppose that he was helped over the first steps of his progress by some supernatural go-cart, in the shape either of direct inspiration, or, what comes to the same thing, of an instinct unknown to us at the present day, but lent for a while to Primitive Man in order to enable him to communicate with his fellows, and then withdrawn when its purpose was accomplished.

"Perhaps, after all, it will be found that the principal obstacle to belief in the rational origin of Language is an excusable repugnance to think of Man as having ever been in so brutish a condition of life as is implied in the want of speech. Imagination has always delighted to place the cradle of our race in a golden age of innocent enjoyment, and the more rational views of what the course of life must have been before the race had acquired the use of significant speech, or had elaborated for themselves the most necessary arts of subsistence, are felt by unreflecting piety as derogatory to the dignity of Man and the character of a beneficent Creator. But this is a dangerous line of thought, and the only safe rule in speculating on the possible dispensations of Providence (as has been well pointed out by Mr. Farrar) is the observation of the various conditions in which it is actually allotted to Man (without any choice of his own) to carry on his life. What is actually allowed to happen to any family of Man cannot be incompatible either with the goodness of God or with His views of the dignity of the human race. And God is no respecter of persons or of races. However hard or degrading the life of the Fuegian or the Bushman may appear to us, it can be no impeachment of the Divine love to suppose that our own progenitors were exposed to a similar struggle.

"We have only the choice of two alternatives. We must either suppose that Man was created in a civilized state, ready instructed in the arts necessary for the conduct of life, and was permitted to fall back into the degraded condition which we witness among savage tribes; or else, that he started from the lowest grade, and rose toward a higher state of being, by the accumulated acquisitions in arts and knowledge of generation after generation, and by the advantage constantly given to superior capacity in the struggle for life. Of these alternatives, that which embodies the notion of continued progress is most in accordance with all our experience of the general course of events, notwithstanding the apparent stagnation of particular races, and the barbarism and misery occasionally caused by violence and warfare. We have witnessed a notable advance in the conveniences of life in our own time, and, when we look back as far as history will reach, we find our ancestors in the condition of rude barbarians. Beyond the reach of any written records we have evidence that the country was inhabited by a race of hunters (whether our progenitors or not) who sheltered in caves, and carried on their warfare with the wild beasts with the rudest weapons of chipped flint. Whether the owners of these earliest relics of the human race were speaking men or not, who shall say? It is certain only that Language is not the innate inheritance of our race; that it must have begun to be acquired by some definite generation in the pedigree of Man; and as many intelligent and highly-social kinds of animals, as elephants, for instance, or beavers, live in harmony without the aid of this great convenience of social life, there is no apparent reason why our own race should not have led their life on earth for an indefinite period before they acquired the use of speech; whether before that epoch the progenitors of the race ought to be called by the name of Man or not.

"Geologists, however, universally look back to a period when the earth was peopled only by animal races, without a trace of human existence; and the mere absence of Man among an animal population of the world is felt by no one as repugnant to a thorough belief in the providential rule of the Creator. Why, then, should such a feeling be roused by the complementary theory which bridges over the interval to the appearance of Man, and supposes that one of the races of the purely animal period was gradually raised in the scale of intelligence, by the laws of variation affecting all procreative kinds of being, until the progeny, in the course of generations, attained to so enlarged an understanding as to become capable of appreciating each other's motives; of being moved to admiration and love by the exhibition of loving courage, or to indignation and hate by malignant conduct; of finding enjoyment or pain in the applause or reprobation of their fellows, or of their own reflected thoughts; and, sooner or later, of using imitative signs for the purpose of bringing absent things to the thoughts of another mind ?"

The First Book of Botany. By Eliza A. Youmans. New edition. D. Appleton & Company.

A school-book which declares itself to be little else than a finger-board, pointing to something else to be studied, and which is designed to avoid lesson-learning and to break up school-routine, is certainly something unusual in the educational world, and we might suppose from all analogy that it would meet with little favor. Yet such are the character and object of the "First Book of Botany." It was prepared, not to enable the pupil to memorize a certain amount of information about the vegetable kingdom, but to put him in the way of training his observing powers by the actual, systematic study of plants themselves. It is a hand-book of guidance in the work of observation. It is an encouraging sign of improvement in methods of instruction that a book so thoroughly constructed on this plan should still not be a day ahead of the time. Its prompt and extensive adoption by the Boards of Education in many cities is an encouraging evidence of progress in the art of elementary teaching. The work has been reprinted in England, and is reviewed in the *Pall Mall Gazette* by Prof. Payne, of the College of Preceptors, under the title of "Botany as a Fourth Fundamental Branch of Study." He says:

"This book is so remarkably distinguished from the ordinary run of school-books that no apology is necessary for calling the attention, not only of teachers, but of all who are interested in education, to its pretensions and merits. Too many school-books, professedly compiled for the use of children, are really fit only to be hand-books for the teacher or the adult scientific student. Abounding with definitions and abstractions which presuppose a knowledge of the facts on which they are founded, they tend to quench rather than quicken the dawning intelligence of the child. These abstractions, though called *principia* or beginnings, are, in fact, such only to the mind already trained in deduction. Induction, on the other hand, appears to be the only possible method that a child can employ in gaining a real knowledge of principles. We may, of course—and we usually do—cram him with those intellectual boluses called definitions and rules, in the hope and belief that some time or other he will digest them; but we also very commonly—and here is the absurdity of our plan—leave this process of mental digestion to chance, instead of regarding it as the end to be secured by the training of the teacher. Thousands of children carry about with them this crude, undigested matter, throughout the whole of their school-life; and, if it is ever assimilated and appropriated by the mental system, it is after school-life is over, and the youth takes his education into his own hands and begins it anew. Holding, then, as we do, that the primary aim of all teaching should be the quickening of intellectual life in the pupil, and trying school-books generally by this test, we cannot but pronounce the great mass of them to be hinderances rather than helps to the object in view. They are hinderances and not helps, whenever they supersede the action of the pupil's own mind on the facts which they describe. In matters of science especially, the facts, the concrete things, are the true teachers, and should be allowed to impress their lessons by direct contact—without any foreign intervention—on the mind of the learner. These lessons gained by the authoritative teaching of facts will necessarily be productive of clear, definite, and permanent impressions, and must, therefore, be far more valuable than those given by the conventional bookmaker on his own authority. We go further, and maintain that the principle we have suggested furnishes a true test of the suitability of any given subject for elementary instruction, which, as we believe, should be confined in its earliest stages to those subjects in which the pupil can gain his knowledge at first hand from facts within his own cognizance. If, therefore, as has been declared by good authorities on the subject, that kind of teaching alone is effective which makes the pupil teach himself, it is obvious that elementary education should consist in eliciting the native powers of the child, and make him take an active share in the process by which knowledge is acquired; in setting him forth, in short, however young, on the path of investigation. The implicit reception of truths gained by the observation and experiments of others is, as things are, often unavoidable in the case of the adult man, presumed to be already educated, but is antagonistic to educational training, which consists in the development and direction of the native intellectual forces of the child.

"This conception of the nature and power of education has been firmly grasped and exhibited with remarkable skill by the author of the little book now under notice, which is expressly designed to make the earliest instruction of children a mental discipline. Miss Youmans, of New York, presents in her work the ripe results of educational experience reduced to a system. Wisely conceiving that all education—even the most elementary—should be regarded as a discipline of the mental powers, and that the facts of external Nature supply the most suitable materials for this discipline in the case of children, she has applied that principle to the study of botany. This study, according to her just notions on the subject, is to be fundamentally based on the exercise of the pupil's own powers of observation. He is to see and examine the properties of plants and flowers at first hand, not merely to be informed of what others have seen and examined. His own observation, resulting in the perception for himself of form, color, interrelation of parts, likeness and unlikeness, etc., is to be the *primum mobile* of his whole course of learning. His own examination and investigation of phenomena, his own reasoning and judgment on discovered relations, are to constitute the process by which he learns not only the facts and phenomena of botany, but also the use of his mental faculties. Inasmuch, moreover, as the phenomena that he observes are coördinated in Nature, the process becomes one not only for acquiring separate facts but organized knowledge, and, therefore, a systematic training in the art of observation. 'This plan,' Miss Youmans remarks, 'first supplies the long-recognized deficiency of object-teaching by reducing it to a method, and connecting it with an established branch of school-study. Instead of desultory practice in noting the disconnected properties of casual objects, the exercises are made systematic, and the pupil is trained not only to observe the sensible facts, but constantly to put them in those relations of thought by which they become organized knowledge.' It is obvious that a course of instruction which secures such results as these, and which is applicable to the most elementary education, involving not merely the acquisition of sound knowledge, but the systematic training of the mind as a preparation for subsequent studies, literary as well as scientific, is a very valuable contribution to our educational resources. It supplies 'that exact and solid study of some portion of inductive knowledge' which is pointed out by Dr. Whewell (lecture 'On Intellectual Education,' delivered at the Royal Institution) as a want in education, and which would end in a real discipline for the mind by enabling it to 'escape from the thraldom and illusion which reign in the world of mere words.' 'The knowledge of which I speak,' he adds, 'must be a knowledge of things, and not merely of names of things; an acquaintance with the operations and productions of Nature, as they appear to the eye, not merely an acquaintance with what has been said about them; a knowledge of the laws of Nature, seen in special experiments and observations, before they are conceived in general terms; a knowledge of the types of natural forms gathered from individual cases already made familiar.'

"The desideratum here indicated is, we repeat, supplied for the first time by Miss Youmans's plan of teaching botany, which she accordingly proposes as a 'fourth fundamental branch of study, which shall afford a systematic training of the observing powers.' Some may of course question the pretensions of botany to the position here claimed; but it will be found more easy to object than to propose a substitute.

"It may, however, with better reason, be objected that the study of a descriptive science like botany, which is founded essentially on observation, fails to elicit the inventive and constructive faculties of the child, and to secure that training in the experimental knowledge of the action and reaction of forces, cause and effect, etc., which constitutes the method of scientific investigation. We should, therefore, suggest, as equally, or almost equally, suitable for elementary instruction (see Edgeworth's 'Practical Education,' and 'Harry and Lucy'), a collateral or supplementary training, similar in spirit and plan to Miss Youmans's in experimental mechanics founded on the phenomena of mechanical action. Botany for observation, mechanics for experiment, would complete that foundation of nature and fact on which technical education, if it is to be a reality and not a pretence, must be ultimately based."

MISCELLANY.

THE NATURE OF DISEASE. BY SIR WM. W. GULL, BART., M. D., F. R. S.[1]

In addressing you this evening, gentlemen, I have in some sort to throw myself on the forbearance of the Society, for, though I have been able to bring certain ideas together on the subject on which I desire to speak, I have not, for want of time, been able to adopt a form of words such as I would have liked. In some sense I am the spokesman of the Society as its President, in especial when laying before the public the objects of the Society as I would now do.

We, in our calling, differ from some theologians in one important respect: they look on this world as a decaying world, as much worse than it once was; we, as students of Nature, are opposed to this view, for, if we look to the history of Nature, we see we are ever advancing toward perfection, even if we are not likely to reach it. This is an improving world, and we are met to advance that idea. We believe that this world has something better in store for all than any thing which has yet been seen, and are like to the convalescent, whose last day should always be the very best he has ever spent. Some men are apt to think that science has certain limits set to it, beyond which no man may go; but we believe that knowledge extends far beyond the strictly scientific limit. Doubtless, were the early lower animals assembled together in conclave, they would conceive it quite impossible to transcend their status; that when the world came to megatheriums, let us say, then it must stop. They could not conceive the possibility of such a being as man. But at this point we join the theologians again in accepting a metaphysical element, in forming conceptions of things of which we can have no positive knowledge. In this way we may be said to worship Nature, but only in a very limited sense. We look upon our being, not as perfect, but as becoming perfect, and we are here to-night —and at all times have it as our object—to improve these defects of Nature, and to endeavor to perfect the human frame.

Respecting the object we work for—this living organism of ours—one great advance has of late been made. We are acquiring a physiological notion of disease. Disease is no entity; it is but a modification of health—a perverted physiological process; and this must at all times be insisted upon. Were it not that we fear death, and dislike pain, we should not look upon disease as any thing abnormal in the life-process, but to be as part and parcel of it. Few would now venture on a definition of disease; for in reality it is but the course of Nature in a living thing which is not health. In health the balance of function is even; incline it to either side, and there is disease. That being so, just as the life-process constitutes an individual and puts him apart from his fellows, so must any alteration in it be individual, and not general. But to the ignorant disease is an entity—an evil spirit which attacks us and seizes us. Hence arises the word "seizure," which, though in a somewhat different way, we still use, but with a protest. To the charlatan, disease is a set of symptoms to be attacked by a variety of drugs—a drug for each symptom. To us, disease is a life-process of a perverted kind.

Many states are not now called diseases which used to be, and there are still some to be expunged. Some people are always ailing. Some have feeble stability, and to them it is as natural to be ill as it is to others to be well; but this is not disease. So, too, aged persons get ill; but this is not disease—in reality, it is natural change simulating disease, and, when we try to cure such, we use all the farrago of the chemist's shop to prevent the sun setting. So syphi

[1] Remarks before the Clinical Society of London.

lis at last ceases in the system to be syphilis, and becomes an early decay.

It is curious to consider the various morbific agents at work within our bodies, the lines in which they work, and their seats of action. These as yet have been but little studied, and deserve attention. Thus, it is very doubtful if scarlatina begins in the blood, as we should all be apt to say, rather than in any other tissue or fluid. Let it be our object to find out where all these begin within the body, and how they enter the body. In future, I hope, comparative pathology, which is just beginning to be studied, will teach us much; for in our bodies we men have many organs which are of little or no use to us, and are only relics of a former state of being. What, for instance, is the comparative anatomy of tonsils? Were I to make a man, I do not think I would put tonsils in him. Yet these, and such like organs, in accordance with the general law, are more prone to disease than are the others which are of real use in the system. I remember the case of a man who had a permanent vitelline duct. He had been out on a cold day, and the motion of the intestines twisted them in a mass round this persistent duct, and he died. I made a preparation of the duct, and wrote under it, "Cui vitam atque mortem dedit diverticulum." Every part of the body is alive, and has its own individual life and pathology, whether it be immediately required or not; only, if not required, it is more prone to disease than if it were. I could, for instance, suppose a fœtus of four months going to the doctor and saying: "I am going all wrong; my Wolffian bodies are disappearing, and kidneys are coming in their stead." Yet that is as much a condition of disease as some of those conditions of which I speak.

It is of the utmost possible importance, then, to be able to tell what we have and what we have not to cure. How often do we find people trying to do what is impossible! Some women have no more vital capacity than a canary-bird; they are constantly ill, and it is useless to attempt to make them well. A man came to me, and said: "I don't know what to do with So-and-so. I have given her every thing I could think of, and she will not get strong." "Why," I said, "you have been trying to put a quart into a pint pot. You cannot make her strong, and never will."

So, when a new instrument or mechanical means of diagnosis is introduced, we must try to make ourselves masters of it, so as to be able to use it aright, even though this is troublesome to ourselves; only we must beware of applying the knowledge thus acquired too early to practice. Thus, as regards the thermometer, doubtless it yields us most valuable information, but we must beware of using it as a guide to our treatment until we have a more complete knowledge of the condition of bodily temperature.

But after the physical comes the vital diagnosis. It is well to know exactly what is the condition of each part of the system; but to what is the wrong due? That no weighing or measuring can give you—only experience. A man has pneumonia—that is a too vague fact; what are the dynamics of the disease? One man with a pneumonia will get rapidly well and be right again in a few days, whereas another man will not get well at all. So, in different individuals, a form of disease apparently the same may be different from the beginning, and this we cannot always make out in our diagnosis, especially in internal disease. In skin-diseases we can do better.

During the last week I had been called on, as most of you know, to form a diagnosis of the workings of the mind. Here the break-down may be the first sign of the diseased condition, just as it may be in heart-disease, peritonitis, and a score of other diseases. A man, after racing up a hill, finds himself breathless and spitting blood. He comes to you, and you find heart-disease. It does not mean that the heart-disease was produced by running up the hill; it only means that an organ, equal to its ordinary duties, failed when unusual stress came to be laid upon it. So is peritonitis often the result of disease previously latent, but brought on by exposure to cold, or some such agency. Some men say that such cases as those of doubtful sanity should not be taken up by us—that ordinary men are quite as well fitted for finding out the truth as we are, with all our training. If so, all I say is, that it is no honor to us that it is so.

Now, therapeutics is the end, though the study of diseased conditions might be pleasant enough by itself. We are sometimes twitted with letting Nature alone to do her work. We do not. And here, again, we join issue with the theologians. They say, "If it is God's will that a man die, so be it." But, say we, "God's will is to be found out; it is not a mere fate." We are not ignorant worshippers of Nature, and, whether a man is doomed to die or no, we know only by the result. We are connective agents. We have to adjust and correct. We know the tendency to recurrence to the equilibrium—that is, health—and we endeavor to assist in adjusting this balance in each individual.

In fever, for instance, two things are promptly at work—destructive changes, and changes tending to recovery. In such diseases there are certain superficial accidents which we are apt to notice. In fever there are often complications; but these are really part of the fever-process, and are not to be interfered with by themselves. Our study must be, how best to bring the condition to a safe ending; for a patient in fever may get well of the fever, and yet die of a bedsore.

In conclusion, if I have spoken more as regards medicine than as regards surgery, I think the surgeons ought to be indebted to me for hints toward the extirpation of superfluous organs—a grand prospect for the surgeons of the future.—*British Medical Journal.*

SOUTHERN ALASKA.

The following statements are from a paper entitled "Medical Notes on Alaska," by W. T. Wythe, M. D., read before the Sacramento Society for Medical Improvement, and published in the *Pacific Medical Journal:*

The country is very mountainous; lofty peaks, clad with snow throughout the year, being everywhere visible. One mountain-chain, identical with the Sierra Nevada and Coast Range of California, extends along the coast, through the Alaskan Peninsula and the Aleutian Islands; another chain, the continuation of the Rocky Mountain system, extends across the country to Behring's Strait, and, passing under the sea, is said to reappear in Asia. Between these two mountain-chains lies an immense valley, drained by the Youkon, a river nearly as large as the Mississippi, and which Dr. Dall has well described in his work on Alaska. These mountains, with their numerous branching chains and foot-hills, cover the whole country with impassable barriers. Among them lie many valleys, where, during the few days of summer, some vegetation can be seen, and it is here that the natives live; sometimes, however, a glacier will encroach upon the valley, or an avalanche of snow and rocks from the neighboring hills fill it up, or in spring a flood overflow it. In these inhabitable spots there is but little soil; all the vegetation seems to spring up in the peat-bogs, which are found everywhere except on the mountains. In these bogs, when sheltered from the winds, many kinds of trees will grow, but they are almost totally worthless. Grass grows very rapidly during the warmer days of summer, and sometimes attains a height of five feet. For agricultural purposes the territory is worthless.

The climate of the interior of Alaska is very different from that of the coast. Along the coast the average temperature is about 40° Fahr. during the year, while on the other side of the mountains it is many degrees lower. The coast is very foggy and damp. The rainfalls are very frequent, and it is subject to very severe storms of wind. At Sitka, it is said that for a number of years past the number of days during the year when it did not rain or snow, has been thirty-five. In the interior the climate is very cold in winter, and in summer somewhat warmer than on the coast. There is but little rain or fog. Snow falls to a great depth, and I have seen the ground frozen thirteen inches below the surface in midsummer. The cause of this peculiar climate, and of the difference of average temperature on the coast and the interior, is the same that modifies the whole Pacific coast. The Japan current, which brings the warm waters of the southeast shores of Asia, is undoubtedly the principal agent in controlling the climate of the northwest coast of America. From the Aleutian Islands to Sitka the whole coast is bathed by this "Pacific Gulf Stream." In addition to this current, the winds have a share in influencing the climate. Along the coast the prevailing winds are from the southwest, and are decidedly warmer than from any other quarter, having been warmed in passing over the Japan current.

There are four principal tribes in Alaska, each having distinct manners and customs: 1. The Koloshians, who dwell along the south coast, and are found as far north as Cook's Inlet. They are tall and powerful men, very savage and warlike; during the Russian government they were very troublesome, and even now are the terror of the northwest coast. 2. The Aleutians, who live on the islands, are short of stature; their almond eyes and peculiar features proclaim their Mongolian origin. They are fishermen, and travel long distances in their skin bydarks or canoes. Among the many facts which prove their Tartar descent, is the remarkable one that the inhabitants of Attou, the most westerly of the Aleutian Islands, speak a language so nearly like that of the Corrile Islands on the Asiatic coast, that they need no interpreter between them. 3. The Kenaians, who live on the main-land, are tall and powerful men, nearly as white as Europeans. They are hunters, and live by trading. They are peaceful, but not cowardly, as the Alutes are, and are able to defend themselves from the Koloshians. 4. The Esquimaux are found on the north coast. Many of the Aleutians, who have been partially civilized by the Russians, live in log huts, and clothe themselves as white people do; the majority, however, dress in skins, and live in holes which they dig in the ground, and cover with a sort of hut of logs. Civilized and uncivilized, all display great ingenuity in making their houses air-tight; every crevice through which the cold wind could enter is closed, and the walls are lined with moss. In these huts, not more than ten feet long and ten wide, half a dozen people will live; day and night they keep up a large fire, until the heat and odor are more than a white man can endure. The filth of these houses is indescribable. During the Russian administration the natives were obliged to bathe once a week in the steam-bath, which was erected in every village. Uncle Sam's advent put an end to this tyranny, and now each man is free, and remains as dirty as he pleases. The food consists of fish dried in the sun, and, when they can get it, black bread and tea.

The diseases of the northwest coast are modified by, and in many cases owe their origin to, the peculiar topography of the place and its climate, whether it is that of the coast or interior. In the damp, cold climate along the ocean, where the winds blow the greater portion of the time with great violence directly from the sea, disorders of the respiratory organs are the most frequent. Bronchitis is never absent; catarrh is seen at every change of weather. Sudden changes, when they are severe, often produce a catarrhal fever or influenza, with more or less bronchitis. Pneumonia often occurs, and seemed in sporadic cases to assume a typhoid type. During a few days of unusually warm weather, an epidemic of bilious pneumonia made its appearance at Kodiak, attacking about fifty of the natives. The treatment consisted in opening their doors and windows so as to admit air, attention to the police of their houses, and quinine. Rheumatism is very obstinate, and occurs very often, and generally takes the articular form. Tuberculous diseases are very common among both natives and whites, and occur most frequently among the half-breeds. Phthisis pulmonalis runs a fearfully rapid course. Skin-diseases are much more frequent than in the interior; eczema, especially, is often seen, but yields readily to treatment. Syphilis, in all its forms, seems to be found everywhere on the coast, and, most of all, in places where the whites have traded longest; it is slowly but surely killing all the natives of the northwest coast.

In the interior, rheumatism and bronchitis seem to be the prevailing diseases. On Cook's Inlet I met with a number of cases of intermittent fever: all occurred on a bluff several hundred feet above the sea, and where the houses were exposed to a strong breeze directly from the inlet. These cases were among white people, and might have been contracted elsewhere; but, happening after a sea-voyage of forty days, and in persons previously in good health, I attributed it to the locality. Scurvy also appears frequently in the interior, caused by lack of vegetables and fresh meat, and faulty hygiene. The long nights of that high latitude, the excessive cold and deep snow, and the lack of antiscorbutics, render it difficult to keep large bodies of men entirely free from this disease.

The value of the country may be summed up thus: Its fur-bearing animals are numerous and valuable. There are large and valuable banks of codfish among the islands, and St. Paul and St. George Islands contain fur-seals enough to give to the monopoly having possession the control of the market for that article throughout the world. Beyond this, nothing valuable has been found as yet.

HINTS ON HOUSE-BUILDING.

The great object of sanitary legislation is to secure for each individual the greatest amount of fresh air, pure water, sunshine, and dryness of soil. Public sanitation in towns should provide for width of streets, paving, the removal of fluid and solid nuisances, open places for the circulation of air, and recreative resorts for the inhabitants. The width of streets is important in relation to the height of the houses. The width should never be less than the height. The healthiest sites for dwelling-houses are known to be those on trap, granite, and metamorphic rocks, where water readily escapes, and the soil, and consequently the air, is dry. Cholera is rare in houses on such sites. Permeable sandstone, gravel, and chalk, if unmixed with clay, are also healthy. Sands which contain organic matter, clay, and alluvial soils, are always to be suspected. Thorough draining, both subsoil and surface, is a necessary preliminary to building. Dampness of ground necessitates dampness of air and of the walls. This causes chemical alteration in the organic materials in the houses, with absorption of oxygen and discharge of other gases; it favors, too, the growth of low animal and vegetable organisms, which poison the air of the dwellings, and produce disease. The decomposition of the organic contents of the soil is hastened by its dampness, and especially by rapid alterations of its hygrometric state. Calcareous stone is best; some sandstone is so porous that, though dry to-day, it may be soaked with damp to-morrow. Houses should never be built on ground filled up with ashes and other *débris*. The large amount of organic matter contained in it, which is freely exposed to the action of the air and moisture, becoming decomposed, must cause poisonous emanations, destructive to those who, living above, must breathe it. The drainage and other pipes laid in this soil are extremely liable to be entered by these poisons, and thus they are conducted into houses directly. Frequent sweeping and washing are necessary in every house. Dust is not alone unpleasant, but it is a fruitful source of disease—perhaps the most so. The dust of curtains, carpets, papers, and other colored substances, consisting of organic and coloring matter, being swallowed with the food and inhaled, causes many a doctor's visit. Every house should have a kitchen and wash-room distinct from the dwelling-rooms. The latter should be large enough to allow of each inhabitant obtaining 10½ cubic feet of fresh air per hour, when doors and windows are shut. Each house should have abundance of good water for drinking, cooking, and washing, including bathing: five to six pints per day should be allowed for drinking, at least 18 gallons for washing, and eight to 10 should be used daily to flush the sewers. Sick people require more: from 40 to 50 gallons daily. Water-closets consume various quantities, according to their construction. The nature of the closet and the method of removing the contents have become one of the most important questions which advancing civilization has created. The dry-earth system is quite inapplicable to large towns; it suits private houses of the rich or jails well. The Goux system is equally unsuitable. The water system, where there is a plentiful supply of water, is infinitely the best and the cheapest. A sufficient fall of ground can nearly always be obtained. The improvement of the dwelling-house and the establishment of comfortable homes, worthy of human beings, is a necessary duty of the state, and a noble work for the philanthropist. These necessary conditions may be advantageously supplemented by a little comfort and elegance. A little garden is a civilizer of great power.—*The Builder*

CONCERNING CROOKES.

As relates to the claims of this man as a scientific discoverer, a writer in the *Engineering and Mining Journal* says:

"Mr. Crookes, whose accounts of experiments with the 'Psychic Force' have been severely criticised at home and in this country, replies to a personal attack by Dr. Carpenter in a pamphlet which is attached to the last number of the *Quarterly Journal of Science* of which Mr. Crookes is editor. Dr. Carpenter's article (published in the *Quarterly Review*) was certainly a savage assault; and the style of Mr. Crookes's reply is calculated to win the sympathy of the reader. We have not entered the debate upon Psychic Force, and we do not care to express an opinion concerning the furious personalities into which it has degenerated But we lost confidence in Mr. Crookes a good while ago; and in this last vindication of himself he has repeated the offence which dishonored him then in the eyes of all who were familiar with the facts. These we shall briefly recapitulate:

"1. The discovery of sodium-amalgam and its uses by Prof. Henry Wurtz, of this city, and his application for a patent for the invention was swiftly followed by a similar invention by Mr. Crookes, in London, which led to a discussion of the question of priority and originality.

"2. In this discussion, all the dates of announcement, application, issuance of patent—in fact, the whole of the circumstantial evidence—were in favor of the American chemist. Mr. Crookes was on the defensive throughout; he never breathed the suggestion that Prof. Wurtz got the idea from *him;* on the contrary, he attempted to remove the very natural suspicion that he received the hint of it, at least, from the American Patent-Office, through some one of the spies, who, it is well known, make a business of sending to England information of new discoveries to be patented there (according to the lovely British law) by the 'introducer' without reference to original authorship. We repeat that Mr. Crookes rested on his own solemn declaration that this was not the case with the sodium-amalgam patent; that the instance was one of independent, simultaneous discovery, not unknown in the history of science. This declaration of Mr. Crookes was accepted, in view of his respectable standing, as conclusive; and certain curious coincidences between his specifications and the earliest papers filed at Washington, by Prof. Wurtz, were ranked as accidental.

"3. A year or two later, Mr. Crookes published a translation of Kerl's 'Metallurgy,' and in the chapter on silver introduced a flattering description of Crookes's Sodium-Amalgamation Process. No allusion whatever is made to Prof. Wurtz in the book. This is brazen enough; but worse remains behind. A letter in the San Francisco *Mining and Scientific Press;* an address by Prof. Silliman before the National Academy of Science at Washington; an account of experiments at Tulare County, California, published in a San Francisco paper; and an account of experiments in Colorado, given in this paper (then the *American Journal of Mining*), are all quoted as referring to Crookes's process, whereas they all referred to the process patented in this country by Prof. Wurtz. Some of these documents, indeed, contained his name, which Mr. Crookes deliberately avoided quoting.

"4. We branded this piece of dishonesty as it deserved, more than three years ago; and we have never seen or heard of any 'vindication' from Mr. Crookes. And now, in his reply to Dr. Carpenter, he proudly alludes to his discovery of sodium-amalgam, extensively used in Australia, California, etc., as one of his claims to the respect of scientific men. The psychic force of 'a lie, well stuck to,' is proverbial; but it will not work in this case, across the Atlantic Ocean. We do not accept any statements whatever, on the authority of Mr. Crookes, until he has confessed and atoned for the outrage we have now for the second time exposed.

"It is quite immaterial whether he did really discover sodium-amalgam; it is immaterial that the discovery is of no great practical value, and that the process is *not* in general use anywhere, and has long been abandoned in this country. Our charge is not against the originality or the value of Mr. Crookes's 'invention;' it affects directly his conception of truthfulness and honor, his claims to belief as a witness and to respect as a man. According to our notions of the brotherhood of science, its members always confide in one another's sincerity and good faith. A person who cannot be trusted so far is, *ipso facto*, not a member."

NOTES.

Mechanism of Thought.—An important paper was read at the last meeting of the Medico-Chirurgical Society of London on this interesting but very complicated subject, by Dr. Broadbent. His theory was based partly on the results of his own dissections, partly on remarkable cases of loss of speech and paralysis that either came under his own notice or have been recorded by others. The chain of physical actions which he claims to be implicated in the process of thinking, can only be followed in detail by the anatomist; but the general sequence of events on this theory is: the formation of ideas in the marginal convolutions at the summit of the sensory tract; the employment of these in trains of thought in the convolutions withdrawn from immediate relation with the outer world; the propagation of excitations to the third left frontal convolution, leading to the selection of certain sound-groups; the coördination in the corpus striatum of the muscular movements required to produce those sounds; and, finally, the transmission of impulses from the several nuclei of the medulla oblongata to each individual muscle required to be brought into play.—*Academy.*

Aërial Navigation.—Dupuy de Lorne gives a brief account of an aërial journey made by the author in company with fourteen others in a newly-constructed air-balloon, and machinery for imparting to this balloon and the car thereto attached any desired direction or motion, independent of that which the wind or air-currents will give to the balloon. The experiment has proved a complete success in every respect; a speed of 50 kilometres (31.065 English miles) per hour could be readily obtained.

Prof. Ehrenberg, who has published from time to time the results of his examination of those microscopic bodies that are carried by the atmosphere and deposited as substances of a red color, has collected all the observations on this subject made by him between the years 1847 and 1870. This important memoir, consisting of 150 pages, two tables, and two plates, will appear in the forthcoming volume of the Transactions of the Berlin Academy for 1871. He enumerates all the instances of this phenomenon which have been placed on record; the earliest being a case of dust-shower which fell for ten days in the Chinese province Honan, in the year 1154 b. c. As his examination was directed chiefly to organisms contained in the showers, the analysis was entirely microscopical, not chemical. The number of analyses made by himself is altogether 70, and he was able to distinguish not less than 460 distinct forms of organic life.—*Academy.*

If there were any reasonable question of the value of vaccination as a preventive of small-pox, strong evidence in its support is furnished by the circumstance of an epidemic now prevailing in the Island of Jersey. It appears that, of 39 persons comprising all who were attacked with small-pox in the small town of Gorey, but five had ever been vaccinated. Six of the 39 died, and but one of these had ever been vaccinated. At last accounts, the epidemic was rapidly spreading, and under very favorable conditions it would seem, for investigation has shown that at least one-third of the children under 15 years of age in the whole island are unvaccinated.

Nitrate of Ammonia in Respiration.—Dr. Struve states that, by breathing for some moments in a large-sized beaker-glass previously moistened with water, and next rinsing the glass with some pure distilled water, this liquid will be found, by the usual tests, to contain ammonia and nitric acid. This formation of nitrate of ammonia is stated to become increased after dinner has been taken. The author is of opinion that atmospheric nitrogen is not entirely passive in the process of respiration, but it should be observed that this opinion is contradicted by the direct experiments of Drs. Regnault and Reiset.—*Chemical News.*

Dr. Livingstone's safety is not yet despaired of by his brother, Mr. Charles Livingstone, her Majesty's consul at Fernando Po. This gentleman is no stranger to Africa, having been long resident on the west coast, and travelled much about that portion of the continent. He is stated to be confident that the doctor will, in the course of a few months, reach the seaboard at or near Zanzibar, and to hold the fact of the opening up of a new river on the west coast, between Opobo and New Calabar, to be a proof that Africa, even there, is only imperfectly known. —*Lancet.*

Since attention has been directed to the subject, cases of lead-poisoning, traceable to the use of hair-preparations containing lead, are found to be very frequent. A case of this sort was recently reported in the medical journals, which was at first mistaken for muscular rheumatism, and treated as such, with but slight amendment. Paralysis of the extensor muscles of the fingers and hands, with "wrist-drop" coming on, the true nature of the affection was seen, and its cause readily found in the frequent use of a hair-renewer containing a large proportion of sugar of lead. No lines were seen upon the gums, but attacks of colic had been frequent. Discontinuance of the hair-dressing, and a resort to the ordinary remedies, soon effected a cure.

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ON THE ARTIFICIAL PRODUCTION OF STUPIDITY IN SCHOOLS.

IT is related of a learned judge, that he once praised a retiring witness in the following words: "You are entitled to great credit, sir. You must have taken infinite pains with yourself. No man could naturally be so stupid."

We cite this well-worn anecdote because it contains, probably, the earliest public recognition of the principle which the title of our article is intended to convey. Existing in all ages of the world, in all conditions of life, and described by a copious vocabulary in every language, stupidity is something which it has never been possible to ignore or to forget. The fact of its all-pervading presence, its vitality in the most different climates and scenes, has tended to convince mankind of the necessity of an evil which they have never failed to perceive; and which has served, from time immemorial, as a subject for the lamentation of the wise, and a basis for the calculations of the designing. The lessons of proverbial wisdom, the results of hasty generalization, and the daily experiences of life, all point out, or seem to point out, that stupidity is inseparable from the existence of the human race; and that it must appear, not in every individual, but in many individuals of every community. It follows that the persons in whom the phenomenon is most conspicuously manifested are regarded with something of the compassion which attaches to physical infirmity; and enjoy, in a certain degree, the power of blundering, with the privilege of being exempt from punishment.

We have long entertained a conviction that this passive acquiescence in stupidity, as an ultimate fact of human nature, and this confident expectation of its unmitigated recurrence in each succeeding generation, are founded upon errors of considerable practical importance. By directing attention to causes that are remote, they induce forgetfulness of those which lie at every man's door; and, by bringing into prominence the stupidity which is irremediable, they lead us to neglect examination of that which may be prevented.

In truth, the varieties of hebetude are numerous. It must be admitted that some of them are displayed by persons whose intellects are obscured by organic defect, "native and to the manner born," in the nervous apparatus—by continuing deficiency, or excess, in the composition or quantity of the circulating fluid; and it is probable that, in many cases of this nature, the scalpel, or the microscope and test-tube, would fail to disclose the cause of the infirmity. Inherited diathesis, or hereditary disease, may doubless weaken the faculties of the mind, as they evidently weaken the physical powers of the body, and may produce effects varying in degree from idiocy to mere dulness of apprehension. We are far from saying that in these instances stupidity can neither be alleviated by judicious, nor confirmed by improper treatment; but we indicate them as affording a substratum of truth to popular prejudices touching the general invincibility of the state in question, and as giving evidence of its centric rather than eccentric origin.

But leaving this subdivision of the stupid entirely out of consideration, and remarking, by-the-way, that the word stupidity is misapplied when used to denote the mere absence of brilliant talent, we would call attention to the large class of persons who are dull and obtuse, not by reason of any probable congenital deficiency, nor by an unfair comparison with great wits or geniuses, but by comparison with what the individuals themselves clearly ought to be—with what they would have been had their faculties been developed in the right way. And this comparison is not so difficult as it may appear; for the simple reason that the human capabilities do not greatly depart, save in exceptional cases, from the standard of mediocrity. Among a score of men taken at random, but approaching to equality in point of conformation, we may observe that physical strength or endurance will vary only within very narrow limits: there being perhaps a single athlete, or a single weakling, and a remainder composed of individuals whose powers are not precisely on a level, but nearly so.

Let us suppose, however, that among the twenty men there were a certain number who had been employed from their early years in pursuits calculated to produce muscular vigor and hardihood, and who had observed all rules and precautions likely to insure to such pursuits their most favorable effects. It is certain that, whatever differences might exist among themselves, these men would surpass all their competitors. Bendigo, the champion of the prize-ring, was one of a triple birth, and was the weakliest child of the family in which, by reason of diligent training, he became the strongest man.

So universally has this principle been recognized and acted upon, that in every barbarous or half-civilized community, or under all circumstances which give an unquestioned superiority to bodily strength, we may find evidences of special care to foster and increase it. The "games" obligatory upon the little Spartans, the exercises of "gentle youth" during the age of chivalry, the description given by Mr. Catlin of the early training of the American aborigines, are all instances in point; and all show the recognition, under circumstances widely dissimilar, of the principle that the powers of the human organism are bestowed only in possibility—to be developed by culture, or to dwindle under neglect.

The state of physiological knowledge permits us to lay it down as an axiom that what is true of one system or apparatus, among those given to man, must also be true, *mutatis mutandis* (the necessary changes being made), of the rest. Without in the least degree failing to perceive the dependence of the higher faculties upon a spiritual nature, we must also perceive their dependence, during this life, upon the qualities of their material organs, the nervous centres; and the dependence of these qualities upon the laws which regulate nutrition and cell-growth. We are therefore entitled to assume, *a priori*, that, precisely as the methods of the trainer raise the physical powers of his disciples to the highest point attainable by each organism, so analogous methods would raise the intellectual powers in the same manner and degree. The conclusion which may be formed by reasoning is not unsupported by experience; but the masters of the art are few, and the examples of their skill are rare.

In an age of bodily repose, with nearly all locomotion artificial, with money as the principal purveyor, it is not surprising that men are careless about their physical powers, and think them hardly worth the trouble which their full cultivation would entail. Under circumstances in which strength of arm and fleetness of foot have afforded the chief sources of security, or have opened the most direct paths to renown, there has never been an approach to indifference about the means by which these qualities might be attained. If physical education be now almost wholly neglected, it is because the utility of its results has been diminished by the progress of civilization.

But this age of bodily sloth and weakness is also, it must be remembered, an age of intellectual activity and strength. The wide diffusion of knowledge, the facilities for travel, and the application of philosophy to the comforts and conveniences of life, have increased a thousand-fold the value, to each possessor, and to the whole human race, of the perceptive and conceptive faculties of the mind. Every one who observes the facts within his sphere, and reflects upon them, may find the key to some, as yet, unopened door in the temple of Nature, or may excogitate results calculated to increase the happiness of man. The career that offers itself to the intellect surpasses immeasurably all that has ever been offered to the corporeal powers; and it might, therefore, reasonably be expected that intellectual development would be the subject of the same foresight now, which the development of the corporeal powers was wont to call forth in former days. It might be expected (although strength and activity of limb are left to come of themselves, under the unaided influence of that playful restlessness of the young which provides against muscular atrophy) that the training of the higher faculties of the mind into due vigor and perfect symmetry would be carefully studied as a science, and diligently practised as an art. It might be expected that the mechanism of observation and of thought, the nature and order of the processes by which, chiefly, wealth, and power, and fame are to be acquired, would be the subjects of an attention corresponding to the degree in which wealth, and power, and fame are prized. It might be expected that every one—the poor man to the extent of his means, and the rich man to the extent of his knowledge—would seek to confirm and strengthen in his offspring the qualities by which the world is ruled.

That the endeavor would not be fruitless, we have abundant evidence. Reasoning from an analogy which cannot fail, we find that the human organism scarcely ever approaches, under the influence of casual impressions or spontaneous acts, to any thing like the full measure of its powers. The average athlete is but the corporeal perfection of the average man—a perfection the result of labor, and which the common games of youth or pursuits of manhood are insufficient to produce or to maintain. The most striking example upon record of the physical predominance of one class of men over all others with whom they came in contact, was furnished by the Roman legionaries, in the days of the Roman conquests. It may be explained by the system which trained each legionary like a gladiator; and it disappeared as that system was relaxed and abandoned. The citizens of Rome, as such, could possess no natural superiority over, and in some cases not even an equality with, the inhabitants of the countries they subdued; but the citizens of Rome were trained to the exercises and formed to the discipline of war. Their physical powers were improved to the utmost, and they were inured to every variety of labor, fatigue, and hardship. The world has not witnessed a school of mental education upon a method so excellent, or upon a scale so grand; but the proverbial sagacity of the Jesuits, and the proverbial erudition of the Benedictines, may be cited to show that the mind will respond, always in some degree, and often vigorously, to a stimulus greater than that which is supplied by the usual events of life. It has been well said that Nature throws forth her able men as a salmon does its spawn, but produces her great ones as a lioness does her cub—singly, and at rare intervals. Whenever the want of an able man is felt and acknowledged, it is almost invariably supplied from among a limited circle of lookers-on, one of whom will find in the occasion a means of at once discovering and developing capabilities formerly dormant.

The various persons whose duties have required them to undertake original investigations into the phenomena of physical science have nearly always exhibited a remarkable intellectual growth as one reward of their exertions. They have become more cautious, more sagacious, more diffident than before; and there is not the slightest reason to suppose that they were, in the majority of instances, men of exceptional natural powers. On the contrary, the parallel facts connected with the muscular system, and the remarkable uniformity with which the faculties of reflection and judgment expand and strengthen under proper use, may conjointly be taken to prove that the ordinary life of civilized Europe does not develop either body or mind in a degree at all commensurate with their capacities for action. The cricket-field and the boating-club produce a certain amount of vigor and hardihood; but their most ardent votaries would be exhausted by the pastimes of a savage, or by the daily drill and duty of a soldier of old Rome. From the universities, and from schools of the first order, issue many men unquestionably of high attainments, and some of great and cultivated parts; but the aggregate of both classes may be said to have a point of resemblance to Brummel's finished cravat, and to suggest that a large number of "failures" have been quietly conveyed down-stairs.

In schools of an inferior kind, the attainments of the pupils are less conspicuous; and the existing state of mental education may be summed up in the earnest and weighty words of Prof. Faraday, who declares that, "in physical matters, multitudes are ready to draw conclusions who have little or no power of judgment in the cases; that the same is true of other departments of knowledge; and that, generally, mankind is willing to leave the faculties which relate to judgment almost entirely uneducated, and their decisions at the mercy of ignorance, prepossessions, the passions, or even accident." The same authority says again, that "society, speaking generally, is not only ignorant as respects education of the judgment, but is also ignorant of its ignorance."

It must be conceded, we apprehend, that in the present day no man is called upon to undergo a course of severe physical training, or to exercise the muscular system to the acme of its powers. But it must also be conceded that there have been conditions of society which rendered such training the duty of every one, and in which it was enforced by a public opinion of the most rigid kind. We think that, in the times in which we live, the duty of mental cultivation is at least equally binding, and that its performance requires to be prompted by the same incentive.

For we are convinced that a very large proportion of the stupidity now existing in the world is the direct result of a variety of influences, educational and social, which operate to the prejudice of the growing brain, either by checking its development altogether, or by unduly stimulating the sensorium at the expense of the intelligence. In the former case, general obtuseness is the result; and, in the latter subjugation of the reasoning powers to the sensations or emotions. We are entitled to think these conditions strictly artificial; and to look upon them as distortions, analogous, in some respects, to the physical distortions of Hindoo fakirism.

The educational influence which, more than any other, is concerned in producing them, appears to us to be due to confusion of thought on the subject of those very distinct realities called knowledge and wisdom. While the prevailing weaknesses of the human mind—those apparent to the philosopher, and those also which are manifest to the vulgar—are alike due to want of wisdom, the efforts of ordinary instructors and the general current of the events of life are chiefly valued as they appear calculated to impart knowledge. It is not surprising that such should be the case, a great impulse having been given to education in this country at a time when the operations of the mind were not sufficiently understood to allow of a just discrimination between them.

Moreover, learning was a thing apparent and undeniable, easily perceptible to many who were unable to fathom its depths; while wisdom could only be recognized by the kindred wise, or in a fruition not always directly traceable to its causes. Hence, and in a manner not difficult to comprehend, arose a general impression that the acquisition of knowledge was the principal, or even the only, means of gaining wisdom; and this impression was confirmed by experience of the fact that mental development is frequently coincident with efforts to learn. The exact relation between the two is not easy to define, even with all the aid afforded by recent advances in psychology; but, in former times, it was the opinion of the most advanced educationists, that a certain routine of teaching afforded the best discipline for the growing brain, and that this routine, when aided by good abilities, was certain to produce the highest attainable results—so that men of moderate or inferior performance, who had received "a good education," were considered to be the failures of Nature, and not of the preceptor. The hypothesis was most comfortable, serving to shift responsibility from tutors and professors, and to place it where it was borne without a murmur, while the necessary interval between the schools and life was sufficient to render obscure any possible connection between bad teaching and eventual stupidity.

During the universal prevalence of such principles as these, commenced a movement which was formerly described as "the march of intellect," but which was, more correctly, a march of schooling. Men of various calibre, and various degrees of learning, were cordially united in an attempt to elevate the masses by education. For this purpose they organized a scheme by which to pour forth knowledge like water, and, in carrying it into practice, they spared neither age nor sex. Cheap publications explained every thing—in a manner to be comprehended by everybody. The fathers of England were taught (with diagrams) the philosophy of their daily duties; the mothers, of their household avocations. Even unhappy little children, struggling through the sands of school, were caught and engulfed by the advancing wave. The great and good promoters of the original measure were overwhelmed by the coöperation of innumerable amateurs, who expected to make learning universal, by addressing, to the untaught, condensed statements of scientific results, and who looked forward to a time when the intellectual vigor of the community would be gauged by the reports of the Society for the Confusion of Useless Knowledge, or by the sale of illustrated penny serials, as the material prosperity is at present by the quarterly returns of the Registrar-General. The idea seemed to be, that the diffusion of knowledge would act as a stimulant upon all minds of sufficient natural power, and would call forth their energies—would set them thinking, comparing, judging; and that the rest of mankind, those not vitalized by the potent influence, were to be regarded as unworthy of consideration in a philosophical sense, however formidable in point of numbers.

Notwithstanding the great and sudden illumination to which we have referred, there is no evidence of any remarkable advancement, any increase at all commensurate with the pains bestowed, in that cultivation of mind by which alone knowledge can be applied or rendered useful. The words (already quoted) of Prof. Faraday may be taken as conclusive that the reasoning faculties, in all classes of the community, are very imperfectly and insufficiently developed—imperfectly as compared with their natural capabilities—insufficiently when considered with reference to the extent and variety of information with which they are called upon to deal. We are compelled to seek for the causes of this deficiency in an educational system that makes no adequate provision for mental training; and we think that a brief review of the relations between the nervous centres and the impressions that form the basis of knowledge will enable us to point out the precise nature of the chief errors in existing practice, and to define the principles by adherence to which those errors might be obviated.

The first point to which we would call attention is the existence, in the young of the human species, of a distinctly *duplex* educability, depending upon distinct functions of the brain. It may be taken as conceded, we apprehend, by all physiologists, that the encephalon of man differs from that of other mammalia chiefly by the super-addition of parts whose office it is to control the succession of ideas, and to determine the course of conduct. The powers of *re-collection*, comparison, reflection, and volition, are attributes essentially human, or, at least, are possessed by men in common with higher intelligences alone. The powers of sensation, ideation, and spontaneous remembrance, are possessed also by the lower animals, and are sufficient to explain all the particulars of their conduct.

It is manifest, therefore, that the education of a child may be conducted, in the direction, and to the extent, in which it is possible to educate a horse, a dog, or an elephant, without necessarily trenching upon or at all arousing any faculty that is distinctly human in its nature. The child, moreover, possesses an endowment, of a purely sensational or animal kind, in which brutes are deficient, namely, the power (subsidiary to the gift of language) to remember a great number of sounds, and to imitate them with facility; so that, just to the extent of this power, the *sensational educability* of the human race exceeds that of the lower animals.

It should be remembered, moreover, that the functional activity of the sensorial tract of the encephalon is an absolute necessity of animal existence; and that, in men and brutes alike, it is provided for by an energetic tendency to spontaneous development under the influence of its appropriate excitants. In what may be termed the natural life, a blind submission to the promptings of sensations, present or remembered, would in all ordinary cases supply the wants, or gratify the passions of man. It is only in life modified by human aggregation that these promptings require to be controlled by an exercise of will, guided by a prior exercise of judgment; and, therefore, while Divine Providence has endowed the human race with sensational faculties that are called into vigorous action by daily wants or by physical impressions from without, we may observe that the higher powers of the mind, in a great majority of instances, cannot be matured excepting by assiduous cultivation.

In this respect, however, there is probably a considerable original diversity between individuals; and we are much inclined to think that herein consists the chief cause of gradations of ability among persons who neither greatly surpass an average standard nor fall greatly short of it. Observation teaches that it is far more easy in some children than in others to carry instruction beyond the sense-perceptions, and to call the intellect into activity; but, it teaches, also, that the supposed difficulty often arises from an improper selection or application of the means employed, and is simply a failure to open a lock with a wrong key. The apparently dull child not unfrequently receives the necessary stimulus from a trivial circumstance, from a conversation, a book, or a pursuit, and may grow into a gifted man; while a parallel transformation may be accomplished much later in life, under the influence of some new opportunity for action. It is possible that, in minds of the highest order, the intellectual faculties may possess the character of spontaneity which is commonly limited to the sensorial tract; but, in all ordinary cases, these faculties require to be excited in the pupil by their presence and their activity in the teacher.

The sensational and intellectual functions of the human brain are not only distinct, but also in some degree antagonistic, through the application of the ordinary law of nutrition to their respective organs. The portions of the encephalon that are most employed will receive the largest supply of blood, and will be the seats of the most vigorous cell-growth, precisely as the same rule will apply to the development of muscle; while, on the other hand, a certain duration of disuse, or of restricted use, will occasion atrophic changes, and will be followed by that functional impairment which is a natural result of structural degeneration. It follows that men of the highest intellectual activity are often somewhat inattentive to impressions made upon their senses; and also that great sensational acuteness is often purchased at the cost of some torpor as regards the operations of the judgment.

Upon testing the educational customs of the present day by even the most elementary principles of psychology, it becomes apparent that a very large number of children receive precisely the kind of training which has been bestowed upon a learned pig. There are scarcely any teachers who have in the least degree studied the operations or the development of the mind (indeed, it is only within a very few years that this study has borne any fruit of great practical utility), and those who have not done so cannot realize the existence of a kind of learning which is sensational alone. Indeed, it is more in accordance with ordinary preconceptions to refer brute actions to a process of reasoning, than to consider that any human actions are automatic. The truth is, however, that the first impressions made upon the consciousness of a child have a strong natural tendency to expend themselves through the sensorium; and usually do so, unless directed higher by the manner in which they are produced or maintained. For the purpose of such direction, time is an element of the first importance, and the idea which would be grasped by the intelligence after a certain period of undisturbed attention, will excite the sensational faculties alone if that attention be diverted by the premature intrusion of something else that solicits notice. And while in almost every child the power of intelligent attention may be aroused by care, and perfected by perseverance, the natural inclination is toward a rapid succession of thoughts, variously associated, and remembered in their order without being understood. The faculty of comprehension, like all others, is a source of pleasure to the possessor, even in the first feeble attempts to bring it into exercise; and hence, as well as from the impulse given to nutrition, when once a habit of endeavoring to comprehend has been formed, although in very young children, it is not readily relinquished, but, on the contrary, is applied to the most unpromising materials.

In schools, however, under the stern pressure of the popular demand for knowledge, it is an extremely common practice to accumulate new impressions with greater rapidity than they can be received even by children who have enjoyed the inestimable advantage of early domestic training toward the right employment of their higher faculties. The work laid down can often only be accomplished by means of the promptitude that is a chief characteristic of instinctive action. The child who uses his sensorium to master the sounds of his task, uses an instrument perfected for him by the Great Artificer. The child who uses his intelligence must perfect the instrument for himself, must grope in the dark, must puzzle, must catch at stray gleams of light, before his mind can embrace the whole of any but the simplest question. The former brings out his result, such as it is, immediately; the latter, by slow degrees; often first giving utterance to the steps by which he is reaching it. The former is commonly thought quick and clever; the latter, slow and stupid: and the educational treatment of each is based upon this assumption, widely as it is often at variance with the facts. The child whose tendency is to sensational activity should be held back, and be made to master the meaning of every thing he is allowed to learn. He is usually encouraged to remember sounds, is pushed forward, is crammed with words to the exclusion of knowledge, and is taught to consider himself a prodigy of youthful talent. The child who tries to understand his lessons should be encouraged, praised, supplied with food for thought of a kind suited to his capacity, and aided by a helping hand over the chief difficulties in his path. He is usually snubbed as a dunce, punished for his slowness, forced into sensational learning as his only escape from disgrace. The master, in many cases, has little option in the matter. Children are expected to know more than they have time to learn; parents and examiners must have show and surface, things only to be purchased at the expense of solidity and strength. A discreet teacher may often feel sympathy with the difficulties of a pupil; but the half-hour allotted to the class is passing away, the next subject is treading upon the heels of the present one, the child must complete his task like the rest, and so a budding intellect may be sacrificed to the demands of custom.

Among the children of the educated classes, the circumstances of domestic life usually afford to the intelligence an amount of stimulus which, if not of the best possible kind, is at least sufficient to compensate, in some degree, for the sensational work of school. The easy nursery-lessons of the prescholastic age, the story-books of childhood, the talk of parents and friends, all furnish food for leisurely reflection, all serve to suggest those strange questions that are one chief evidence of thoughtfulness in the young. Minds thus prepared may often flourish in spite of subsequent excessive teaching; and, by forgetting nine-tenths of what has been learned, may find it possible to understand the rest.

In what are called "elementary schools," however, those aided by the nation for the instruction of the children of the poor, we do not find this accidental provision against the paralyzing effects of the prescribed routine. For the most part, the children have grown up like wild animals, excepting for the advantage of an occasional beating, and their nervous centres have received few impressions unconnected with the simplest wants of existence. Coincidently with an entire absence of intellectual cultivation, they usually display a degree of sensational acuteness not often found in the nurseries of the wealthy, and arising from that habitual shifting for themselves in small matters which is forced upon them by the absence of the tender and refined affection that loves to anticipate the wants of infancy. They go to school for a brief period, and the master strives to cram them with as much knowledge as possible. They learn easily, but *they learn only sounds*, and seldom know that it is possible to learn any thing more. In many cottages there are children who, as they phrase it, "repeat a piece" at the half-yearly examination. We say, from frequent experiments, that they will learn for this purpose a passage in any foreign language as easily as in English; or, that they will learn an English paragraph backward way, if told to do so; and that, in neither case, will any curiosity be excited about the meaning of the composition. In ordinary practice, the master explains what they repeat, saying this means so-and-so; and the pupils have sufficient sensational acuteness to remember the sounds he utters, and to reproduce them when called upon. They do not usually understand what "meaning" is. An urchin may be able to say correctly that a word pointed out to him is an adverb or a pronoun, may proceed to give a definition of either, and examples of instances of its occurrence, and may produce an impression that he understands all this, when the truth is that he has only learned to make certain noises in a particular order, and when he is unable to say any thing intelligible about the matter in language of his own. Or he may repeat the multiplication-table, and even work by it, saying that $7 \times 8 = 56$, without knowing what 56 is or what 7 times 8 means. He knows all about 7 or 8, not from schooling, but from the lessons of life, from having had 7 nuts or 8 marbles; but of the 56 which is beyond his experience he knows *nothing*. The nature of the mental operations of such children is perhaps as little known to the teacher, to the vicar of the parish, or the kind ladies who take an interest in the school, as the nature of the mental operations of the inhabitants of Saturn. The adults distinctly understand a thing which they feel to be very easy, and do not know that any children *can* talk about it correctly without attaching an idea to their words. They often think the teaching satisfactory which enables the pupil to explain things in set phrases. They do not realize the possibility that the explanation may be as little understood as the statement which it explains—that it may be like the tortoise in the Hindoo myth, which supports the elephant, but which, requiring support itself, only removes the difficulty by a single step—that it may be a second unknown quantity balancing the first in the equation $x=y$. Such, however, instead of bare possibilities, are too frequently actual results. We have already referred incidentally to a learned pig, and to the parallelism between its training and some kinds of human education. Persons familiar with the tricks taught to animals are aware that these may all be described as muscular actions performed each consecutively to its proper signal. On hearing the finger-nails of the master click together, the animal does something in obedience to the sensation; nods its head, or shakes its head, or stands erect, as the case may be. It has no idea that the nod is an affirmation, or the shake a negation, and probably has no thirst for knowledge about the matter, being content to play its part correctly, and to escape the whip. In the case of children, the medium of communication is different, and the kind of response is different; but the faculty in action is commonly the same. The words of the pig's master are mere by-play, intended to amuse the audience, and the signal is conveyed by other sounds. The words of the human teacher or examiner, his questions, for instance, are the signals to the child, each requiring its appropriate answer; but, like the signals to the pig, they are aural sensations, capable, as such, of producing muscular action through the medium of the sensorium alone. The responses of the child are in words—that is to say, in sounds that he has been taught, and that he remembers, but of which he need not understand one iota in order to repeat them, any more than the pig need understand the affirmative or negative character of its nod or shake. In the human species, articulate speech is an act precisely analogous to locomotion, requiring the combined and harmonious working of several muscles, and the guidance of sense, but in no way essentially connected with the intelligence; and the child may make the right noises in the right order, just as the pig does not nod its head when the signal requires it to be shaken.

A general idea of the facts, which we have endeavored to state, was conveyed to the public many years age by a phrase now almost forgotten. Educationists found, by experience, that children managed to retain sounds without meaning, and they called the process "learning by rote." Books, pamphlets, and speeches, bore witness to the practical inutility of such learning, and were full of suggestions for improving upon it. But these suggestions, to the best of our recollection of them, did not go to the root of the matter, and were mainly based on the assumption that learning by rote was characterized by some sort of deficiency only, and not by a radical error in the kind of impression made upon the pupil. It was not distinctly stated, or commonly conceded (although often implied in phraseology), that the action of the child's mind was of a nature essentially distinct from that which it would be the object of a wise instructor to excite; and the cause of the error was mainly sought in teaching not carried far enough to be beneficial, or not continued sufficiently long to produce permanent results. We conceive that the recent development of nervous physiology entitles us to maintain that learning by rote is at once the effect and the evidence of operations limited to the sensorial ganglia; and that such operations have no tendency, however they may be complicated or prolonged, to excite those functions of the cerebrum which are the peculiar attributes of humanity.

Our brief remaining space must be devoted to an examination of the effects of sensational learning, both as it exists in most schools for the poor, and also in the form, more or less modified, which may be found in other institutions.

Physiologically speaking, the effect of purely sensational learning will be to stimulate the nutrition and increase the vigor of the sensorial tract at the expense of neighboring and related organs. As we have seen, the sensorium has a natural tendency to predominance in the encephalon; and this tendency will be increased in every way, absolutely by direct excitation, and relatively by neglect of the intellect and volition. The sensations by which the stimulus has been given will not be long remembered, being superseded by fresh ones arising out of events, as the apparatus of the gymnasium would be superseded by the instruments of actual conflict. With the exception of being, perhaps, able to read with labor, and to write with difficulty, the pupils must not be expected, six months after leaving school, to possess any traces of their "education" beyond an invigorated sensorium and a stunted intelligence.

Now, when it is remembered that present sensations are the source of the least exalted kinds of animal gratification, and that sensations, either present, or remembered, or conceived, when combined with a feeling of pleasure or pain, constitute the emotions which so powerfully influence human conduct, it must be admitted that the sensorium is at least the seat of development of those passions and propensities which society, for its own good, is compelled to keep in check, and which every consideration of right teaches individuals to subdue. When, therefore, we reflect upon the operation of predominant emotions in producing, among other evils, chorea, hysteria, epilepsy, and insanity, or when we consider the aggregate of misery produced, especially among the lower orders, by the unbridled indulgence of various appetites, we cannot altogether concur in the propriety of a system of education which has a direct tendency to raise the source of these emotions and appetites to an undue and unnatural prominence in the organism. In our own experience we have met with so many examples of what may be called habitual non-reflection in young people who had been six months before among the most glib and fluent pupils at a sensational school, that we fancy that we can recognize a kind of stupidity thus induced, and that we can readily distinguish it from any thing at all similar that is purely natural.

We should be disposed, on the whole, to seek the *rationale* of many educational failures rather in a partial and misdirected training of the intelligence, than in its complete suppression. The pupils mix intellectual and sensational acts, not in their proper relations with each other, but in a jumble. Comprehension is brought to bear upon every thing that is easy; while a difficulty of any kind is committed to the safe keeping of the sense perceptions, and the explanation of it is only remembered. Hence arise a habit of resting upon imperfect knowledge, and a habit of loading the memory by the aid of faulty associations; and these habits, in their turn, are the sources of the lively superficial stupidity which is so common among the better classes. The sufferers from it form that great public to whom are addressed the Morisonian system of pathology and therapeutics, and the elaborately argued advertisements of Norton's Camomile Pills. Every thing that follows "because" is to their minds an explanation; every thing that has an antecedent is to their minds an effect. Their creed is, that all questions lie in a nutshell; and, according to Prof. Faraday, their shibboleth is "it stands to reason." On this ground they would placidly maintain against Owen the existence of the sea-serpent. For their especial behoof bubble companies are formed; and upon their weaknesses innumerable imposters thrive. Their deficiency is chiefly this—that, having been permitted from childhood to do many things superficially and with inexactness, they have forfeited the power of arranging their ideas with precision, or of comparing them with caution. They can therefore scarcely be said to possess any assured convictions, or rooted principles of conduct; but, nevertheless, they are ready to decide in all controversies; and are "wiser in their own conceit than seven men who can render a reason."

The cause of such educational errors we should express in the single word—empiricism. For successive ages teachers had no guide but experience; and the results of this experience appeared to defy generalization. The almost self-evident proposition, that the training of the mind should be guided by an analysis of its powers, was brought into early disrepute by the conditions under which such analysis was attempted. The men engaged in it, learned, patient, laborious, profound, reached the limit of discovery by the method of reflection long before the method of observation was disclosed to them. Too exclusively metaphysical, they wanted a link to connect them with the material world. Like the children of Israel, they were wandering in a wilderness before they entered the promised land. Their advanced messengers had not yet returned, bringing of the fruits that were hereafter to reward their labor. Foiled in their advance by a barrier that seemed impassable, they were tempted to waste their energies in the invention of technicalities and the multiplying of verbal distinctions. Under such circumstances the science and its professors were too broad a mark to escape the shafts of satire; and thus, even at the present day, there are scars to show the wounds which those shafts have made.

During the last few years, however, the dark portions of this muchcontemned pursuit have received unexpected illumination from the study of the nervous centres. The painstaking researches of Bell, Marshall Hall, and less conspicuous fellow-laborers, endowed with value and stamped with currency by the lofty generalizations of the living philosopher who has so long been *facile princeps* (the admitted chief) among all inquirers into the functions of the nervous system, have already produced a psychology that is available for practical purposes, and that promises to increase daily in importance. In the mean while education has spread enormously, but educators persist in traversing the broad old road. The larger the field for their efforts, the more conspicuous becomes the poverty of their results. At one time, learning by rote was the great obstacle; and they attacked, as the last difficulty in their path, what was but the first aspect of a Proteus. At present (with the scheme of national education all but a confessed and palpable failure; with numerous individuals in all ranks displaying powers developed late in life by circumstances, but never suspected before; and with a waste of the national intellect that may possibly be equivalent to the daily loss of a century's progress), the office of preceptor is still confided to persons who have never bestowed a single thought upon the faculties, or the mechanism of the mind, and who cannot distinguish between sensational and intellectual action, if the former be veiled by the smallest complexity.

Toward the carrying out of any improvement in education, the first step must be to demand from teachers, either a knowledge of mental philosophy, or, at least, of a scholastic art founded upon the principles which mental philosophy would inculcate. We believe this demand must inevitably be made in process of time; but we feel also that it would be greatly promoted if the medical profession would recognize, and strive to impress, the distinct bearing of physiology upon the development of the mind, as well as upon that of the body.

The practical difficulties, which it is easy to foresee, all resolve themselves, pretty clearly, into one. An inquiry after intelligent and intelligible teaching has not yet issued from the public. They are content with something else. Whenever this contentment ceases, the means of supply will spring out of the want. And, until then, we would urge upon individual parents that they may accomplish much by encouraging in their little ones a spirit of curiosity, and a habit of comprehension. Whether the fire of intellect shall blaze, or smoulder, will depend in many cases upon the manner in which it is kindled; and this kindling is among the things that can be done, most effectually, under the mild influences of home.—*London Journal of Psychological Medicine.*

THE SPOTS ON THE SUN.

By THE EDITOR.

SHALL the Eye of the Universe suffer from ophthalmia? Shall the orb of celestial fire in the incorruptible heavens—type of purity and perfection—noblest symbol of God—be stained and blackened with impurities? Such were the questions indignantly asked when it began to be whispered about that there are spots of darkness on the face of the sun.

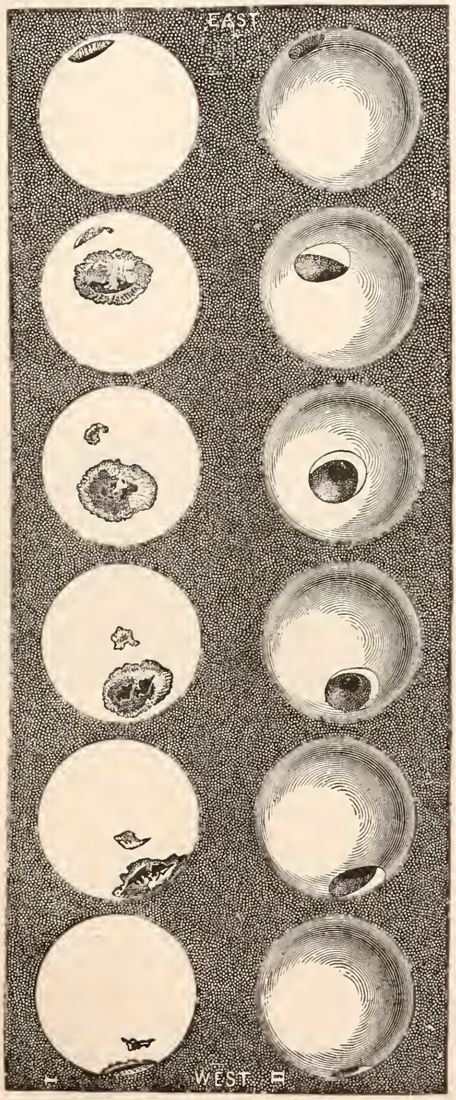
Yet again what was thought impious and impossible proved true: and again it was demonstrated that the cherished opinions of thousands of years were not only erroneous, but were in flat contradiction to the truth. Not only were spots, which it was thought profane even to suspect, shown to be realities, but they have turned out to be the principal means of letting us into a knowledge—such knowledge as we have—of the solar constitution.

It is now upward of 250 years since the invention of the spy-glass led to the revelation of the solar spots, which has been variously attributed to Fabricius, Galileo, and Scheiner, the Jesuit astronomer. It is said of Scheiner, and it well illustrates the spirit of his age, that he dared not publish his discovery, and at first confided it to only a few of his most intimate pupils. After repeated observations that removed all doubt as to their existence, he consulted the provincial father of his order, who refused to believe in any thing of the kind; "For," said he, "has not Aristotle said that the sun is all over shining with light? I have several times," he sagely observed, "read my Aristotle all through from beginning to end, and I can assure you that he mentions not a syllable about it. Go, my son, make yourself easy, and take it for certain that what you suppose to be spots on the sun, are nothing but specks in your eyes or flaws in your glasses." Scheiner obeyed, admitting that his eyes must be in the wrong, and Aristotle in the right, for he lived in an age of credulous faith and blind authority. A doubting pupil of his, however, wrote to Galileo, who replied: "Scheiner's eyes are as good as need be; I have myself watched those spots for some time past."

Scheiner at first considered these dark specks to be minute planets travelling round the sun close to his surface, but Galileo more shrewdly concluded that they were part of the sun itself, perhaps floating scum or scoria, and he saw their importance in astronomy. For not only do they prove the revolution of the sun on its axis, but they afford the only means of ascertaining the time of that revolution, the position of the solar axis and its inclination to the earth's orbit. Galileo therefore watched the spots with an interest and assiduity so great that it finally cost him his eyesight.

When we look at the sun through clouds, or through a darkened glass, it appears as a uniform disk of light. But, when we look at it through a telescope of moderate magnifying power, the uniformity of

Fig. 1.



The Changes in the Appearance of a Spot, caused by the Rotation of the Sun.

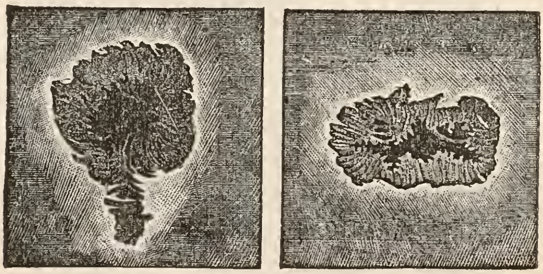
surface disappears, and we see it irregularly sprinkled with dark points known as *solar spots*. These are, however, not always seen; sometimes the solar disk is perfectly clear. It has been found that for a period of ten years, from 1840 to 1850, out of a total number of 1,982 days when the sun was observed, there were only 372 days when spots were not seen.

The spots vary in size and number: sometimes but a single one appears, and as many as 80 have been visible at one time. Nor are they equally distributed over the solar surface. The region of the spots is generally confined to the part of the sun within about 30° of its equator, beyond which they are rarely seen.

The *photosphere* is the name given to the silver sea of light by which the spots are surrounded, and in which they seem to swim; it is the immediate source of illumination, and, viewed through a glass of low power, it appears flat and smooth, and of a uniform whiteness.

But, when a telescope of high magnifying power is directed to the sun, its aspect is greatly changed: the spots lose their simplicity, and the photosphere its uniformity, and in both there are a revelation of *structure*, a diversity of parts, and a variety of changes, which at once provoke questions in the mind of the observer, as to the causes of this diversified appearance, and the constitution of the body which presents

Fig. 2.



Solar Spots, showing Furrows in the Penumbra.

them. The hypotheses put forth are ingenious; but, while the facts of observation are rapidly increasing, and there is a growing agreement on many points, there is still profound uncertainty as to the interpretation to be given to the leading phenomena.

Spots upon the sun's surface have been frequently seen with the naked eye. Galileo saw one at sunrise. It was the observation of a solar spot with unassisted vision that so impressed Sir William Herschel as to determine his attention to the physical nature of the sun. The eminent observer Schwabe has also seen many without the aid of the telescope. Solar spots, therefore, are discernible without glasses at a distance of 91,000,000 of miles; but Lockyer says that the finest telescope enables us to see the sun as we should do with the naked eye at a distance of 186,000 miles, that is, 52,000 miles nearer than the moon. The sun is about 62,000,000 times larger than the moon, and Brände states that the smallest space that can be discovered in the sun's disk must subtend an angle of one second, which is equal to about 460 miles. These facts give us some idea of the mighty scale of solar phenomena.

The solar spots have a general movement with the surface of the revolving sun, and they have also minor movements of displacement. They always make their first appearance on the same side of it; they travel across it in from twelve to fourteen days, and then disappear on the other side. The form of a spot in its first appearance is that of a small, dark streak, the length of which is much greater than the breadth. Its motion appears slow at first; it afterward increases, then slowly diminishes, until again assuming the form of a narrow streak. Fig. 1, from Dr. Schellen's finely-illustrated work on Spectrum Analysis (as are all the illustrations of the present article), represents this change of appearance of a spot as it emerges, passes across the field of view, and disappears. Of course, its relative size, as here shown, is enormously exaggerated.

The solar spot consists principally of a dark, almost black, central portion, generally irregular in form, called the *umbra.* Mr. Dawes has shown that, within this part of a spot, one or more still blacker spots may generally be observed, to which he gives the name of *nucleus.* The term *black*, however, as applied to an object on the sun, is to be taken with caution, and means merely a diminished intensity of solar light, which, by contrast, appears black. Zollner states that the black umbra of a spot emits four thousand times as much light as that derived from an equal area of the full moon; and Sir John Herschel says that the Drummond light, which is so bright that the eye can hardly endure it, when projected on the sun, appears as a black spot!

Surrounding the umbra is a tract less dark, usually more regular in form, and of a fringe-like aspect, called the *penumbra.* Its appearance is illustrated in Fig. 2, and is represented by the half-tints around the darker umbra in all the accompanying delineations. But, before we can understand the structure of the penumbra, it will be necessary to refer to what is known of the surrounding bright solar surface.

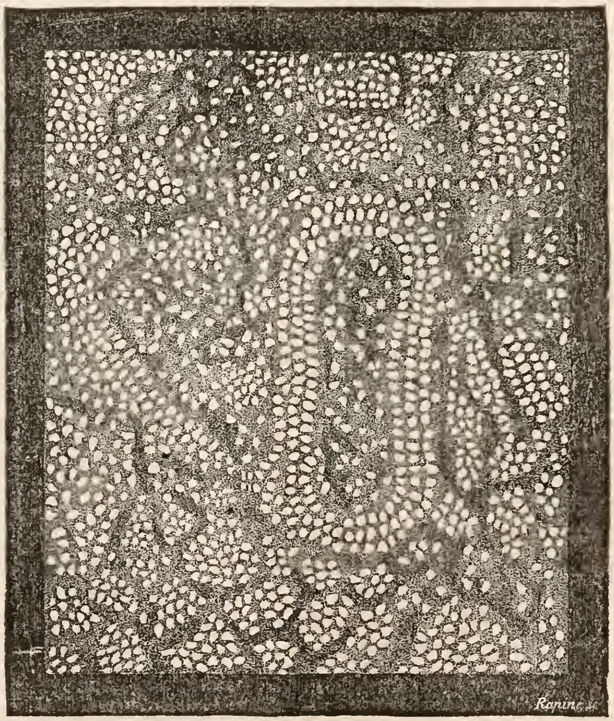
Viewed by a telescope of moderate power, the photosphere loses its uniform aspect, and exhibits a coarsely *mottled* appearance. But, if an instrument of the highest grade is used, the photosphere is seen to have a far more definite structure, and exhibits appearances which are variously described by different observers. Sir William Herschel calls these appearances "corrugations." They are small points of unequal light, imperfectly separated from each other by rows of minute dark spots called *pores;* the intervals between them being extremely small, and occupied by a substance decidedly less luminous than the general surface. Some call them "rice-grains;" Mr. Huggins names them "granules," and his representation of them is given in Fig. 3. The photosphere is again described as resembling a net of bright meshes interwoven with dark threads.

Certain portions of the photosphere are much brighter than others;

these are termed *faculæ*, and are, in fact, the opposites of the solar spots. They are devious, undulating, shining ridges, like irregular ranges of snowy mountains, and are represented as from 1,000 to 40,000 miles long, and from 1,000 to 4,000 miles in breadth. They are frequent near the sun's edge, and often accompany the coming and going of the spots. But they are generally the attendants of the spots, and often appear at points where spots are about to break out. Their bright, concentrated, tortuous appearance in the neighborhood of a spot is represented in Fig. 4.

Another remarkable appearance of the sun's surface consists of

Fig. 3.



"Granules," "Pores," or "Rice-Grains," shown upon the Sun's Surface, by the Telescope.

streaks or blades of light—the "slashed straws" of Dawes, or the "willow-leaves" of Nasmyth. These, says Sir John Herschel, cover the whole disk of the sun (except the spaces occupied by the spots) in countless millions, and lie crossing each other in every imaginable direction. Mr. Dawes denies that they are so general, but they are universally recognized in the vicinity of the solar spots, taking a radial direction around the penumbra, and giving it a jagged or coarsely-thatched appearance. Father Secchi says: "I would compare them to elongated masses of cotton of every possible form, sometimes entangled with one another, sometimes neatly truncated, or again spread out with no distinct termination. Their head is generally turned toward the centre of the nucleus. They are not unlike strokes of color laid on with a painting-brush, very white near the head, and gradually less brilliant toward the tail." Fig. 5 represents a group of solar spots, in which this closely-meshed appearance of the ovoid bodies is impressively presented; and in Fig. 6 we see the willow-leaf structure stretching completely across the umbra and forming bridges of light.

The dimensions of solar spots are as variable as their forms. Some are very small, appearing under the highest magnifying power like mere specks; others are of enormous magnitude. Many have been observed which measure from 30,000 to 100,000 miles in diameter, so that, if they are truly chasms and gulfs in the luminous envelope of the sun, our entire globe, as Guillemin remarks, would appear in their depths no larger than a fragment of a rock rolled into the crater of a volcano!

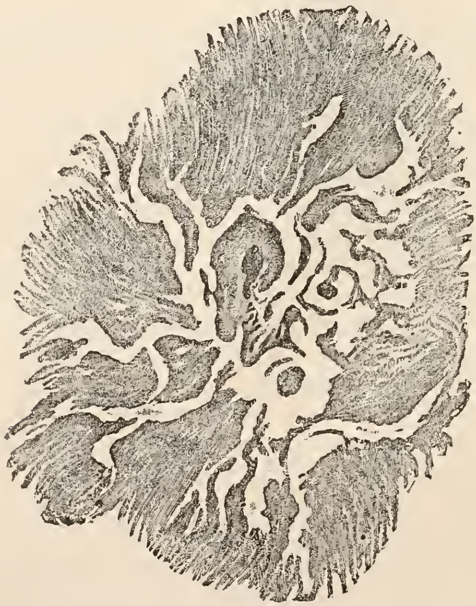
The changes which these bodies undergo are extraordinary. They seem to have an order of development. Proctor says the formation of a spot is usually preceded by the appearance of faculæ. Then a dark point makes its appearance, which increases in size, the penumbral fringe being presently recognized around it, and the distinction between the umbra and the penumbra being well defined. But, when the spot is about to diminish, the edges lose their sharpness as if screened by a luminous veil; capes and promontories jut out, and bridges of light are formed. Lockyer says sometimes changes are noticed even within an hour. Their periods are most variable; the smallest merely appear and disappear, lasting a mere fraction of the time of solar rotation. The larger live frequently during two rotations, and Schwabe saw one which returned eight times, continuing 200 days.

The remarkable changes that sometimes occur are well illustrated in Fig. 7, which represents four drawings of the large spot that appeared October 7, 1865, and which was more than 46,000 square miles in area. The drawings are numbered in the order of date. No. 1 exhibits the oblong, fore-shortened view presented when it first appeared on the edge of the sun. No. 2 represents its aspect three days afterward. No. 3 shows its appearance four days later, and No. 4 is a view of it on October 16th.

Sometimes spots exhibit a rotatory or whirlpool appearance, as if the solar envelope were subject to tremendous tornadoes. Fig. 8 represents a spot seen and drawn by Secchi at Rome, May 5, 1857, which represents a vortex, into which the substance of the photosphere is rushing with an eddying motion. De La Rue took two photographic pictures of the same spot at an interval of two days, and, when these are placed together and looked at through the stereoscope, the spot exhibits a funnel-like concavity with remarkable exactness. There is other evidence that the sun-spots are of the nature of depressions or openings in the photosphere. Both Herschels claim to have observed a notch in the sun's edge as a spot is disappearing; and the order in which the parts of a spot appear and disappear at the solar border is not what it would be if the spot were *even with the surface*, but is just what it would be if it were a rent or opening.

The question before us is one of solar meteorology. Spectrum analysis proves that matter exists upon the sun in a gaseous form. The great mobility of its envelope, and the rapidity and extent of its changes, imply an atmosphere of extreme complexity, and probably of great depth. The appearances of the solar atmosphere are believed to

Fig. 4.



Faculæ in the Neighborhood of a Spot.—(Chacornac.)

be due to masses of the nature of clouds. But, while our clouds are watery, or are formed by precipitated aqueous vapor, the solar clouds are inferred to be more or less metallic, or to be composed of particles of various metals and other substances in a state of intense heat. Metallic vapors, at any rate, are proved to exist on the surface of the sun.

The first hypothesis of the solar constitution, which professed to account for the spots, was put forth in the last century by a Scotch astronomer, Alexander Wilson, and was accepted with modifications by Bode and Herschel, and continued to prevail until within a few years, being accepted by Arago. It was formed under the old *anthropocentric* bias; that is, the notion that man is the central object of the universe, which has been built around him and for him, and with reference to him as the supreme object. This led to the belief in the inhabitability of worlds; for, if stars and planets were not for man to live on, what can they be good for! And, hence, solar theories were so framed that it might be possible to conceive of the sun as the dwelling-place of man. The nucleus or body of the sun was assumed to be opaque and solid, or, at all events, that it had a solid shell corresponding to the earth's crust. Surrounding the spherical nucleus at a certain distance above it, there was supposed to be a first atmosphere which may be compared to the earth's atmosphere when the latter is occupied by a continuous layer of opaque, reflecting clouds. Above this first layer, and more or less distant from it, there was held to be a second atmosphere which is luminous, and answers to the photosphere, or the visible periphery of the solar orb.

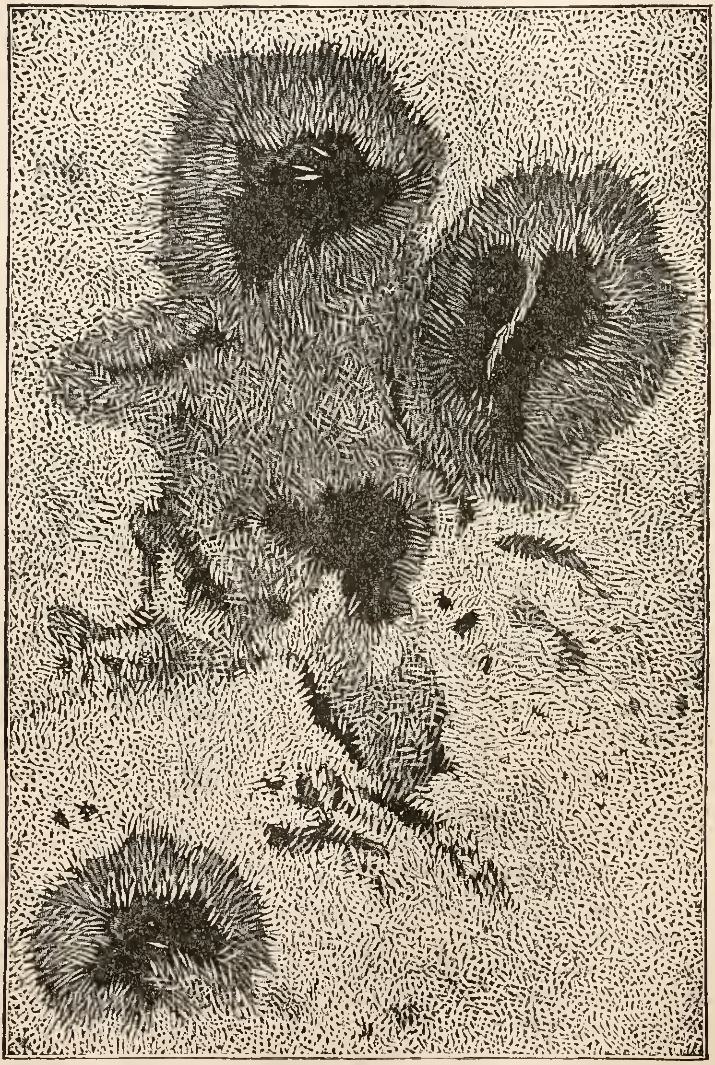
On this view a solar spot results from a rent in the atmospheric layers, by which the dark nucleus becomes visible, forming the umbra. The rupture of the two atmospheres, it was supposed, might be caused by volcanic action, or by "gaseous matter formed from time to time at the surface of the dark nucleus, the high temperature of which causes its deflagration." Again it was said: "It may happen that the opening is wider in the cloudy atmosphere than in the luminous envelope or photosphere, in which case the dark nucleus alone would be seen; and we should have a spot without a penumbra. Or the rupture of the first gray envelope becoming closed before that of the photosphere, would have for effect to shut out the view of the dark globe, and we should have a penumbra without a nucleus."

The later tendency is to abandon the notion of a dark nucleus. Indeed, the explanations of the spots now most in favor recall that of Galileo: he suggested a floating scum, while all the late physicists hold that the spots are due to the agency of precipitated clouds.

Kirchhoff, whose honor it is to have first applied spectrum analysis to the study of the sun, and discovered its chemical elements, maintains that the visible portion of the sun, the surface which constitutes the photosphere, is a solid or liquid sphere in a state of incandescence. Its temperature is very high, and it is surrounded by a dense atmosphere formed of the elements which constitute the incandescent globe itself, whose extremely high temperature maintains them in a state of vapor or gas. The lines of the solar spectrum, instead of being bright and variously colored, are dark, which proves that the light has passed through a medium of absorption. Kirchhoff's view is, that the light emanates from the solid or liquid photosphere, and is filtered of its colors or has its lines reversed in passing through the sun's atmosphere.

He explains the spots by supposing that, from some unknown cause, certain parts of the sun's surface undergo a temporary cooling, by which clouds are condensed above that intercept the rays and then ap pear as an opaque layer—the umbras of spots. A cloud once formed in this manner acts as a screen toward the higher regions; hence a secondary cooling effect in those regions also, and the formation of another cloudy layer, less dense—the penumbra.

Fig. 5.



Group of Solar Spots observed and drawn by Nasmyth, June 5, 1864.

The speculations of M. Faye upon this subject have also attracted some attention. He assumes the sun to be still in a gaseous state. The photosphere he regards as consisting of clouds which are the simple consequence of cooling, and looks upon it, in fact, as the limit which separates the intense heat of the interior portions of the sun from the cold surrounding space. He holds to powerful ascending and descending currents, which result here and there in breaks and dispersions by which openings are made to the gaseous interior, giving the appearance of spots; to which Kirchhoff replies that an incandescent interior, at so high a temperature, would certainly be luminous.

In 1858, before the views of either Kirchhoff or Faye were announced, or spectrum analysis had been applied to the subject, Mr. Herbert Spencer published an article on "Recent Astronomy and the Nebular Hypothesis," in which he anticipated some of the most important results that have been arrived at since by others. He took the ground that the sun is still passing through that incandescent stage which all the planets have long ago passed through, the lateness of his cooling being due to the immensely greater ratio of his mass to his surface. He supposes the sun to have now reached the state of a molten shell with a gaseous nucleus; and that this shell is ever radiating its heat, but is sustained at its high temperature by the progressive condensation of the sun's total mass.

As respects the solar atmosphere, Mr. Spencer said in 1858:

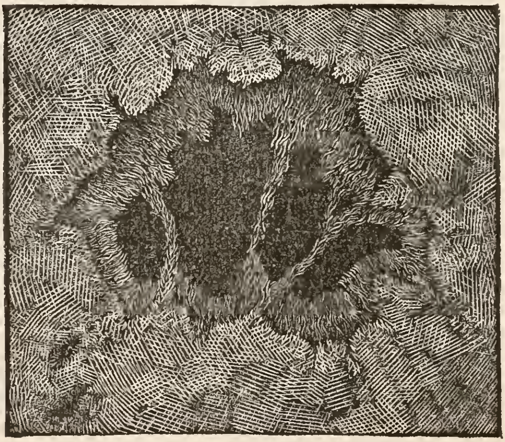
"If we consider what must have been the state of things here when the surface of the earth was molten, we shall see that, round the still molten surface of the sun, there probably exists a stratum of dense aëriform matter, made up of sublimed metals and metallic compounds, and above this a stratum of comparative rare medium analogous to air. What now will happen with these two strata? Did they both consist of permanent gases, they could not remain separate: according to a well-known law, they would eventually form a homogeneous mixture. But this will by no means happen when the lower stratum consists of matters that are gaseous only at excessively high temperatures. Given off from a molten surface, ascending, expanding, and cooling, these will presently reach a limit of elevation above which they cannot exist as vapor, but must condense and precipitate. Meanwhile, the upper stratum, habitually charged with its quantum of these denser matters, as our air with its quantum of water, and ready to deposit them on any depression of temperature, must be habitually unable to take up any more of the lower stratum; and therefore this lower stratum will remain quite distinct from it. We conclude, then, that there will be two concentric atmospheres, having a definite limit or separation."

This view was sustained in the most remarkable manner, by the subsequent discoveries, through spectrum analysis, of the metals iron, calcium, magnesium, sodium, chromium, and nickel, in a gaseous state in the atmosphere of the sun.

As respects the solar spots, in the article above quoted, Mr. Spencer suggested that they were due to cyclonic action. He has subsequently developed this view, which is now regarded as the most rational explanation we have of the cause of solar spots. In the latest edition of "The Heavens," by Guillemin, published last year, translated by Lockyer, and edited by Proctor, after a review of the subject, and an examination of all the theories that have been proposed, the view of Mr. Spencer is presented last, as more in conformity to the facts than any other. After showing how the hypothesis of M. Faye is discredited by the spectroscopic observations of Lockyer, Huggins, and Secchi, they say: "It follows conclusively that the spots are regions of increased absorption. This accords with Mr. Herbert Spencer's theory, with which also the observations of Mr. De La Rue and Dr. Balfour Stewart are in satisfactory agreement. Let us now," say they, "present the theory of Mr. Spencer, whose suggestions as to the possible causes of solar spots are very valuable.

"Mr. Spencer, basing his reasoning on terrestrial analogies, thus accounts for the spots: 'The central region of a cyclone must be a region of rarefaction, and consequently a region of refrigeration. In an atmosphere of metallic gases rising from a molten surface, and reaching a limit at which condensation takes place, the molecular

Fig. 6.



Solar Spot, with Three Bridges of Light.—(Nasmyth.)

state, especially toward its upper part, must be such that a moderate diminution of density and fall of temperature will cause precipitation; that is to say, the rarefied interior of a solar cyclone will be filled with cloud; condensation, instead of taking place only at the level of the photosphere, *will here extend to a great depth below it.*' It will be seen that Mr. Spencer, as opposed to Kirchhoff, not only accounts for the formation of a cloud, but places it where the objections made to Kirchhoff's clouds do not hold good. He next shows that a cloud thus occupying the interior of a cyclone will have a rotary motion, and this accords with observation. Being funnel-shaped, as analogy warrants us in assuming, its central parts will be much deeper than its peripheral parts, and therefore more opaque. This, too, corresponds with observation. Nor are we, on this hypothesis, without some interpretation of the penumbræ. If we may suppose the so-called 'willow-leaves'—the 'things' on the sun—to be the tops of the currents ascending from the sun's body, what changes of appearance are they likely to undergo in the neighborhood of a cyclone? For some distance round a cyclone there will be a drawing-in of the superficial gases toward the vortex. All the luminous spaces of more transparent clouds, forming the adjacent photosphere, will be changed in shape by these centripetal currents; they will be greatly elongated, and those peculiar aspects which the penumbra presents will so be produced."

Mr. Spencer, however, in his article in the former number of The Popular Science Monthly, says that at present none of the interpretations of the solar spots can be regarded as established.

"All this is, no doubt, very curious, but it is very remote and unpractical. What have the solar spots to do with me, or I with the solar spots?" exclaims some impatient reader. But suppose it turns out that the spots on the sun do have a very close connection with earthly affairs—what then? The story of these strange appearances is incomplete till this point also is noticed.

The view which connects the spots with cyclonic action is confirmed by the now demonstrated fact that they are mighty solar agitations, whose influence is felt in distant planets. Schwabe has discovered that the spots, instead of being uniform in number and intensity from year to year, have a periodicity increasing to a maximum, and then declining to a minimum in a course of years. The variations consisted in the number of days in the year in which spots were visible, and in the number of groups observed. The indomitable perseverance of this astronomer is something wonderful. The president of the English Astronomical Society, in awarding him its gold medal, said: "For thirty years, never has the sun exhibited his disk above the horizon of Dessau, without being confronted by Schwabe's imperturbable telescope, and that appears to have happened about 300 days in a year. So that, supposing he observed but once a day, he has made 9,000 observations, in the course of which he has discovered 4,700 groups." In these observations, he traced three complete oscillations from maximum frequency, through minimum back to maximum again. The period assigned by Schwabe was about ten years, although Prof. Wolf, of Zurich, has showed that 11.11 years (or the ninth part of a century) is indicated rather than a ten-yearly period.

It has been established that there is a coincidence between this sun-spot period and magnetic disturbances on the earth. In every part of the earth the magnetic needle has at any given time a certain definite position, about which, under normal conditions, it will oscillate during the day. Proctor says:

"Each day the needle oscillates gently about its position of rest, the oscillation corresponding to a very slight tendency, on the part of that end of the needle which lies nearest to the sun, to direct itself toward his place. The daily oscillation is itself variable in a systematic manner, not only with the progress of the year, but with that of the lunar month. The daily oscillation also varies at times in a sudden and irregular manner. The needle has been exhibiting, for several weeks, the most perfect uniformity of oscillation. Day after day the careful observation of the needle's progress has revealed a steady swaying to and fro, such as may be seen in the masts of a stately ship at anchor on the scarce-heaving breast of the ocean. Suddenly a change is noted; irregular movements

Fig. 7.

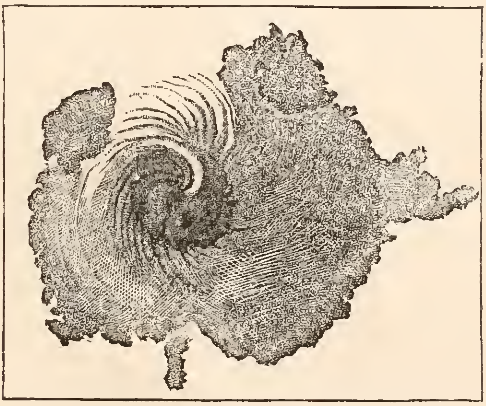
Changes of Appearance of the Great Sun-Spot of 1865.

become perceptible which are totally distinct from the regular periodic oscillations. A magnetic storm is in progress, and its progress does not affect only the place of observation, but widely-extended regions of the earth; and in some well-authenticated instances these magnetic vibrations thrill in one moment the whole frame of the earth."

Lamont, of Munich, in 1850, was the first to announce that these magnetic disturbances attain a maximum of frequency in about ten years. Two years later, Sabine, Wolf, and Gautier, noticed the coincidence of this period with that of the solar spots. And this coincidence was more than general. There was a coincidence of maximum spot-frequency with maximum of magnetic disturbance, and of minimum with minimum, which compelled them to assert a causal connection between the two periods. Wolf subsequently proved that the period of magnetic disturbance has the length of 11.11 years.

But there is still more striking evidence of this connection. On September 1, 1859, Mr. Carrington, an eminent English astronomer, happened to be intently engaged in observing and mapping a group of spots, when a sudden and most extraordinary outburst occurred, of so startling a nature that, having noted the exact moment by his chronometer, he hastily ran to call some one to see the exhibition with him;

FIG. 8.



Spiral Solar Spot, or Cyclone, observed by Secchi.

when upon returning, within 60 seconds, the whole spectacle had disappeared. "The spots had travelled considerably from their first position, and vanished as two rapidly-fading dots of white light. In the interval of five minutes, the two spots transvered a space of about 35,000 miles." He likens the appearance to that of a sudden conflagration. This was also independently seen at the same moment by Mr. Hodgson, who says: "I was suddenly surprised at the appearance of a very brilliant star of light, much brighter than the sun's surface, and most dazzling to the protected eye. It lasted some five minutes, and disappeared instantaneously."

At the moment when the sun was thus disturbed, the magnetic instruments at Kew exhibited the signs of great magnetic disturbance. "It was found," says Dr. Balfour Stewart, "that a magnetic storm had broken out at the very moment when this singular appearance had been observed." Nor was this all. A magnetic storm never rages without various signs of electrical disturbance. On this occasion vivid auroras were seen, not only in both hemispheres, but in latitudes where auroras are very seldom witnessed. They were conspicuous, on the nights following this observation, in Cuba, Rome, South America, and Australia—at Melbourne greater than was ever witnessed there before. Sir John Herschel says:

"These auroras were accompanied with unusually great electro-magnetic disturbances in every part of the world. In many places, the telegraphic wires struck work. They had too many private messages of their own to convey. At Washington and Philadelphia, in America, the telegraphic signal-men received severe electric shocks. At a station in Norway, the telegraphic apparatus was set fire to; and at Boston, in North America, a flame of fire followed the pen of Bain's electric telegraph."

The establishment of so important a fact as the periodicity of the phenomenon of solar spots, and a corresponding periodicity in the action of one of the most subtle of the terrestrial forces, was an event of great moment in the scientific world. For, as the physical forces are correlated and convertible, if any one of them be implicated there arises the presumption that others also may be involved, and a new branch of inquiry is thus opened. Wolf, of Zurich, impressed by the import of the case, addressed himself to the Herculean task of exploring the whole history of past observations of the sun-spots. He overhauled the unknown and forgotten records of old observations, collating the results found in some eleven hundred volumes of print and manuscript, and consulting double that number, which did not pay for the trouble of unearthing them from the dust in which they were buried. His data enable him to give the annual course of the phenomena of spots from 1750 to 1860, that is, for more than a hundred years. For one-half of that time he can make a monthly statement; and is able to trace the maxima and minima with sufficient exactness during the past 140 years. The data procured by Prof. Wolf in this protracted investigation comprehended observations in the seventeenth century on 2,113 days; in the eighteenth century on 5,490 days; in the nineteenth century on 14,860 days, or a total of 22,463 days. The old observers little suspected the ultimate meanings that were to be drawn from what they were doing. But in science nothing is lost; observations at first thought trivial, become at length significant, and serve to establish the most comprehensive views.

It follows from these discoveries that, in the system of the universe, there is reason to rank the sun with the variable stars. How far the phenomena of his spots are linked with planetary influences, is an interesting question to which astronomers are directing their attention. They are also investigating the relations of the sun's spots to the temperature of the earth, and other terrestrial conditions, with results which we have no space left to consider.

THE STUDY OF SOCIOLOGY.

By HERBERT SPENCER.

II.—Is there a Social Science?

ALMOST every autumn may be heard the remark that a hard winter is coming, for that the hips and haws are abundant: the implied belief being that God, intending to send much frost and snow, has provided a large supply of food for the birds. Interpretations of this kind, tacit or avowed, prevail widely. Not many weeks since, one who had received the usual amount of culture said, in my hearing, that the swarm of lady-birds which overspread the country some summers ago had been providentially designed to save the crop of hops from the destroying aphides. Of course this theory of the divine government, extended to natural occurrences bearing but indirectly, if at all, on human welfare, is applied with still greater confidence to occurrences that directly affect us individually and socially. It is a theory carried out with logical consistency by the Methodist who, before going on a journey or removing to another house, opens his Bible, and, in the first passage his eye rests upon, finds an intimation of approval or disapproval from Heaven. And in its political applications it yields such appropriate beliefs as that the welfare of England, in comparison with Continental States, has been a reward for better observance of the Sunday, or that an invasion of cholera was consequent on the omission of *Dei gratia* from an issue of coins.

The interpretation of historical events in general after this same method accompanies such interpretations of less important events; and, indeed, outlives them. Those to whom the natural genesis of similar phenomena has been made manifest by increasing knowledge, still believe in the supernatural genesis of phenomena that are very much involved, and cannot have their causes readily traced. The attitude of mind which, in an official dispatch, prompts the statement that "it has pleased Almighty God to vouchsafe to the British arms the most successful issue to the extensive combinations rendered necessary for the purpose of effecting the passage of the Chenaub,"[1] is an attitude of mind which, in the records of the past, everywhere sees interpositions of the Deity to bring about results that appear to the interpreter the most desirable. Thus, for example, Mr. Schomberg writes:

> "It seemed good to the All-beneficent Disposer of human events, to overrule every obstacle; and through His instrument, William of Normandy, to expurgate the evils of the land; and to resuscitate its dying powers."[2]

[1] Daily paper, January 22, 1849.

[2] The "Theocratic Philosophy of English History," vol. i., p. 49.

And elsewhere:

"The time had now arrived when the Almighty Governor, after having severely punished the whole nation, was intending to raise its drooping head—to give a more rapid impulse to its prosperity, and to cause it to stand forth more prominently as an EXEMPLAR STATE. For this end, He raised up an individual eminently fitted for the intended work [Henry VII.]." [1]

And again:

"As if to mark this epoch of history with greater distinctness, it was closed by the death of George III., the GREAT and the GOOD, who had been raised up as the grand instrument of its accomplishment." [2]

The late catastrophes on the Continent are similarly explained by a French writer who, like the English writer just quoted, professes to have looked behind the veil of things; and who tells us what have been the intentions of God in castigating his chosen people, the French. For it is to be observed in passing that, just as the evangelicals among ourselves think we are divinely blessed because we have preserved the purity of the faith, so it is obvious to the author of "*La Main de l'Homme et le Doigt de Dieu*," as to other Frenchmen, that France is hereafter still to be, as it has hitherto been, the leader of the world. This writer, in chapters entitled "Causes providentielles de nos malheurs," "Les Prussiens et les fléaux de Dieu," and "Justification de la Providence," carries out his interpretations in ways we need not here follow, and then closes his "Epilogue" with these sentences:

"The moderate Revolution, characterized by ability, sagacity, Machiavelism, diabolical wisdom, was vanquished and confounded by Divine Justice in the person and government of Napoleon III.

"The advanced Revolution, full of fervor and headlong audacity, was vanquished and confounded by Divine Justice in the persons and successive governments of Gambetta, Felix Pyat, etc.

"Human wisdom, now everywhere applauded and triumphant, personified by M. Thiers, will quickly be vanquished and confounded by this same Revolution, which, though twice laid low, still is ever springing up again, ever aggressive.

"This is no prophecy: 'tis the foresight of Christian philosophy and faith.

"Then will it be the opportunity of the Most High; for God and his Son must reign through His Gospel and through His Church.

"Frenchmen and Christians! Pray, work, suffer, and have confidence! We are near to the end. When all shall appear to be lost, then shall all be truly saved.

"If France could have known how to profit by the disasters she has suffered, God would have bestowed on her His chiefest favors. But she is stiff-necked in error and vice. Let us be assured that God will save her in spite of herself, regenerating her by water and by fire. When man is powerless, then it is that God's wisdom is displayed. But oh the tribulations, the anguish! Happy

[1] The "Theocratic Philosophy of English History," vol. i., p. 289.

[2] Ibid., vol. ii., p. 681.

they who shall live through all this distress, and who then shall share in the triumph of God, and of His holy Church, catholic, apostolic, and Roman." [1]

Conceptions of this kind are not limited to historians whose names have dropped out of remembrance, and to men who, while the drama of contemporary revolution is going on, play the part of a Greek chorus, telling the world of spectators what has been the divine purpose and what are the divine intentions; but we have lately had a professor of history setting forth conceptions essentially identical in nature. Here are his words:

"And now, gentlemen, was this vast campaign" (of Teutons against Romans) "fought without a general? If Trafalgar could not be won without the mind of a Nelson, or Waterloo without the mind of a Wellington, was there no one mind to lead those innumerable armies on whose success depended the future of the whole human race? Did no one marshal them in that impregnable convex front, from the Euxine to the North Sea? No one guide them to the two great strategic centres of the Black Forest and Trieste? No one cause them, blind barbarians without maps or science, to follow those rules of war without which victory in a protracted struggle is impossible; and, by the pressure of the Huns behind, force on their flagging myriads to an enterprise which their simplicity fancied at first beyond the powers of mortal men? Believe it who will: but I cannot. I may be told that they gravitated into their places, as stones and mud do. Be it so. They obeyed natural laws, of course, as all things do on earth, when they obeyed the laws of war: those, too, are natural laws, explicable on simple mathematical principles. But while I believe that not a stone or a handful of mud gravitates into its place without the will of God; that it was ordained, ages since, into what particular spot each grain of gold should be washed down from an Australian quartz-reef, that a certain man might find it at a certain moment and crisis of his life; if I be superstitious enough (as, thank God, I am!) to hold that creed, shall I not believe that, though this great war had no general upon earth, it may have had a general in heaven? and that, in spite of all their sins, the hosts of our forefathers were the hosts of God." [2]

It does not concern us here to seek a reconciliation of the seemingly incongruous ideas bracketed together in this paragraph—to ask how the results of gravitation, which acts with such uniformity that under given conditions its effect is calculable with certainty, can at the same time be regarded as the results of will, which we class apart because, as known in our experience, it is so irregular; or to ask how, if the course of human affairs is divinely predetermined just as material changes are, any distinction is to be drawn between that prevision of material changes which constitutes physical science and historical prevision: the reader may be left to evolve the obvious conclusion that either the current idea of physical causation has to be abandoned, or the current idea of will has to be abandoned. All which I need here call attention to, as indicating the general character of such historical

[1] "The Hand of Man and the Finger of God in the Misfortunes of France." By J. C., ex-chaplain in the auxiliary army.

[2] "The Roman and the Teuton," pp. 339, 340.

interpretations, is, the remarkable title of the chapter containing this passage—"The Strategy of Providence."

In common with some others, I have often wondered how the universe looks to those who use such names for its cause as "The Master Builder," or "The Great Artificer;" and who seem to think that the cause of the Universe is made more marvellous by comparing its operations to those of a skilled mechanic. But really the expression, "Strategy of Providence," reveals a conception of this cause which is in some respects more puzzling. Such a title as "The Great Artificer," while suggesting simply the process of shaping a preëxisting material, and leaving the question whence this material came untouched, may at any rate be said not to negative the assumption that the material is also created by the Great Artificer who shapes it. The phrase, "Strategy of Providence," however, necessarily implies difficulties to be overcome. The Divine Strategist must have a skilful antagonist to make strategy possible. So that we are inevitably introduced to the conception of a cause of the universe continually impeded by some independent cause which has to be outgeneralled. It is not every one who would thank God for a belief, the implication of which is that God is obliged to overcome opposition by subtle devices.

The disguises which piety puts on are, indeed, not unfrequently suggestive of that which some would describe by a quite opposite name. To study the Universe as it is manifested to us; to ascertain by patient observation the order of the manifestations; to discover that the manifestations are connected with one another after a regular way in time and space; and, after repeated failures, to give up as futile the attempt to understand the power manifested; is condemned as irreligious. And meanwhile the character of religious is claimed by those who figure to themselves a Creator moved by motives like their own; conceive themselves as discovering his designs; and even speak of him as though he laid plans to outwit the devil.

This, however, by the way. The foregoing extracts and comments are intended to indicate the mental attitude of those for whom there can be no such thing as Sociology, properly so called. That mode of conceiving human affairs which is implied alike by the "D. V." of a missionary-meeting placard and by the phrases of Emperor William's late dispatches, where thanks to God come next to enumerations of the thousands slain, is one to which the idea of a social science is entirely alien, and indeed repugnant.

An allied class, equally unprepared to interpret sociological phenomena scientifically, is the class which sees in the course of civilization little else than a record of remarkable persons and their doings. One who is conspicuous as the exponent of this view writes: "As I take it, universal history, the history of what man has accomplished in this world is at bottom the history of the great men who have worked here." And this, not perhaps distinctly formulated, but everywhere implied, is the belief in which nearly all men are brought up. Let us glance at the genesis of it.

Round their camp-fire assembled savages tell the events of the day's chase; and he among them who has done some feat of skill or agility is duly lauded. On a return from the war-path, the sagacity of the chief, and the strength or courage of this or that warrior, are the all-absorbing themes. When the day, or the immediate past, affords no remarkable deed, the topic is the achievement of some noted leader lately dead, or some traditional founder of the tribe: accompanied, it may be, with a dance dramatically representing those victories which the chant recites. Such narratives, concerning as they do the prosperity and indeed the very existence of the tribe, are of the intensest interest; and in them we have the common root of music, of the drama, of poetry, of biography, of history, and of literature in general. Savage life furnishes little else worthy of note; and the chronicles of tribes contain scarcely any thing more to be remembered. Early historic races show us the same thing. The Egyptian frescoes and the wall-sculptures of the Assyrians represent the deeds of their chief men; and inscriptions such as that on the Moabite stone tell of nothing more than royal achievements: only by implication do these records, pictorial, hieroglyphic, or written, convey any thing else. And similarly from the Greek epic: though we gather incidentally that there were towns, and war-vessels, and war-chariots, and sailors, and soldiers to be led and slain, yet the direct intention is to set forth the triumphs of Achilles, the prowess of Ajax, the wisdom of Ulysses, and the like. The lessons given to every civilized child tacitly imply, like the traditions of the uncivilized and semi-civilized, that throughout the past of the human race the doings of the leading persons have been the only things worthy to be chronicled. How Abraham girded up his loins and gat him to this place or that; how Samuel conveyed divine injunctions which Saul disobeyed; how David recounted his adventures as a shepherd, and was reproached for his misdeeds as a king—these, and personalities akin to these, are the facts about which the juvenile reader of the Bible is interested and respecting which he is catechised: such indications of Jewish institutions as have unavoidably got into the narrative being regarded neither by him nor by his teacher as of moment. So too, when, with hands behind him, he stands to say his lesson out of "Pinnock," we see that the things set down for him to learn are—when and by whom England was invaded; what rulers opposed the invasions and how they were killed; what Alfred did and what Canute said; who fought at Agincourt and who conquered at Flodden; which king abdicated and which usurped, etc.; and if by some chance it comes out that there were serfs in those days, that barons were local rulers, some vassals of others, that subordination of them to a central rule took place gradually, these are facts treated as relatively unimportant. Nay, the like happens when the boy passes into the hands of his classical master, at home or elsewhere. "Arms and the man" form the end of the story as they form its beginning. After the mythology, which of course is all-essential, come the achievements of rulers and soldiers from Agamemnon down to Cæsar: what knowledge is gained of social organization, manners, ideas, morals, being such only as the biographical statements involved. And the value of the knowledge is so ranked that while it would be a disgrace to be wrong about the amours of Zeus, and while ignorance concerning the battle of Marathon would be discreditable, it is excusable to know little or nothing of the social arrangements that preceded Lycurgus or the origin and functions of the Areopagus.

Thus the great-man theory of history finds everywhere a ready-prepared conception—is, indeed, but the definite expression of that which is latent in the thoughts of the savage, tacitly asserted in all early traditions, and taught to every child by multitudinous illustrations. The glad acceptance it meets with has sundry more special causes. There is, first, this universal love of personalities, which, active in the aboriginal man, dominates still—a love seen in the child which asks you to tell it a story, meaning, thereby, somebody's adventures; a love gratified in adults by police-reports, court-news, divorce-cases, accounts of accidents, and lists of births, marriages, and deaths; a love displayed even by conversations in the streets, where fragments of dialogue, heard in passing, prove that mostly between men, and always between women, the personal pronouns recur every instant. If you want roughly to estimate any one's mental calibre, you cannot do it better than by observing the ratio of generalities to personalities in his talk—how far simple truths about individuals are replaced by truths abstracted from numerous experiences of man and things. And, when you have thus measured many, you find but a scattered few likely to take any thing more than a biographical view of human affairs.

In the second place, this great-man theory commends itself as promising instruction along with gratification. Being already fond of hearing about people's sayings and doings, it is pleasant news that, to understand the course of civilization, you have only to read diligently the lives of conspicuous men. What can be a more acceptable doctrine than that while you are satisfying an instinct not very remotely allied to that of the village gossip—while you are receiving through print, instead of orally, remarkable facts concerning notable persons—you are gaining that knowledge which will make clear to you why things have happened thus or thus in the world, and will prepare you for forming a right opinion on each question coming before you as a citizen?

And then, in the third place, the interpretation of things thus given is so beautifully simple—seems so easy to comprehend. Providing you are content with conceptions that are out of focus, as most people's conceptions are, the solutions it yields appear quite satisfactory. Just as that theory of the Solar System, which supposes the planets to have been launched into their orbits by the hand of the Almighty, looks quite feasible so long as you do not insist on knowing exactly what is meant by the hand of the Almighty; and just as the special creation of plants and animals seems a satisfactory hypothesis until you try and picture to yourself definitely the process by which one of them is brought into existence; so the genesis of social phenomena through the agency of great men may be very comfortably believed so long as, resting in general notions, you do not ask for particulars.

But now, if, dissatisfied with vagueness, we demand that our ideas should be brought into focus and exactly defined, we discover the hypothesis to be utterly incoherent. If, not stopping at the explanation of social progress as due to the great man, we go back a step and ask whence comes the great man, we find that the theory breaks down completely. The question has two conceivable answers: his origin is supernatural, or it is natural. Is his origin supernatural? Then he is a deputy-god, and we have Theocracy once removed—or, rather, not removed at all; for we must then agree with Mr. Schomberg, quoted above, that "the determination of Cæsar to invade Britain" was divinely inspired, and that from him, down to "George III., the Great and the Good," the successive rulers were appointed to carry out successive designs. Is this an unacceptable solution? Then the origin of the great man is natural; and immediately he is thus recognized he must be classed with all other phenomena in the society that gave him birth, as a product of its antecedents. Along with the whole generation of which he forms a minute part—along with its institutions, language, knowledge, manners, and its multitudinous arts and appliances, he is a resultant of an enormous aggregate of causes that have been coöperating for ages. True, if you please to ignore all that common observation, verified by physiology, teaches—if you assume that two European parents may produce a Negro child, or that from woolly-haired prognathous Papuans may come a fair, straight-haired infant of Caucasian type—you may assume that the advent of the great man can occur anywhere and under any conditions. If, disregarding those accumulated results of experience which current proverbs and the generalizations of psychologists alike express, you suppose that a Newton might be born in a Hottentot family, that a Milton might spring up among the Andamanese, that a Howard or a Clarkson might have Fiji parents, then you may proceed with facility to explain social progress as caused by the actions of the great man. But if all biological science, enforcing all popular belief, convinces you that by no possibility will an Aristotle come from a father and mother with facial angles of fifty degrees, and that out of a tribe of cannibals, whose chorus in preparation for a feast of human flesh is a kind of rhythmical roaring, there is not the remotest chance of a Beethoven arising; then you must admit that the genesis of the great man depends on the long series of complex influences which has produced the race in which he appears, and the social state into which that race has slowly grown. If it be a fact that the great man may modify his nation in its structure and actions, it is also a fact that there must have been those antecedent modifications constituting national progress before he could be evolved. Before he can remake his society, his society must make him. So that all those changes of which he is the proximate initiator have their chief causes in the generations which gave him birth. If there is to be any thing like a real explanation of these changes, it must be sought in that aggregate of conditions out of which both he and they have arisen.

Even were we to grant the absurd supposition that the genesis of the great man does not depend on the antecedents furnished by the society he is born in, there would still be the quite-sufficient facts that he is powerless in the absence of the material and mental accumulations which his society inherits from the past, and that he is powerless in the absence of the coexisting population, character, intelligence, and social arrangements. Given a Shakespeare, and what dramas could he have written without the multitudinous traditions of civilized life—without the various experiences which, descending to him from the past, gave wealth to his thought, and without the language which a hundred generations had developed and enriched by use? Suppose a Watt, with all his inventive power, living in a tribe ignorant of iron, or in a tribe that could get only as much iron as a fire blown by hand-bellows will smelt; or suppose him born among ourselves before lathes existed; what chance would there have been of the steam-engine? Imagine a Laplace unaided by that slowly-developed system of Mathematics which we trace back to its beginnings among the Egyptians; how far would he have got with the "*Mécanique Céleste?*" Nay, the like questions may be put and have like answers, even if we limit ourselves to those classes of great men on whose doings hero-worshippers more particularly dwell—the conquering rulers and generals. Xenophon could not have achieved his celebrated feat had his Ten Thousand been feeble, or cowardly, or insubordinate. Cæsar would never have made his conquests without disciplined troops inheriting their *prestige* and tactics and organization from the Romans who lived before them. And, to take a recent instance, the strategical genius of Moltke would have gained no great campaigns had there not been a nation of some forty millions to supply soldiers, and had not those soldiers been men of strong bodies, sturdy characters, obedient natures, and capable of carrying out orders intelligently.

Were any one to marvel over the potency of a grain of detonating powder, which explodes a cannon, propels the shell, and sinks a vessel hit—were he to enlarge on the transcendent virtues of this detonating powder, not mentioning the ignited charge, the shell, the cannon, and all that enormous aggregate of appliances by which these have severally been produced, detonating powder included, we should not regard his interpretation as very rational. But it would fairly compare in rationality with this interpretation of social phenomena which, dwelling on the important changes which the great man works, ignores that immense preëxisting supply of latent power which he unlocks, and that immeasurable accumulation of antecedents to which both he and this power are due.

Recognizing what truth there is in the great-man theory of history, we may say that, if limited to early societies, the histories of which are histories of little else than endeavors to destroy or subjugate one another, it approximately expresses the fact in representing the capable leader as all-important; though even here it leaves out of sight too much the number and the quality of his followers. But its immense error lies in the assumption that what was once true is true forever; and that a relation of ruler and ruled which was possible and good at one time is possible and good for all time. Just as fast as this predatory activity of early tribes diminishes, just as fast as larger aggregates are formed by conquest or otherwise, just as fast as war ceases to be the business of the whole male population, so fast do societies begin to develop, to show traces of structures and functions not before possible, to acquire increasing complexity along with increasing size, to give origin to new institutions, new activities, new ideas, sentiments, and habits: all of which unobtrusively make their appearance without the thought of any king or legislator. And if you wish to understand these phenomena of social evolution, you will not do it though you should read yourself blind over the biographies of all the great rulers on record, down to Frederick the Greedy and Napoleon the Treacherous.

In addition to that passive denial of a Social Science implied by these two allied doctrines, one or other of which is held by nine men out of ten, there comes from a few an active denial of it—either entire or partial. Reasons are given for the belief that no such thing is possible. The essential invalidity of these reasons can be shown only after the essential nature of Social Science, overlooked by those who make them, has been pointed out; and to point this out here would be to forestall the argument. Some minor criticisms, may, however, fitly precede the major criticism. Let us consider first the positions taken up by Mr. Froude:

> "When natural causes are liable to be set aside and neutralized by what is called volition, the word Science is out of place. If it is free to a man to choose what he will do or not do, there is no adequate science of him. If there is a science of him, there is no free choice, and the praise or blame with which we regard one another is impertinent and out of place." [1]

[1] "Short Studies on Great Subjects," vol. i., p. 11.

"It is in this marvellous power to do wrong . . . . that the impossibility stands of forming scientific calculations of what men will do before the fact, or scientific explanations of what they have done after the fact."[1]

Mr. Buckle "would deliver himself from the eccentricities of this and that individual by a doctrine of averages. . . . Unfortunately, the average of one generation need not be the average of the next. . . . No two generations are alike."[2]

"There" (in history) "the phenomena never repeat themselves. There we are dependent wholly on the record of things said to have happened once, but which never happen or can happen a second time. There no experiment is possible; we can watch for no recurring fact to test the worth of our conjectures."[3]

Here Mr. Froude chooses, as the ground on which to join issue, the old battle-ground of free-will *versus* necessity: declaring a Social Science to be incompatible with free-will. The first extract implies, not simply that individual volition is incalculable—that "there is no adequate science of" man, no science of Psychology; but it also asserts, by implication, that there are no causal relations among his states of mind: the volition by which "natural causes are liable to be set aside," being put in antithesis to natural, must be supernatural. Hence we are, in fact, carried back to that primitive form of interpretation contemplated at the outset.

A further comment is, that because volitions of some kinds cannot be foreseen, Mr. Froude concludes that no volitions can be foreseen: ignoring the fact that the simple volitions determining ordinary conduct are so regular that prevision having a high degree of probability is easy. If, in crossing a street, a man sees a carriage coming upon him, you may safely assert that, in nine hundred and ninety-nine cases out of a thousand, he will try to get out of the way. If, being pressed to catch a train, he knows that by one route it is a mile to the station and by another two miles, you may conclude with considerable confidence that he will take the one-mile route; and, should he be aware that losing the train will lose him a fortune, it is pretty certain that, if he has but ten minutes to do the mile in, he will either run or call a cab. If he can buy next door a commodity of daily consumption better and cheaper than at the other end of the town, we may affirm that, if he does not buy next door, some special relation between him and the remoter shopkeeper furnishes a strong reason for taking a worse commodity at greater cost of money and trouble. And though, if he has an estate to dispose of, it is within the limits of possibility that he will sell it to A for £1,000 though B has offered £2,000 for it; yet the unusual motives leading to such an act need scarcely be taken into account as qualifying the generalization that a man will habitually sell to the highest bidder. Now, since the predominant activities of citizens are determined by motives of this degree of regularity, there

[1] "Short Studies on Great Subjects," vol. i., p. 24.
[2] Ibid., vol. i., p. 22. [3] Ibid., vol. i., p. 15.

must be resulting social phenomena that have corresponding degrees of regularity—greater degrees, in fact; since in them the effects of exceptional motives become lost in the effects of the aggregate of ordinary motives.

Another comment may be added. Mr. Froude exaggerates the antithesis he draws by using a conception of science which is far too narrow—a conception seemingly limited to *exact* science. Scientific previsions, both qualitative and quantitative, have various degrees of definiteness; and, because among certain classes of phenomena the previsions are but approximate, it is not, therefore, to be said that there is no science of those phenomena: if there is some prevision, there is some science. Take, for example, Meteorology. The Derby has been run in a snow-storm, and you may occasionally want a fire in July; but such anomalies do not prevent us from being perfectly certain that the coming summer will be warmer than the past winter. Our south-westerly gales in the autumn may come early or may come late, may be violent or moderate, at one time or at intervals; but that winds will be in excess from that quarter at that part of the year we may be quite sure: and similarly with the northeasterly winds during the spring and early summer. The like holds with the relations of rain and dry weather to the quantity of water in the air and the weight of the atmospheric column: though exactly true predictions cannot be made, approximately true ones can. So that, even were there not among social phenomena more definite relations than these (and the all-important ones are far more definite), there would still be a Social Science.

Once more, Mr. Froude contends that the facts presented in history do not furnish subject-matter for science, because they "never repeat themselves," because "we can watch for no recurring fact to test the worth of our conjectures." I will not meet this assertion by the counter-assertion often made, that historic phenomena *do* repeat themselves; but, admitting that Mr. Froude here touches on one of the great difficulties of the Social Science (that social phenomena are in so considerable a degree different in each case from what they were in preceding cases), I still find a sufficient reply. For in no concrete science is there any absolute repetition; and in some concrete sciences the repetition is no more specific than in Sociology. Even in the most exact of them, Astronomy, the combinations are never the same twice over: the repetitions are but approximate. And on turning to Geology, we find that, though the processes of denudation, deposition, upheaval, subsidence, have been ever going on in conformity with laws more or less clearly generalized, the effects have been always new in their proportions and arrangements; though not so completely new as to forbid comparisons, consequent deductions, and approximate previsions based on them.

Were there no such replies as these to Mr. Froude's reasons, there would still be the reply furnished by his own interpretations of history; which make it clear that his denial must be understood as but a qualified one. Against his professed theory may be set his actual practice, which, as it seems to me, tacitly asserts that explanations of some social phenomena in terms of cause and effect are possible, if not explanations of all social phenomena. Thus, respecting the Vagrancy Act of 1547, which made a slave of a confirmed vagrant, Mr. Froude says: "In the condition of things which was now commencing . . . . neither this nor any other penal act against idleness could be practically enforced."[1] That is to say, the operation of an agency brought into play was neutralized by the operation of natural causes coexisting. Again, respecting the enclosure of commons and amalgamation of farms, etc., Mr. Froude writes: "Under the late reign these tendencies had, with great difficulty, been held partially in check, but on the death of Henry they acquired new force and activity."[2] Or, in other words, certain social forces previously antagonized by certain other forces produced their natural effects when the antagonism ceased. Yet again, Mr. Froude explains that "unhappily, two causes" (debased currency and an alteration of the farming system) "were operating to produce the rise of prices."[3] And throughout Mr. Froude's "History of England" there are, I need scarcely say, other cases in which he ascribes social changes to causes rooted in human nature; though, in the lecture from which I have quoted, he alleges the "impossibility of forming scientific calculations of what men will do before the fact, or scientific explanations of what they have done after the fact."

Another writer who denies the possibility of a Social Science, or who at any rate admits it only as a science that has its relations of phenomena so traversed by providential influences that it does not come within the proper definition of a science, is Canon Kingsley. In his address on the "Limits of Exact Science as appled to History" he says:

"You say that, as the laws of matter are inevitable, so probably are the laws of human life? Be it so: but in what sense are the laws of matter inevitable? Potentially or actually? Even in the seemingly most uniform and universal law, where do we find the inevitable or the irresistible? Is there not in Nature a perpetual competition of law against law, force against force, producing the most endless and unexpected variety of results? Cannot each law be interfered with at any moment by some other law, so that the first law, though it may struggle for the mastery, shall be for an indefinite time utterly defeated? The law of gravity is immutable enough: but do all stones veritably fall to the ground? Certainly not, if I choose to catch one, and keep it in my hand. It remains there by laws; and the law of gravity is there, too, making it feel heavy in my hand: but it has not fallen to the ground, and will not, till I let it. So much for the inevitable action of the laws of gravity, as of others. Potentially, it is immutable; but actually, it can be conquered by other laws."[4]

[1] "History of England," vol. v., p. 70.
[2] Ibid., vol. v., p. 108.
[3] Ibid., vol. v., p. 109
[4] Page 20.

This passage, severely criticised, if I remember rightly, when the address was originally published, it would be scarcely fair to quote, were it not that Canon Kingsley has repeated it at a later date in his work, "The Roman and the Teuton." The very unusual renderings of scientific ideas which it contains need here be only enumerated. Mr. Kingsley differs profoundly from philosophers and men of science, in regarding a law as itself a power or force, and so in thinking of one law as "conquered by other laws;" whereas the accepted conception of law is that of an established *order*, to which the manifestations of a power or force conform. He enunciates, too, a quite exceptional view of gravitation. As conceived by astronomers and physicists, gravitation is a universal and ever-acting *force*, which portions of matter exercise on one another when at sensible distances; and the *law* of this force is that it varies inversely as the square of the distance. Mr. Kingsley's view, however, appears to be that the law of gravitation is "defeated" if a stone is prevented from falling to the ground—that the law "struggles" (not the force), and that because it no longer produces motion, the "inevitable action of the laws of gravity" (not of gravity) is suspended: the truth being that neither the force nor its law is in the slightest degree modified. Further, the theory of natural processes which Mr. Kingsley has arrived at seems to be, that when two or more forces (or laws, if he prefers it) come into play, there is a partial or complete suspension of one by another. Whereas, the doctrine held by men of science is, that the forces are all in full operation, and the effect is their resultant; so that, for example, when a shot is fired horizontally from a cannon, the force impressed on it produces in a given time just the same amount of horizontal motion as though gravity were absent, while gravity produces in that same time a fall just equal to that which it would have produced had the shot been dropped from the mouth of the cannon. Of course, holding these peculiar views of causation as displayed among simple physical phenomena, Canon Kingsley is consistent in denying historical sequence; and in saying that, "as long as man has the mysterious power of breaking the laws of his own being, such a sequence not only cannot be discovered, but it cannot exist."[1] At the same time it is manifest that, until he comes to some agreement with men of science respecting conceptions of forces, of their laws, and of the modes in which phenomena produced by compositions of forces are interpretable in terms of compound laws, no discussion of the question at issue can be carried on with profit.

Without waiting for such an agreement, however, which is probably somewhat remote, Canon Kingsley's argument may be met by putting side by side with it some of his own conclusions set forth elsewhere. In an edition of "Alton Locke" published since the delivery of the address above quoted from, there is a new preface, containing, among others, the following passages:

[1] Page 22.

"The progress toward institutions more and more popular may be slow, but it is sure. Whenever any class has conceived the hope of being fairly represented, it is certain to fulfil its own hopes, unless it employs or provokes, violence, impossible in England. The thing will be[1] . . . .

"If any young gentlemen look forward . . . . to a Conservative reaction of any other kind than this . . . . to even the least stoppage of what the world calls progress—which I should define as the putting in practice the results of inductive science—then do they, like King Picrochole in Rabelais, look for a kingdom which shall be restored to them at the coming of the Cocqcigrues."[2]

And in a preface addressed to working-men, contained in an earlier edition, he says:—

"If you are better off than you were in 1848, you owe it principally to those laws of political economy (as they are called) which I call the brute natural accidents of supply and demand, etc."[3]

Which passages offer explanations of changes now gone by as having been wrought out by natural forces in conformity with natural laws, and also predictions of changes which social forces at present in action will work out. That is to say, by the help of generalized experiences there is an interpretation of past phenomena and a prevision of future phenomena. There is an implicit recognition of that Social Science which is explicitly denied.

A reply to these criticisms may be imagined. In looking for whatever reconciliation seems possible between these positions, which seem so incongruous, we must suppose the intended assertion to be, that general interpretations and previsions only can be made, not those which are special. Bearing in mind Mr. Froude's occasional explanations of historical phenomena as naturally caused, we must conclude that he believes certain classes of sociological facts (as the politico-economical) to be scientifically explicable, while other classes are not; though, if this be his view, it is not clear how, if the results of men's wills, separate or aggregated, are incalculable, politico-economical actions can be dealt with scientifically, since, equally with other social actions, they are determined by aggregated wills. Similarly, Canon Kingsley, recognizing no less distinctly economical laws, and enunciating also certain laws of progress—nay, even warning his hearers against the belief that he denies the applicability of the inductive method to social phenomena—must be assumed to think that the applicability of scientific methods is here but partial. Citing the title of his address, he will possibly hold its implication to be merely that there are limits to the explanation of social facts in precise ways; though this position does not seem really reconcilable with the doctrine that social laws are liable to be at any time suspended, providentially or otherwise.

[1] "Alton Locke," new edition, preface, p. xxi.
[2] Ibid., pp. xxiii., xxiv.
[3] Ibid., preface (1854), p. xxvii.

But, merely hinting these collateral criticisms, this reply is to be met by the demurrer that it is beside the question. If the sole thing meant is that sociological previsions can be approximate only—if the thing denied is the possibility of reducing Sociology to the form of an exact science—then the rejoinder is, that the thing denied is a thing which no one has affirmed. Only a moiety of science is exact science—only phenomena of certain orders have had their relations developed from the qualitative form into the quantitative form. Of the remaining orders there are some produced by factors so numerous and so difficult to measure, that development of their relations into the quantitative form is extremely improbable, if not impossible. But these orders of phenomena are not therefore excluded from the conception of Science. In Geology, in Biology, in Psychology, most of the previsions are qualitative only; and where they are quantitative their quantitativeness, never quite definite, is mostly very indefinite. Nevertheless we unhesitatingly class these previsions as scientific. Similarly with Sociology. The phenomena it presents, involved in a higher degree than all others, are less than all other capable of precise treatment: such of them as can be generalized, can be generalized only within wide limits of variation as to time and amount; and there remains much that cannot be generalized. But, so far as there can be generalization, and so far as there can be interpretation based on it, so far there can be science. Whoever expresses political opinions—whoever asserts that such or such public arrangements will be beneficial or detrimental, tacitly expresses a belief in Social Science; for he asserts, by implication, that there is a natural sequence among social actions, and that, as the sequence is natural, results may be foreseen.

Reduced to a more concrete form, the case may be put thus: Mr. Froude and Canon Kingsley both believe to a considerable extent in the efficiency of legislation—probably to a greater extent than it is believed in by some of those who assert the existence of a Social Science. To believe in the efficiency of legislation is to believe that certain prospective penalties or rewards will act as deterrents or incentives—will modify individual conduct, and therefore modify social action. Though it may be impossible to say that a given law will produce a foreseen effect on a particular person, yet no doubt is felt that it will produce a foreseen effect on the mass of persons. Though Mr. Froude, when arguing against Mr. Buckle, says that he "would deliver himself from the eccentricities of this and that individual by a doctrine of averages," but that "unfortunately, the average of one generation need not be the average of the next;" yet Mr. Froude himself so far believes in the doctrine of averages as to hold that legislative interdicts, with threats of death or imprisonment behind them, will restrain the great majority of men in ways which can be predicted. While he contends that the results of individual will are incalculable, yet, by approving certain laws and condemning others, he tacitly affirms that the results of the aggregate of wills are calculable. And, if this be asserted of the aggregate of wills as affected by legislation, it must be asserted of the aggregate of wills as affected by social influences at large. If it be held that the desire to avoid punishment will so act on the average of men as to produce an average foreseen result; then it must also be held that, on the average of men, the desire to get the greatest return for labor, the desire to rise into a higher rank of life, the desire to gain applause, and so forth, will each of them produce a certain average result. And to hold this is to hold that there can be prevision of social phenomena, and therefore Social Science.

In brief, then, the alternative positions are these: On the one hand, if there is no natural causation throughout the actions of incorporated humanity, government and legislation are absurd. Acts of Parliament may, as well as not, be made to depend on the drawing of lots or the tossing of a coin; or rather there may as well be none at all: social sequences having no ascertainable order, no effect can be counted upon—every thing is anarchic. On the other hand, if there is such natural causation, then the combination of forces, by which every effect or combination of effects is produced, produces them in conformity with the laws of the forces. And if so, it behooves us to use all diligence in ascertaining what the forces are, what are their laws, and what are the ways in which they coöperate.

Such further elucidation as is possible will be gained by discussing the question to which we now address ourselves—the Nature of the Social Science. Along with a definite idea of this, will come a perception that the denial of a Social Science has arisen from the confusing of two essentially different classes of phenomena which societies present—the one class, almost ignored by historians, constituting the subject-matter of Social Science, and the other class, almost exclusively occupying them, admitting of scientific coördination in a very small degree, if at all.

EFFECTS OF FAULTY VISION IN PAINTING.[1]

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WHEN I arrived in England about eighteen months ago, little thinking that a short vacation tour would end in my permanent residence here, I at once paid a visit to the National Gallery. I was anxious to see Turner's pictures, which on the Continent I had had no opportunity of doing. How great was my astonishment when, after

[1] A lecture delivered at the Royal Institution on March 8, 1872.

having admired his earlier works, I entered another room which contained his later paintings! Are these really by the same hand? I asked myself on first inspecting them; or have they suffered in any way? On examining them, however, more closely, a question presented itself to my mind which was to me a subject of interesting diagnosis. Was the great change, which made the painter of "Crossing the Brook" afterward produce such pictures as "Shade and Darkness," caused by an ocular or cerebral disturbance? Researches into the life of Turner could not afford an answer to this question. All that I could learn was, that during the last five years of his life his power of vision as well as his intellect had suffered. In no way, however, did this account for the changes which began to manifest themselves about fifteen years before that time. The question could therefore only be answered by a direct study of his pictures from a purely scientific, and not at all from an æsthetic or artistic point of view.

I chose for this purpose pictures belonging to the middle of the period which I consider pathological, i. e., not quite healthy, and analyzed them in all their details, with regard to color, drawing, and distribution of light and shade.

It was particularly important to ascertain if the anomaly of the whole picture could be deduced from a regularly-recurring fault in its details. This fault is a vertical streakiness, which is caused by every illuminated point having been changed into a vertical line. The elongation is, generally speaking, in exact proportion to the brightness of the light; that is to say, the more intense the light which diffuses itself from the illuminated point in Nature, the longer becomes the line which represents it on the picture. Thus, for instance, there proceeds from the sun in the centre of a picture a vertical yellow streak, dividing it into two entirely distinct halves, which are not connected by any horizontal line. In Turner's earlier pictures, the disk of the sun is clearly defined, the light equally radiating to all parts; and, even where through the reflection of water a vertical streak is produced, there appears, distinctly marked through the vertical streak of light, the line of the horizon, the demarcation of the land in the foreground, and the outline of the waves in an horizontal direction. In the pictures, however, of which I am now speaking, the tracing of any detail is perfectly effaced when it falls in the vertical streak of light. Even less illuminated objects, like houses or figures, form considerably elongated streaks of light. In this manner, therefore, houses that stand near the water, or people in a boat, blend so entirely with the reflection in the water, that the horizontal line of demarcation between house and water or boat and water entirely disappears, and all becomes a conglomeration of vertical lines. Every thing that is abnormal in the shape of objects, in the drawing, and even in the coloring of the pictures of this period, can be explained by this vertical diffusion of light.

How and at what time did this anomaly develop itself?

Till the year 1830 all is normal. In 1831 a change in the coloring becomes for the first time perceptible, which gives to the works of Turner a peculiar character not found in any other master. Optically this is caused by an increased intensity of the diffused light proceeding from the most illuminated parts of the landscape. This light forms a haze of a bluish color which contrasts too much with the surrounding portion in shadow. From the year 1833 this diffusion of light becomes more and more vertical. It gradually increases during the following years. At first it can only be perceived by a careful examination of the picture, but from the year 1839 the regular vertical streaks become apparent to every one. This increases subsequently to such a degree that, when the pictures are closely examined, they appear as if they had been wilfully destroyed by vertical strokes of the brush before they were dry, and it is only from a considerable distance that the object and the meaning of the picture can be comprehended. During the last years of Turner's life, this peculiarity became so extreme that his pictures can hardly be understood at all.

It is a generally-received opinion that Turner adopted a peculiar manner, that he exaggerated it more and more, and that his last works are the result of a deranged intellect. I am convinced of the incorrectness, I might almost say of the injustice, of this opinion. The word "manner" has a very vague meaning. In general we understand by it something which has been arbitrarily assumed by the artist. It may be the result of study, of reflection, of a development of principle, or the consequence of a chance observation, of an experiment, or of an occasional success. Nothing of all this applies to what has been called Turner's manner. Nothing in him is arbitrary, assumed, or of set purpose. According to my opinion, his manner is exclusively the result of a change in his *eyes*, which developed itself during the last twenty years of his life. In consequence of it the aspect of Nature gradually changed for him, while he continued in an unconscious, I might almost say in a *naïve* manner, to reproduce what he saw. And he reproduced it so faithfully and accurately, that he enables us distinctly to recognize the nature of the disease of his eyes, to follow its development step by step, and to prove by an optical contrivance the correctness of our diagnosis. By the aid of this contrivance we can see Nature under the same aspect as he saw and represented it. With the same we can also, as I shall prove to you by an experiment, give to Turner's early pictures the appearance of those of the later period.

After he had reached the age of fifty-five, the crystalline lenses of Turner's eyes became rather dim, and dispersed the light more strongly, and in consequence threw a bluish mist over illuminated objects. This is a pathological increase of an optical effect, the existence of which, even in the normal eye, can be proved by the following experiment:

If you look at a picture which hangs between two windows, you will not be able to see it distinctly, as it will be, so to speak, veiled by a grayish haze. But, if you hold your hands before your eyes so as to shade them from the light of the windows, the veiling mist disappears, and the picture becomes clearly visible. The disturbing light had been diffused by the refracting media of the eye, and had fallen on the same part of the retina on which the picture was formed. If we examine the eye by an illumination resembling that by means of which Prof. Tyndall, in his brilliant experiments, demonstrated to you the imperfect transparency of water, we find that even the clearest and most beautiful eye is not so perfectly transparent as we would suppose. The older we get the more the transparency decreases, especially of the lens. But, to produce an effect equal to that visible in Turner's pictures after the year 1831, pathological conditions are required. In the years that followed, as often happens in such cases, a clearly-defined opacity was formed in the slight and diffuse dimness of the crystalline lens. In consequence of this the light was no longer evenly diffused in all directions, but principally dispersed in a vertical direction. At this period the alteration offers, in the case of a painter, the peculiarity that it only affects the appearance of natural objects, where the light is strong enough to produce this disturbing effect, while the light of his painting is too feeble to do so: therefore, the aspect of Nature is altered; that of his picture correct. Only within the last years of Turner's life, the dimness had increased so much, that it prevented him from seeing even his pictures correctly. This sufficiently accounts for the strange appearance of his last pictures, without its being necessary to take into account the state of his mind.

It may seem hazardous to designate a period as diseased, the beginning of which art-critics and connoisseurs have considered as his climax. I do not think that the two opinions are in decided contradiction to each other. To be physiologically normal is not at all a fundamental condition in art; and we cannot deny the legitimacy of the taste which regards that which is entirely sound and healthy as commonplace, trivial, and uninteresting, and which on the contrary is fascinated by that which approaches the border of disease and even goes beyond it.

Many of the best musicians, for instance, and some of the greatest admirers of Beethoven, prefer his latest works, and consider them the most interesting, although the influence of his deafness upon them is apparent to others.

In poetry, we rank some poems among the highest productions of art, in which the imagination of the poet goes far beyond the normal region of the mind:

> "The poet's eye, in a fine frenzy rolling,
> Doth glance from heaven to earth, from earth to heaven."

Thus it seems to me perfectly natural that the peculiar poetical haze which is produced by the diffusion of light in Turner's pictures after 1831 should have a particular attraction for many of Turner's admirers. On the other hand, passing over the faults, we discover in these pictures peculiar merits, and we recognize that the great artist continued in many ways to improve, even at a time of his life when his failing sight began to deprive his works of general favor. I cannot, however, defend the opinion of those who are enraptured with Turner's pictures belonging to a still later period—who consider a picture beautiful which, in consequence of this optical defect, is entirely disfigured and defaced, and who, calling this Turner's style, would like to form it into a school and imitate it. They resemble the porter of a certain dealer in works of art, who one day, when he had to deliver the torso of a Venus at a gentleman's house, answered the servant, who had expressed his astonishment that his master should have bought a thing without head, arms, or legs, "You don't understand; that's just the beauty of it."

I show you here first a picture which is copied from an oil-painting in the South-Kensington Museum. This picture was not exhibited till the year 1833, but it was painted some time before, and from sketches taken in Venice previous to any change in Turner's sight. I shall now try so to change this picture, by an optical contrivance, as to make it resemble the pictures he painted after 1839. You must, of course, not expect to see in this rough representation, which a large theatre necessitates, any thing of the real beauty of Turner's pictures. Our object is to analyze their faults.

In order to show you in a single object what you have already observed in the general aspect of a picture, I choose purposely a tree, because there are no trees in the "Venice" you have just seen, and more particularly because after the year 1833 Turner painted trees that were unknown to any botanist, had never been seen in Nature, nor been painted by any other artist. I do not think it likely that Turner invented a tree he had never seen; it seems to me more probable that he painted such trees because he saw them so in Nature. I searched for them with the aid of the lens, and soon discovered them. Here is a common tree; the glass changes it into a Turner tree.

Let us now turn from the individual case of a great artist to a whole category of cases, in which the works of painters are modified by anomalies in their vision—I mean cases of irregularities in the refraction of the eye. The optical apparatus of the eye forms, like the apparatus of a photographer, inverted images. In order to be seen distinctly, these images must fall exactly upon the retina. The capacity of the eye to accommodate itself to different consecutive distances, so as to receive on the retina distinct images of objects, is called accommodation. This faculty depends upon the power of the crystalline lens to change its form. The accommodation is at its greatest tension if we adapt our eye to the nearest point. It is, on the contrary, in complete repose if we adapt it to the farthest point. The optical state of the eye during its adaptation for the farthest point, when every effort of accommodation is completely suspended, is called its refraction.

There are three different kinds of refraction: firstly, that of the normal eye; secondly, ot the short-sighted eye; thirdly, of the over-sighted eye:

1. The normal eye, when the activity of its accommodation is perfectly suspended, is adjusted for the infinite distance; that is to say, it unites upon the retina parallel rays of light.

2. The short-sighted eye has, in consequence of an extension of its axis, a stronger refraction, and unites, therefore, in front of the retina the rays of light which proceed from infinite distance. In order to be united upon the retina itself, the rays of light must be divergent; that is to say, they must come from a nearer point. The more short-sighted the eye is, the stronger must be the divergence; such an eye, in order to see distinctly distant objects, must make the rays from a distant object more divergent, by aid of a concave glass. We determine the degree of short-sightedness by the power of the weakest concave glass that enables the eye to see distinctly at a great distance.

3. The over-sighted, or hypermetropic eye, on the contrary, has too weak a refraction: it unites convergent rays of light upon the retina; parallel or divergent rays of light it unites behind the retina, unless an effort of accommodation is made. The degree of hypermetropy, or over-sightedness, is determined by the focal distance of the strongest convex glass with which objects can still be distinctly seen at a great distance.

Hypermetropy has no essential influence upon painting; it only reduces the power of application, and must therefore be corrected by wearing convex glasses. This can never be avoided if the hypermetropy is so great as to diminish the distinctness of vision. Short-sightedness, on the contrary, generally influences the choice of the subject of the artist and also the manner of its execution. As a very small handwriting is an indication of short-sightedness, so we find that artists who paint small pictures, and finish the details with great minuteness, and with fine touches of the brush, are mostly short-sighted.

Sometimes the shape of the eye diverges from its normal spherical form, and this is called astigmatism. This has only been closely investigated since Airy discovered it in his own eye. Figure to yourself meridians drawn on the eye as on a globe, so that one pole is placed in front: then you can define astigmatism as a difference in the curvature of two meridians, which may, for instance, stand perpendicularly upon each other; the consequence of which is a difference in the power of refraction of the eye in the direction of the two meridians. An eye may, for instance, have a normal refraction in its horizontal meridian, and be short-sighted in its vertical meridian. Small differences of this kind are found in almost every eye, but are not perceived. Higher degrees of astigmatism, which decidedly disturb vision, are, however, not uncommon, and are, therefore, also found among painters. I have had occasion to examine the eyes of several distinguished artists which presented such an anomaly, and it interested me much to discover what influence this defect had upon their works. The diversity depends in part upon the degree and nature of the optical anomaly, but its effect shows itself in different ways, according to the subjects the artist paints. An example will explain this better. I know a landscape-painter and a portrait-painter who have both the same kind of astigmatism; that is, the refraction of the vertical meridian differs from the refraction of the horizontal one. The consequence is, that their sight is normal for vertical lines, but for horizontal lines they are

Fig. 1.

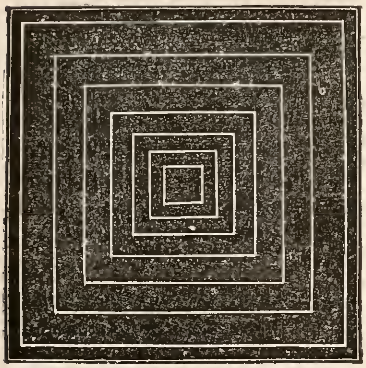
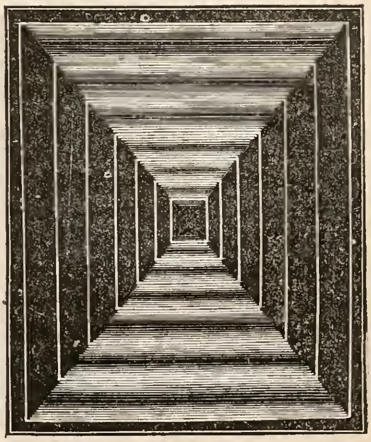


Fig. 2.

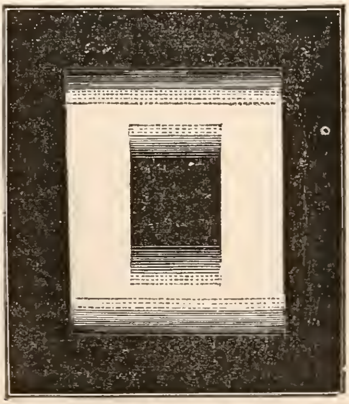


slightly short-sighted. Upon the landscape-painter this has hardly any disturbing influence. In painting distant views, sharp outlines are not requisite, but rather undefined and blending tones of color. His eye is sufficiently normal to see these. I was struck, however, by the fact that the foreground of his pictures, which generally represents water with gently-moving waves, was not painted with the same truthfulness to Nature as the middle and background. There I found short horizontal strokes of the brush in different colors, which did not seem to belong to the water. I therefore examined the picture with a glass, which, when added to my eye, produced the same degree of astigmatism as existed in the painter's eye, and the whole picture appeared much more beautiful, the foreground being now as perfect as the middle and background. In consequence of this artificially-produced astigmatism, I saw the horizontal strokes of the brush indistinctly, and so mixed together that through them the color and transparency of the water were most exquisitely rendered.

Upon the portrait-painter astigmatism had a very different influence. He was held in high esteem in Paris, on account of his excellent grasp of character and intellectual individuality. His admirers considered even the material resemblance of his portraits as perfect; most people, however, thought he had intentionally neglected the material likeness by rendering in an indistinct and vague manner the details of the features and the forms. A careful analysis of the picture shows that this indistinctness was not at all intentional, but simply the consequence of astigmatism. Within the last few years, the portraits of this painter have become considerably worse, because the former indistinctness has grown into positively false proportions. The neck and oval of the face appear in all his portraits considerably elongated, and all details are in the same manner distorted. What is the cause

Fig. 3.

Fig. 4.



of this? Has the degree of his astigmatism increased? No; this does not often happen: but the effect of astigmatism has doubled, and this has happened in the following manner: An eye which is normal as regards the vision of vertical lines, but short-sighted for horizontal lines, sees the objects elongated in a vertical direction. When the time of life arrives that the normal eye becomes far-sighted, but not yet the short-sighted eye, this astigmatic eye will at short distance see the vertical lines indistinctly, but horizontal lines still distinctly; and, therefore, near objects will be elongated in an horizontal direction. The portrait-painter, in whom a slight degree of astigmatism manifested itself at first only by the indistinctness of the horizontal lines, has now become far-sighted for vertical lines, and therefore sees a distant person elongated in a vertical direction; his picture, on the contrary, being at a short distance, is seen by him enlarged in an horizontal direction, and is thus painted still more elongated than the subject is seen: so the fault is doubled. I shall be able to show this more clearly by experiments.

The vertical and horizontal lines of the diagram (Fig. 1) are reflected with equal distinctness upon the screen by the spherical apparatus.

Those among my audience who have a decided form of astigmatism will, nevertheless, see them differently. Those whose sight is normal will only observe a difference after I have added a cylindrical lens to this apparatus, and thus made it astigmatical (Fig. 2). Ordinary spectacle-glasses are worked by a rotating movement on the surface of a sphere; cylindrical lenses are worked by moving the glass backward and forward upon a cylindrical surface. Such glasses produce an optical effect only in one direction. If instead of white lines I make the experiment with colored lines, it will show the mixing of colors produced by astigmatism; and if I now turn the axis of the lens, you will observe the effect of different forms of astigmatism. I show you a square (Fig. 3): if I add a cylindrical concave glass, with its axis placed horizontally, the square becomes an oblong.

In order now to show you how it is possible that the same eye may see an object at too great a distance elongated in a vertical direction, and, on the contrary, one that is too near enlarged in an horizontal direction, I need only place this cylindrical glass before or behind the focus of the apparatus without turning the axis, and you will then see the square, first elongated in a vertical direction (Fig. 4), and then enlarged in an horizontal direction.

Lastly, I show you a portrait. Imagine to yourself that it represents the person whom the astigmatical painter is painting; then, by aid of the cylindrical glass, you can form an idea how the painter sees this person.

If I alter the position of the glass, the portrait assumes the form in which the painter sees his own painting on the canvas. This will explain to you why he paints the portrait still longer than he sees the person.

With regard to an anomaly of sight, which seems almost foreign to the subject of painting—I mean color-blindness—I will also say a few words here, as the subject seems to be regarded with particular interest in England.

What we call color-blindness is a congenital defect of vision, which is characterized by the absence of one of the three primary sensations of color. The primary sensations of color are red, green, and violet, according to Thomas Young and Helmholtz; or red, green, and blue, according to Maxwell. When, as may easily happen, to this defect is joined a decided talent for painting, drawing alone ought to be attempted, because so absolute a defect will soon assert itself. But we meet with slighter degrees of color-blindness, where the perception of red is not entirely wanting, but only considerably diminished; so that, for instance, an intense or strongly illuminated red can be perceived as such, while a less intense red appears green. This moderate degree of color-blindness does not always deter people from painting. A proof of this I saw at the last year's Exhibition, in a picture which represented a cattle-market. The roofs of the surrounding houses were all painted red on the sunny side, green in the shadow; but—what particularly struck me—the oxen also were red in the sun, green in the shadow. The slighter degrees of this anomaly, in the form of an insufficient perception of colors, have probably been the real cause why several great artists, who have become famous on account of the beauty of their drawing and the richness of their compositions, have failed to attain an equal degree of perfection in coloring.

In opposition to these isolated cases, I have to draw your attention to other cases which happen more frequently, and in advanced age, in consequence of a change in the perception of colors. They do not arise from a deficient function of the nervous apparatus of the eye, but in consequence of a change in the color of the lens.

The lens always gets rather yellow at an advanced age, and with many people the intensity of the discoloration is considerable. This, however, does not essentially diminish the power of vision. In order to get a distinct idea of the effect of this discoloration, it is best to make experiments with yellow glasses of the corresponding shade. Only, the experiment must be continued for some time, because at first every thing looks yellow to us. But the eye gets soon accustomed to the color, or rather it becomes dulled with regard to it, and then things appear again in their true light and color. This is at least the case with all objects of a somewhat bright and deep color. A careful examination, however, shows that a pale blue, or rather a certain small quantity of blue, cannot be perceived even after a very prolonged experiment, and after the eye has long got accustomed to the yellow color, because the yellow glass really excludes it. This must, of course, exercise a considerable influence when looking at pictures, on account of the great difference which necessarily exists between real objects and their representation in pictures.

These differences are many and great, as has been so thoroughly explained by Helmholtz. Let us for a moment waive the consideration of the difference produced by transmitting an object seen as a body on to a simple flat surface, and consider only the intensity of light and color. The intensity of light proceeding from the sun and reflected by objects is so infinitely greater than the strongest light reflected from a picture, that the proportion expressed in numbers is far beyond our comprehension. There is also so great a difference between the color of light, or of an illuminated object, and the pigments employed in painting, that it appears wonderful that the art of painting can, by the use of them, produce such perfect optical delusions. It can, of course, only produce optical delusions, never a real optical identity; that is to say, the image which is traced in our eye by real objects is not identical with the image produced in our eye by the picture. This is best observed by changing the light. Whoever paints in London has but too frequent opportunities of observing this. A little more or less fog, the reflection of a cloud, illuminated by the sun, suffices to alter entirely the coloring of the picture, while the coloring of natural objects is not changed in the same manner.

Let us now return to our experiment with the yellow glass, and we shall find that it affects our eye very much in the same way as a yellow tint in the light, and therefore modifies natural objects in quite a different degree from pictures. If we continue the experiment for a considerable time, the difference becomes more and more essential. As I said before, the eye becomes dulled with regard to the yellow light, and thus sees Nature again in its normal coloring. The small quantity of blue light which is excluded by the yellow glass produces no sensible difference, as the difference is equalized by a diminution of sensibility with regard to yellow. In the picture, on the contrary, there is found in many places only as much blue as is perfectly absorbed by the yellow glass, and this, therefore, can never be perceived, however long we continue the experiment. Even for those parts of the picture which have been painted with the most intense blue the painter could produce, the quantity of blue excluded by the yellow glass will make itself felt, because its power is not so small with regard to pigments as with regard to the blue in Nature.

Imagine, now, that, in the course of years, one of the transparent media in the eye of a painter had gradually become yellowish, and that this yellow had by degrees considerably increased in intensity, and you will easily understand the influence it must exercise upon his work. He will see in Nature almost every thing correctly; but in his picture every thing will appear to him yellowish, and consequently he will paint it too blue. Does he not perceive this himself? Does he not believe it if told of it? Were this the case, it would be easy for him to correct the fault, since an artist can paint in a yellower or bluer tone, as he chooses. These are two questions which are easily answered by psychological experience. He does not perceive it himself, because he does not remember that he formerly saw in a different way. Our remembrance with regard to opinions, sensations, perceptions, etc., which have become gradually modified in the course of years—not by any external influence or sudden impression, but by a gradual change in our own physical or mental individuality—is almost *nil.*

He does not believe it—I would not say because an artist rarely recognizes what others tell him with regard to his works, but because with him, as with every one else, the impressions received through his own eye have a stronger power of conviction than any thing else. "Sehen geht vor Sagen" ("Seeing is believing"), says the old adage.

We are almost always conscious of *indistinct* vision, be it in consequence of incorrect accommodation or insufficient power of sight, especially if it is not congenital, but has gradually appeared. But it is extremely difficult and in many cases impossible to convince those of their defect who suffer from *incorrect* vision as to form and color. They never become conscious of it themselves, even if it is not congenital, and the most enlightened and intelligent among them remain incredulous, or become even angry and offended, when told of it. Incorrect perception of form may, however, easily be demonstrated. If in consequence of astigmatism a square appears oblong to any one, he can measure the sides with a compass; or, what is more simple still, he can turn it so that the horizontal lines are changed into vertical ones, and *vice versa*, and his own sight will convince him of his error. It is more difficult to demonstrate whether a person sees colors correctly or not. Such glaring mistakes as those produced by color-blindness can be easily recognized, but faults produced by a diminished sensation of small differences in the shades of color can only be recognized as such by the fact that the majority of persons with normal vision declare them to be faults. Such, for instance, are deviations produced by an incorrect perception of pigments, which in painting makes itself felt by a constantly-recurring *plus* or *minus* of a single color in the whole picture. It may also show itself by small faults in the rendering of every color. In discussing this subject with artists, they at once declare these anomalies to represent a school, a taste, a manner, which may be arbitrarily changed. They most unwillingly concede that peculiarities of sight have any thing to do with it. It seems to me sometimes as if they considered it in a certain measure a degradation of their art that it should be influenced by an organ of sense, and not depend entirely upon free choice, intelligence, imagination, and talent.

Thus, to return to the point from which we started: if a painter whose lens becomes yellower begins to paint in a bluer tone, it is said that he has changed his style. The painter himself vehemently protests against this opinion; he thinks that he still paints in his old style, and that he has only improved the tone of his color. His earlier works appear to him too brown. To convince him of his error, it would be necessary to remove his lens suddenly. Then every thing would appear to him too blue, and his paintings far too blue. This is no hypothesis, but a fact. Patients on whom I have operated for cataract, very often spontaneously declared, immediately after the operation, that they saw every thing blue; in these cases I invariably found their crystalline lens to be of an intense yellow color. In pictures painted after the artists were considerably over sixty, the effect of the yellow lens can often be studied. To me their pictures have so characteristic a tone of color, that I could easily point them out while passing through a picture-gallery. As a striking example, I will only mention Mulready. It is generally stated that in his advanced age he painted too purple. A careful examination shows that the peculiarity of the colors of his later pictures is produced by an addition of blue. Thus, for instance, the shadows on the flesh are painted in pure ultramarine. Blue drapery he painted most unnaturally blue. Red of course became purple. If you look at these pictures through a yellow glass, all these faults disappear: what formerly appeared unnatural and displeasing is at once corrected; the violet color of the face shows a natural red; the blue shades become gray; the unnatural glaring blue of the drapery is softened. To make the correction perfect, the glass must not be of a bright gold-color, but rather of the color of pale sherry. It must be gradually darkened in accordance with the advancing age of the painter, and will then correspond exactly with the color of his lens. The best proof of the correctness of this statement is, that the yellow glass not only modifies the blue in Mulready's pictures, but gives truthfulness to all the other colors he employed. To make the proof complete, it would be necessary to show that by the aid of yellow glass we saw Mulready's pictures as he saw them with the naked eye; and this can be proved. It happens that Mulready has painted the same subject twice—first in 1836, when he was 50 years of age and his lens was in a normal state, and again in 1857, when he was 71, and the yellow discoloration had considerably advanced. The first picture was called "Brother and Sister; or Pinching the Ear;" the second was called "The Young Brother." In both pictures a girl, whose back only is visible, is carrying a little child. A young peasant, in a blue smock-frock, stands to the right and seizes the ear of the child. The background is formed by a cloudy sky and part of a tree. Both pictures are in the Kensington Museum. The identity of the composition makes the difference in the coloring more striking. If we look at the second picture through a yellow glass, the difference between the two almost entirely disappears, as the glass corrects the faults of the picture. The smock-frock of the boy no longer appears of that intense blue which we may see in a lady's silk dress, but never in the smock-frock of a peasant. It changes into the natural tint which we find in the first picture. The purple face of the boy also becomes of a natural color. The shades on the neck of the girl and the arms of the child, which are painted in a pure blue, look now gray, and so do the blue shadows in the clouds. The gray trunk of the tree becomes brown. Surprising is the effect upon the yellowish-green foliage, which, instead of appearing still more yellow, is restored to its natural color, and shows the same tone of color as the foliage in the earlier picture. This last fact is most important to prove the correctness of my supposition. My endeavor to explain it became the starting-point of a series of investigations to ascertain the optical qualities of the pigments used in painting, and thus to enable us to recognize them by optical contrivances, when the vision of the naked eye does not suffice to analyze the colors of a picture.

When I had the pleasure of showing this experiment with Mulready's pictures to Prof. Tyndall, he drew my attention to the fact that one single color, namely, the blue of the sky, was not affected by the yellow glass. The blue of the sky was almost the same in both pictures. I could not at once explain the cause of this, but I discovered it afterward. The fact is, it is impossible to change the sky-blue of the first picture so as to form a color that looks like it when seen through a yellow glass. If more white is added, the sky becomes too pale; if a deeper blue is used, it becomes too dark. Mulready was thus forced to content himself by giving to the sky in his later pictures the same color as in the earlier ones.

If we look at Mulready's earlier works through the same yellow glass, they lose considerably in beauty of coloring: the tone appears too weak; the shadows brown; the green, dark and colorless; we see them as he saw them, and understand why he became dissatisfied with them and changed his coloring.

It would be more important to correct the abnormal vision of the artist, than to make a normal eye see as the artist saw when his sight had suffered. This, unfortunately, can only be done to a certain extent.

If it is the dispersion of light which, as in Turner's case, alters the perception of Nature, it can be partly rectified by a kind of diaphragm with a small opening (Donders's sthenopeical spectacles).

In cases of astigmatism, the use of cylindrical glasses will completely correct the aspect of Nature, as well as of the picture. Certain anomalies in the sensation of color may also be counteracted to some extent by the use of colored glasses; for instance, by a blue glass, when the lens has become yellow, as in Mulready's case.

If science aims at proving that certain works of art offend against physiological laws, artists and art-critics ought not to think that, by being subjected to the material analysis of physiological investigation, that which is noble, beautiful, and purely intellectual, will be dragged into the dust. They ought, on the contrary, to make the results of these investigations their own. In this way art-critics will often obtain an explanation of the development of the artist, while artists will avoid the inward struggles and disappointments which often arise through the difference between their own perceptions and those of the majority of the public. Never will science be an impediment to the creations of genius.—*Macmillan's Magazine.*

DARWINISM AND DIVINITY.

By L. S.

WE are going through that change in regard to Mr. Darwin's speculations which has occurred so often in regard to scientific theories. When first propounded, divines regarded them with horror, and declared them to be radically opposed not only to the book of Genesis, but to all the religious beliefs which elevate us above the brutes. The opinions have gained wider acceptance; and, whatever may be the ultimate verdict as to their soundness, it certainly cannot be doubted that they are destined profoundly to modify the future current of thought. As Darwinism has won its way to respectability, as it has ceased to be the rash conjecture of some hasty speculator, and is received with all the honors of grave scientific discussion, divines have naturally come to look upon it with different eyes. They have gradually sidled up toward the object which at first struck them as so dark and portentous a phenomenon, and discovered that after all it is not of so diabolic a nature as they had imagined. Its breath does not wither up every lofty aspiration, and every worthy conception of the destiny of humanity. Darwinists are not necessarily hoofed and horned monsters, but are occasionally of pacific habits, and may even be detected in the act of going to church. Room may be made for their tenets alongside of the Thirty-nine Articles, by a little judicious crowding and rearrangement. Some of the old literal interpretations of the Scriptures must perhaps be abandoned, but after all they were in far too precarious a position already to be worth much lamentation. It would be entirely unfair to accuse persons, who have gone through this change, of the smallest conscious insincerity. They are not merely endeavoring to curry favor with an adversary because he has become too formidable to be openly encountered. They have simply found out, in all honesty and sincerity, that the object of their terror has been invested with half his terrible attributes by their own hasty imagination. They are exemplifying once more the truth conveyed in an old story. A man hangs on to the edge of a precipice through the dark hours of the night, believing that if his grasp fails him he will be instantly dashed to a thousand fragments; at length his strength will bear it no longer, and he falls—only to discover that his feet had been all the time within a couple of inches of the ground! The precipice was a creation of his fancy, and the long agony entirely thrown away. So we may believe that a good many sound divines have resigned themselves to the inevitable plunge, and are astonished to find all their vital functions continuing to operate pretty nearly as well after as before the catastrophe. Perhaps they feel rather foolish, though of course they do not say so. One could wish, certainly, that under these circumstances they would betray a little less uneasiness; and that the discovery that the doctrine is harmless might precede by a rather longer interval the admission that it is true. There would be less room for unkindly cavils. However, it is being discovered, in one way or other, that religion is really not interested in these discussions. We have lately seen, for example, in a very orthodox Romanist organ, that theology has nothing, or next to nothing, to say to Mr. Darwin's theories. It is permissible to believe either that man was made by a single act of the creative energy, or that a pair of apes was selected and improved gradually into humanity, as, if the comparison be admissible, human processes may gradually form the carrier-pigeon out of his wild congeners. We must, indeed, hold that the operation was miraculous; and as the tendency of scientific inquiry is to banish the miraculous, we may say that there is still a fundamental opposition between the teaching of the Church and Mr. Darwin. When we consider how easily the word "miraculous" may itself be rarefied until no particular meaning is left, we may doubt whether this opposition may not be removed; the verdict of science as to the mode in which the phenomena succeeded each other might be accepted, though there would be a difference of opinion as to the efficient cause of the change, and thus a kind of compromise might be effected between the rival forces.

Meanwhile, whatever the validity of this and similar artifices, it may be worth while to consider a little more closely what is the prospect before us. Let us suppose that Darwinism is triumphant at every point. Imagine it to be demonstrated that the long line of our genealogy can be traced back to the lowest organisms; suppose that our descent from the ape is conclusively proved, and the ape's descent from the tidal animal, and the tidal animal's descent from some ultimate monad, in whom all the vital functions are reduced to the merest rudiments. Or, if we will, let us suppose that a still further step has been taken, and the origin of life itself discovered, so that, by putting a certain mixture in an hermetically-sealed bottle, we can create our own ancestors over again. When we endeavor firmly to grasp that conception, we are, of course, sensible of a certain shock. We have a prejudice or two derived from the Zoological Gardens and elsewhere, which, as it were, causes our gorge to rise; but when we have fairly allowed the conception to sink into our minds, when we have brought our other theories into harmony with it, and have lost that uncomfortable sense of friction and distortion which is always produced by the intrusion of a new set of ideas, what is the final result of it all? What is it that we have lost, and what have we acquired in its place? It is surely worth while to face the question boldly, and look into the worst fears that can be conjured up by these terrible discoverers. Probably, after such an inspection, the thought that will occur to any reasonable man will be: What does it matter? What possible difference can it make to me whether I am sprung from an ape or an angel? The one main fact is that, somehow or other, I am here. How I came here may be a very interesting question to speculative persons, but my thoughts and sensations and faculties are the same on any hypothesis. Sunlight is just as bright if the sun was once a nebulous mass. The convenience of our arms and legs is not in the slightest degree affected by the consideration that our great-great-grandfathers were nothing better than more or less movable stomachs. The poet's imagination and the philosopher's reason are none the worse because the only sign of life given by their ancestors was some sort of vague contractility in a shapeless jelly. Our own personal history, if we choose to trace it far enough back, has taken us through a series of changes almost equally extensive, and we do not think any the worse of ourselves on that account. Our affections and our intellectual faculties are in existence. They are the primary data of the problem, and as long as we are conscious of their existence we need not worry ourselves by asking whether they began to exist by some abrupt change or gradually rose into existence through a series of changes. There is still quite as much room as ever for the loftiest dreams that visit the imaginations of saints or poets. The mode in which we express ourselves must, of course, be slightly altered; but, so long as the same instincts exist which sought gratification in the old language, we need not doubt but they will frame a new one out of the changed materials of thought. The fact that religion exists is sufficient demonstration that men feel the need of loving each other, of elevating the future and the past above the present, of rising above the purely sensual wants of our nature, and so on; the need will exist just as much, whether we take one view or other of a set of facts which, on any hypothesis, happened many thousands of years before we were born, and in regard to which a contented ignorance is far from being an impossible frame of mind. One can understand, after a little trouble, how it was that at a particular period of history people fancied that disinterested love would leave the world, and a moral chaos be produced, if it should be made to appear that it was not literally true that we are all descended from a man who was turned out of a garden for eating an apple. The infidels who assailed, and the orthodox who defended that dogma, really believed that it was an essential corner-stone in the foundations of all religion, which, once removed, nothing but a universal crash could follow. Even the statement that it might possibly be an allegory instead of an historical record nearly frightened our prosaic ancestors out of their wits. Remove one brick from the cunningly-adjusted fabric of orthodoxy, prove that a line of the Hebrew Scriptures was erroneous, and God would vanish from the world, heaven and hell become empty names, all motives for doing good be removed, and the earth become a blank and dreary wilderness. In remote country towns and small clerical coteries some vestiges of this cheerful opinion still linger. Most men have grown beyond it, and have found some broader basis for their hopes and aspirations. And yet, when one comes to think about it, is not the alarm which has been caused by the statement that Adam was the great-grandson of an ape equally preposterous? Why should it have so fluttered the dove-cotes of the Church? If science could have proved divines to be apes themselves, there would have been some ground for vexation; but that was obviously out of the question, and their alarm would only prove that they were drawing some very unwarrantable inferences, or else by association of ideas had become unable to distinguish between the essence and the remotest accidental accompaniments of the faith. What interest can the highest part of our nature really take in a dispute as to whether certain facts did or did not occur many ages ago? The *prima-facie* presumption is, certainly, that any change in our opinions would affect rather the external imagery than the faith which it embodies. One would say at first sight that religion is no more likely to leave the world because we have new views as to the mode in which the world began, than poetry to vanish as soon as we have ceased to believe in the historical accuracy of the account of the siege of Troy. Man possesses certain spiritual organs, whose function it is to produce religion. Religion could only be destroyed by removing the organs, and not by supplying them with slightly different food.

The precise nature of the fears entertained by the orthodox is revealed by the arguments generally brought to bear against the new doctrine. There is, for example, what may be called the metaphysical argument, which, in one form or another, seems to be regarded as important. It is substantially an attempt to prove that the gap between the brute and the human mind is so wide that we cannot imagine it to be filled up by any continuous series. It is argued at great length that instinct differs from reason not in degree but in kind, or that brutes do not possess even the rudiments of what we call a moral sense. The argument has long been more or less familiar. Animals have always been regarded with a certain dislike by theological arrogance. It has been held to be a conclusive objection to the validity of certain arguments for the immortality of the soul, that they would open the path to heaven to our dogs as well as to ourselves. It does not seem very easy to give any satisfactory reason for the extreme abhorrence with which such a consummation is regarded, or to say why we should claim a monopoly in another world which we do not enjoy in this. Philosophers, indeed, have gone further, and denied to animals even the most moderate share of our own capacities, and have set them down as nothing better than machines. One is really rather glad to see the poor beasts getting their revenge in public opinion, and being recognized as our relations after having been almost repudiated as fellow-creatures. The distinctions, indeed, which have been drawn seem to us to rest upon no better foundation than a great many other metaphysical distinctions: that is, the assumption that, because you can give two things different names, they must therefore have different natures. It is difficult to understand how anybody who has ever kept a dog, or seen an elephant, can have any doubts as to an animal's power of performing the essential processes of reasoning. We have been saying in thousands of treatises on logic, All men are mortal: Socrates is a man, therefore Socrates is mortal. The elephant reasons: All boys are bun-giving animals; that biped is a boy: therefore I will hold out my trunk to him. A philosopher says, The barometer is rising, and therefore we shall have fine weather; his dog says, My master is putting on his hat, and therefore I am going to have a walk. A dog equals a detective in the sharpness with which he infers general objectionableness from ragged clothes. A clever dog draws more refined inferences. If he is not up to enough simple arithmetic to count seven, he can at least say, Everybody is looking so gloomy that it must be Sunday morning. If he is a sheep-dog, he is probably more capable of finding his way over hills than most members of the Alpine Club, and capable of combining his actions with a view to making the sheep—whose reasoning powers are limited—follow the right track. He can found judgments on cautious experiment, as anybody will admit who has seen a dog testing the strength of a plank which he has to cross, or measuring the height of a jump. In fact, a dog is constantly performing rudimentary acts of reason, which can only be distinguished from our own by the fact that he cannot put them into words. He can understand a few simple words; and, though he cannot articulate, he can make sounds indicative of his wants and emotions, which are to words what the embryo is to the perfect organism. He cannot put together a sentence; but to found a distinction of kind between his intellectual performances and those of man upon that circumstance, seems to be as unreasonable as to make a similar distinction between the intellect of the savage who cannot count five, and that of the philosopher who can use mathematical symbols. The power of abstraction has been carried a step, and a very important step, farther in each case; but there is no more cause to suspect the introduction of an entirely new element in one case than the other.

The condemnation of the poor brutes as non-moral (if we may use such a word) seems to be still more monstrous. We need not speak of exceptional stories, such as the legend in a recent French newspaper of the sensitive dog who committed suicide when deserted by his friends; but who can doubt that his dog has something which serves as a very fair substitute for a sense of duty? Could any thing be more like human heroism than the conduct of the poor collie who drove home her master's sheep, leaving her new-born puppies by the side of the road? Or, to avoid particular instances, is there a barrister in England who can blush half so expressively as a dog found out in sharp practice—blushing, of course, being taken in a sense applicable to the dog's tail? Whether wild animals have such a sense of the value of any positive laws is more than we know; but wild animals, down to the lowest orders, show at least the maternal instinct. The devotion of beasts to their young belongs, one would say, to the highest order of moral beauty—except that it extends too low down among animated beings to please some people. Yet we may presume that the most hard-hearted of metaphysicians would find it hard to suppress an emotion of sympathy and approval at the sight of a bird overcoming its timidity to fight for its little puff-balls of children. It is a more pathetic if not a more sublime sight than those starry heavens with which we are so often bored. There is a bit of metaphysical quibbling, by which it is endeavored to evade the obvious inference. It seems to come to this, when analyzed, that, though the bird performs an heroic action, it has never framed the general proposition, Mothers ought to love their young. That is undeniable; but surely the bird is on the high-road to it. Light up its feeble brain with a little more intelligence, and it will have no trouble in fitting its instincts with the proper strait-waistcoats of formula. To deny virtue to the bird would be to deny it equally to the savage, who has movements of generosity and self-devotion, though it has never occurred to him to speculate on moral philosophy. There is, of course, a difference between the virtue which merely results from the spontaneous play of unselfish instincts, and that which includes a certain list of definite propositions on the subject formed by reflection and observation. But where the first is present, even in a high degree, it is not difficult to account for the gradual development of the second.

The argument, however, has another fatal weakness, if it is intended to raise a presumption against the possible passage from apehood to manhood. Assume, if you please, that the difference is as wide as possible. Suppose that reason and the moral sense are as different from the rudimentary thoughts and passions that animate the feeble brute-brain as water from fire or as mind from matter. That will not raise any presumption that there must be a sudden gap in the chain of animated beings, unless you can prove that the new element, whatever it may be called, must enter, as it were, at one bound. If reason be radically different from instinct, yet reason may be present in some creatures in a merely rudimentary form. The question, indeed, does not admit of argument. We always have before our eyes a perfect and uninterrupted series. The child of six months old is less intelligent than a full-grown dog; and if we would imagine the development of man from monkey, we have only to suppose the first monkey to be the equal of an average baby (say) of one year old, the monkey's son to be equal to a baby of a year and a day, and so on. We may thus proceed by perfectly imperceptible stages, and in the course of three or four thousand generations we shall get a man-monkey fully equal in intelligence to the average Hottentot. Thence upward we cannot deny the possibility of development without heterodoxy. In short, by interpolating a sufficient number of terms we may form an ideal, which, for any thing we can say, may be an actual series ending with the man and beginning with the inferior animals, in which there shall not be a single violent transition. The question whether reason is or is not specially distinct from instinct is simply irrelevant. In one case we must suppose that it begins by entering in homœopathic doses; in the other, that it is simply the development of certain lower faculties; in either case the animal will shade into the human intellect by degrees as imperceptible as those by which night changes into dawn. Indeed, it is impossible to see why—except from fear of certain conclusions, which is not a logical ground for dissent—the possibility of a passage from brute to man should ever have been denied on *a priori* grounds. Whether the theory is confirmed or confuted by observation is an entirely open question; but it is strange that it should be pronounced impossible when we are ready to admit infinitely greater changes. If you can imagine a monkey to have been developed from a sea-anemone, an animal from a plant, or living from inorganic matter—and none of these changes, however little reason we have to believe in their actual occurrence, are supposed to be obnoxious to any insurmountable objection *a priori*—why can we not admit that a monkey may possibly become a man?

It is here that we come upon the confusion already noticed. It results from mixing metaphysical inquiries about the what? with scientific inquiries into the how? A man of science says (possibly he makes a mistake, but that is not to the purpose), Mix such and such elements under such and such conditions, and a living organism will make its appearance. The theologian sometimes meets this statement as if it were equivalent to an assertion that life is nothing but an arrangement of matter. He has really said nothing of the kind: he does not know what is the essence of life or of matter; he has merely to do with the order in which phenomena occur; and has absolutely no concern with the occult substratum in which they are supposed to inhere. The utmost that he can ever say—if he can ever say so much—would come to this: Bring together a set of the phenomena which we call molecules, and there will result a series of the phenomena which we call vital; but what molecules are, or what life is, is a question beyond his competence. Similarly, when he proceeds a step farther and traces the origin of our moral sense to some dumb instinct in the animal world, he is not really speaking treason against the dignity and importance of morality. Mr. Browning, in one of his poems, speaks of some contemptible French author who explained the origin of modesty by referring, as only a very free-speaking person could refer, to the mode in which the sexual instinct operated upon savage natures. If that Frenchman meant to infer that the modesty of a civilized being is no better than the semi-bestial instincts of a man-ape, he was as contemptible as the poet could wish, but he was also grossly illogical. His observation merely went to show by what means one of the most essential of social instincts was originally generated in the world; and it is not the less essential because in its first origin it partook of the grossness of the animal in which it was implanted. Mr. MacLennan has written a very interesting book tending to show that the original marriage ceremony was everywhere like that which survives in Australia to this day, where the wild human being knocks down his beloved with a club, and drags her off to his own den. Suppose this to be true, would it follow that marriage in the most refined and purest societies was no better than forcible abduction as practised in the Australian bush? Surely it would follow no more than the development of a man from a monkey would prove that men still have tails, or that the brain of a Newton is no better than that which directs a chimpanzee in its search for nuts. In short, it is sufficiently plain that we do not diminish the value of any human accomplishments by tracing them back to their remote origin in the brute, or even the insect creation. That shudder which runs through us when we are invited to recognize our poor relations in the Regent's Park is gratuitous. The philosopher may have thrown more light upon the process by which we came to be what we are; but he does not, for he obviously cannot, argue that we are other than we are. Whether in pursuing our genealogy we stop short at "who was the son of Adam," or carry it back through a vast series of links to "who was the son of a monkey," the fact of our present existence, with our present instincts, aspirations, and endowments, remains precisely what it was. The prospect, indeed, is improved for our remote descendants, "far on in summers that we shall not see;" but for us poor creatures living and moving in this nineteenth century after Christ, the circumstances remain unaltered. Turn it as you will, we are the base from which the line is measured, and not the indeterminate point to be discovered by a process of trigonometry.

Is, then, the alarm which has been excited in men's minds totally unreasonable? In one sense it would seem to be so. The speculations of which we have been speaking are absolutely harmless to any one who holds—as surely every sincere believer ought to hold—that religion depends upon certain instincts whose existence cannot be explained away by any possible account of the mode by which they came into existence. Property is not less sacred in the eyes of a reasonable man because it may have originated in mere physical force; nor religion because it first dawned upon mankind in the vague guesses of some torpid brain, which fancied that a bigger Caliban was moving the stars and rolling the thunder. But it may be true that the new theories will transform the mode in which men interpret the universe to themselves, and will therefore destroy some of the old formulæ which involved different perceptions. To those who have succeeded in persuading themselves that any set of Articles constructed some centuries ago were to be final and indestructible expressions of truth, the prospect may certainly be distressing. There may, indeed, be no positive logical irreconcilability between orthodoxy and Darwinism. A little more straining of a few phrases which have proved themselves to be sufficiently elastic, and the first obvious difficulty may be removed. The first chapter of Genesis has survived Sir Charles Lyell; it may be stretched sufficiently to include Mr. Darwin. But in questions of this kind there is a kind of logical instinct which outruns the immediate application of the new theories. The mere change of perspective does much. When the sun was finally placed in the centre of the heavens instead of the earth, the few texts which apparently opposed were easily adapted to the new theories. But there was a further change of infinitely greater importance, which, though not so easily embodied in direct logical issues, profoundly modified all theological conceptions. When people began to realize the fact that we live in a wretched little atom of a planet dancing about the sun, instead of being the whole universe, with a few stars to save candle-light, the ancient orthodoxy was shaken to its base. It is impossible to read the controversies which marked the great intellectual revolt of the last century without seeing how much men's minds were influenced by the simple consideration that Christians were a small numerical minority of the human race, and the habitation of the race a mere grain of dust in the universe. The facts were more or less known before, and were not capable of furnishing syllogisms absolutely incompatible with any orthodox dogma. And yet the mere change in the point of view, working rather upon the imagination than the reason, gradually made the old positions untenable. A similar change is being brought about by the application of that method of which Darwinism is at present the most conspicuous example. Possibly the change may be of even greater importance. Certainly it is of far too great importance to be more than dimly indicated here. Briefly it may be described as the substitution of a belief in gradual evolution for a belief in spasmodic action and occasional outbursts of creative energy; of the acceptance of the corollary that we must seek for the explanation of facts or ideas by tracing their history instead of accounting for them by some short *a priori* method; and thus of the adoption of the historical method in all manner of investigations into social, and political, and religious problems which were formerly solved by a much more summary, if not more satisfactory method.

It is curious to remark how the influence of new methods penetrates the minds of those who would most strenuously repudiate some of the results to which they lead. We may illustrate the point by an analogy drawn from the theory of which we have been speaking. Mr. Wallace has described what he calls protective resemblances. A butterfly which precisely suits the palates of certain birds would be speedily exterminated if it were not for an ingenious device. It cleverly passes itself off under false colors by imitating the external shape of some other butterfly, which the bird considers as disgusting. So oysters, if they were quick enough, might evade the onslaught of human appetites by taking the external resemblance of periwinkles. A very similar variety of protective resemblance may be detected in the history of opinions. The old-fashioned doctrine remains essentially the same, but it changes its phraseology so as to look exactly like its intrusive rival. We have already given an instance. It is permissible, it appears, for orthodox Catholics to hold that the series of facts alleged by Mr. Darwin actually occurred, and that the ape changed by slow degrees into the man; only they must save themselves by calling the process miraculous, and thus, for a time at least, the old theory may be preserved. Perhaps it will strike people, in the course of years, that if all the phenomena conform to the law established by philosophers, it is rather absurd to say that they do not conform in virtue of the law, but in virtue of a specific interference of Divine power. Still the ingenuity of the artifice is obvious, and it affords an instructive example of the method of reconciling old things and new. In the same way, the theological doctrine of development mimics the historical accounts of the process by which opinions have actually been formed. Just as the skeptic rashly fancies that he has brought matters to a conclusive issue, the theologian evades his grasp by putting on the external form of the very doctrines which he has been opposing.

Thus, for example, Dr. Newman argues in the "Grammar of Assent" for the doctrine of the Atonement, on the ground (among others) that a similar belief is found to exist in all barbarous nations. It may seem strange, he goes on to say, that he should take his ideas of natural religion from the initial and not from the final stage of human development. His "answer is obvious," and it comes shortly to this, that our "so-called civilization" is a one-sided development of man's nature, favoring the intellect, but neglecting the conscience; and that, therefore, it is "no wonder that the religion in which it issues has no sympathy with the hopes and fears of the awakened soul, or with those frightful presentiments which are expressed in the worship and the traditions of the heathen." In simpler times the resemblances between the heathen and the orthodox religion would have been indignantly denied, or regarded as diabolic parodies. Now, the Catholic divine is as ready as the philosopher to trace out the analogy, though he puts a different interpretation upon it. The philosopher, that is, regards the Catholic religion as preserving the remains of older forms of thought which are gradually expiring under the influence of free inquiry. The divine accepts just the same facts, but he regards the old barbarous superstition as a dim reflection of revealed truths, while a satisfactory reason is found for putting the civilized intellect out of court altogether. The verdict of the stupid, ferocious savage, who makes an idol out of a bit of wood and a red rag, and then pacifies its spite by slaughtering fowls or prisoners in its honor, is not at first sight superior to that of the modern philosopher; but the philosopher is "one-sided." This, however, is beside the point. It is clear that modern tendencies have penetrated into the hostile camp. It is the much-abused philosopher who has taught us to take a new interest in the lower religions of the world instead of summarily rejecting them as the work of devils. The mere fact that we have risen to such a conception as that of a comparative study of religion is certainly not sufficient by itself to confute the pretensions of what claims to be an exclusive revelation. It is possible to adapt the old to the new beliefs by the methods of which Dr. Newman's argument is an example. After Mr. Darwin and his followers have traced out the resemblance between men and monkeys with the utmost possible clearness, it is always possible for a dogmatist to discover some good reason why the transition should have required a miraculous intervention. In the same way, the analogies which the philosopher may discover between the various religions of the world will never convince him that his own special creed is not of supernatural origin, though the others which resemble it so strangely are traceable to the spontaneous working of the human intellect. A very little dexterity is required to raise the resemblance to that point at which it becomes an argument for the reasonableness of the supposed revelation, and is yet no argument against its supernatural character. Admit your naked savage to prove that man has a need for the belief in Atonement, but do not let him be produced as evidence that the belief finds its most congenial element and grows to the largest dimensions in a debased and torpid intellect. By such logical manipulation as this, the accumulation of uncomfortable facts may long be rendered harmless. It all depends upon the way in which you look at things. The acute thinkers who have helped to elaborate any ancient system of thought have always provided a proper set of pigeonholes in which inconvenient facts may be stowed away. It is long before the facts become weighty enough to break down the framework. But no agent is so powerful in bringing about the change as the subtle and penetrating influence of a new method. It may not follow logically that because catastrophes have been banished from geology, and the series of animated beings has been proved to be continuous, therefore the same conceptions should be applied to the religious beliefs of mankind. And yet nobody can doubt that in practice the influence would be unmistakable. The burden of proof would be shifted, and that in itself makes an amazing difference. The popular belief has hitherto been that, unless you could prove the contrary, it would be reasonable to suppose that the transition from monkey to man involved a sudden leap. If it came to be the popular belief that, unless you could prove the contrary, men must be supposed to have developed out of monkeys by the forces now at work, the imagination would outrun the reason. It would be assumed that a religion was the growth of that stage of development at which the human intellect had arrived, and not the work of a series of sudden interferences. Christianity would be a phenomenon to be studied like others by the investigation of the conditions under which it arose, and the advocates of a theory of supernatural intervention would have to encounter a set of established beliefs instead of finding them in their favor. This is the imperceptible intellectual influence which gradually permeates and transforms the prevalent conceptions by a process which is as irresistible as it is difficult to define by accurate formulæ. Religious instincts, we rightly say, are indestructible; but the forms in which they may be embodied are indefinitely variable, and no one can say how fast and how far the influence of a change worked in one department of thought may gradually spread by a silent contagion to others apparently removed from it.

Thus, admitting to the fullest extent that Darwinism not only does not threaten, but does not even tend to threaten, the really valuable elements of our religious opinions, it is quite consistent to maintain that it may change the conceptions in which they are at present embodied to an extent to which it is impossible to assign any limits. Darwinism, for example, does not make it more difficult to believe in a God. On the contrary, it may be fairly urged that any theory which tends to bring any sort of order out of the confused chaos of facts which we have before us, makes it so far more easy to maintain a rational theism such as is now possible. It helps us to form some dim guess of whence we are coming and of whither we are going—to see, as it were, an arc of the vast orbit in which the world is revolving, instead of being limited to an infinitesimal element, lost at each extremity in hopeless darkness. But it is true that it weakens that conception of the Creator which supposes him to intervene at stated periods, in order to give an impulse to the machinery. How deeply that change may affect all manner of theological conceptions it is unnecessary to consider. There is another doctrine which seems to be more nearly affected; and probably, though we seldom give open expression to our fears, it is this tendency which is really the animating cause of the alarm which is obviously felt. Does not the new theory make it difficult to believe in immortal souls? If we admit that the difference between men and monkeys is merely a difference of degree, can we continue to hold that monkeys will disappear at their death like a bubble, and that men will rise from their ashes? So vast a difference in the ultimate fate and the intrinsic nature of the two links should surely correspond to a wide gap in the chain. We are too proud to admit a gorilla or a chimpanzee to a future world, and yet, if they are only lower forms of humanity, we do not quite see our way to exclude them. The difficulty in one shape or another has long been felt. "Nobody thinks," says Voltaire, "of giving an immortal soul to a flea; why should you give one any the more to an elephant, or a monkey, or my Champagne valet, or a village steward, who has a trifle more instinct than my valet?" The difficulty of drawing the line is enhanced to the imagination when we assume that the flea is the remote ancestor of the village steward, and believe that one has melted by imperceptible degrees into the other. The orthodox may be excused for trembling when they see that central article of their faith assailed, and are in danger of being deprived of the great consolations of their religion—heaven and hell. It would be preposterous to attempt to argue so vast a question in our space. This much, however, may perhaps be said without offence: Whatever reasons may be drawn from our consciousness for the belief that man is not merely a cunning bit of chemistry—a product of so much oxygen, hydrogen, and carbon—must remain in full force. We may doubt how far the belief ever rested on metaphysical arguments, and, indeed, it seems to be the orthodox opinion that it must be accepted on the strength of revelation. It would therefore only be affected so far as Darwinism and the methods to which it gives rise tend to explain the origin and growth of a faith to which all believers cling so fondly. And, whatever the result may be, it is at least natural to suppose that it would rather tend to modify than to destroy the belief, to set bounds to the dogmatic confidence with which we have ventured to define the nature of the soul than to uproot our belief in its existence. After all, it would not be a very terrible result if we should be driven to the conclusion that some kind of rudimentary soul may be found even in the lower animals. The *Spectator*, which is a very amiable and reasonably orthodox journal, has lately been asking whether we have any excuse for refusing immortality to well-conducted cats, or to that admirable and fortunately authentic dog which watched for ten years upon its master's grave. Poor beast! we should be willing to hope that he has found admission to the equal sky; but without jesting on so awful a subject, or venturing into mysteries where the boldest metaphysician walks with uncertain tread, we would simply say that we can see no reason why our new conceptions of the facts—assuming that they establish themselves—should not be accommodated to a spiritual form of belief. After all, it will be hard to convince men that because thought and feeling arise from certain combinations of matter, therefore they are made of matter. But we pause at the threshold of such speculations.

There is, however, one other thing to be said, and it may be said plainly and without irreverence. After all, why is the belief in immortality so essential to the happiness of mankind? It is not because we, as virtuous people, think it necessary that a place should be provided where the virtuous may receive an interminable pension for their good deeds, and the bad be tormented to the end of time. Some people, it is true, ask for a kind of penal settlement in another world, in order to save our police-rates in this. But that doctrine, though it has been preached with amazing emphasis, has not been found to be, on the whole, very edifying. It may serve to remind us that even a belief in immortality may be made as degrading as the grossest forms of materialism. It may convert religion into a specially clever form of selfishness, and take the grace out of the Christian character. The persons who call themselves spiritualists in the present day sometimes claim to be providing an excellent substitute for our old superstitions. The objection which one really feels to them is not so much that they are misled by a contemptible juggle, but that they encourage a kind of prurient religiosity which is inexpressibly revolting. What they really try to persuade us is, not that man has a soul which may be elevated far above our earthly wants and longings, but that there is a set of invisible beings who walk about this world playing tricks with tables and talking nonsense, to which the twaddle of the Yankee young ladies in "Martin Chuzzlewit" is refined and elevating. Their so-called spirits are of the earth, earthy; and it would be more satisfactory to believe that at death we became parts of the ocean and the air—that we formed part of the raw material from which, in the course of the ages, new sentient and thinking beings may be evolved, than that we sank into the likeness of a set of stupid hobgoblins, playing conjuring tricks for the amusement of fools. Gross as some such doctrines may be, they may also be cited for another purpose. Men are virtuous, it is sometimes said, because they believe in hell. Is not this an inversion of the proper order of thought? Should we not rather say that men have believed in hell because they were virtuous? There has been so general a belief that vice was degrading, and was to be discouraged by the strongest possible motives, that even the material part of mankind have exhausted their fancy in devising the most elaborate sentiments to express the horror with which they regarded it. It is painful to dwell upon the pictures of hideous anguish which the perturbed imaginations of past generations have conjured up and regarded as the penalties which the merciful Creator had in store for imperfect creatures placed in a state where their imperfections could not fail to lead them into error; but there is this much of comfort about it, that at least those ghastly images were the reflections of the horror with which all that was best in them revolted against moral evil. It is needless to say how easily those conceptions might be turned to the worst purposes, and religion itself be made an instrument not only for restraining the intellects, but for lowering the consciences of mankind. For our present purpose, it is enough to remark that a similar reflection may convince us that, whatever changes of opinion may be in store for us, we need not fear that any scientific conclusions can permanently lower our views of man's duty here. The belief in immortality, diffused throughout the world, was not, more than any other belief, valuable simply on its own account. It was valuable because it enabled men to rise above the selfishness and the sensuality which otherwise threatened to choke the higher impulses of our nature. But it was the existence of those impulses which gave it its strength, and not any of the metaphysical arguments which can only appeal to a very few exceptional minds. Religions thrive by a kind of natural selection; those which do not provide expression for our best feelings crush out their rivals, not those which are inferred by a process of abstract reasoning. To be permanent, they must bear the test of reason; but they do not owe to it their capacity for attracting the hearts of men. The inference, therefore, from the universality of any creed is not that it is true, for that would prove Buddhism or Mohammedanism as well as Christianity; but that it satisfies more or less completely the spiritual needs of its believers. And, therefore, we may be certain that, if the various tendencies which we have summed up in the name of Darwinism should ultimately become triumphant, they must find some means, though it is given to nobody as yet to define them, of reconciling those instincts of which the belief in immortality was a product. The form may change—we cannot say how widely—but the essence, as every progress in the scientific study of religions goes to show, must be indestructible. When a new doctrine cuts away some of our old dogmas, we fancy that it must destroy the vital beliefs to which they served as scaffolding. Doubtless it has that effect for a time in those minds with whom the association has become indissoluble. That is the penalty we pay for progress. But we may be sure that it will not take root till in some shape or other it has provided the necessary envelopes for the deepest instincts of our nature. If Darwinism demonstrates that men have been evolved out of brutes, the religion which takes it into account will also have to help men to bear in mind that they are now different from brutes.—*Fraser's Magazine.*

ACTION OF DARK RADIATIONS.

By PROF. TYNDALL.

WE now enter upon another inquiry. We have to learn definitely what is the meaning of solar light and solar heat; in what way they make themselves known to our senses; by what means they get from the sun to the earth, and how, when there, they produce the clouds of our atmosphere, and thus originate our rivers and our glaciers.

If in a dark room you close your eyes and press the eyelid with your finger-nail, a circle of light will be seen opposite to the point pressed, while a sharp blow upon the eye produces the impression of a flash of light. There is a nerve specially devoted to the purposes of vision which comes from the brain to the back of the eye, and there divides into fine filaments, which are woven together to a kind of screen called the *retina*. The retina can be excited in various ways so as to produce the consciousness of light: it may, as we have seen, be excited by the rude mechanical action of a blow imparted to the eye.

There is no spontaneous creation of light by the healthy eye. To excite vision the retina must be affected by something coming from without. What is that something? In some way or other luminous bodies have the power of affecting the retina—but *how?*

It was long supposed that from such bodies issued, with inconceivable rapidity, an inconceivably fine matter, which flew through space, passed through the pores supposed to exist in the humors of the eye, reached the retina behind, and, by their shock against the retina, aroused the sensation of light. This theory, which was supported by the greatest men, among others by Sir Isaac Newton, was found competent to explain a great number of the phenomena of light, but it was not found competent to explain *all* the phenomena. As the skill and knowledge of experimenters increased, large classes of facts were revealed which could only be explained by assuming that light was produced, not by a fine matter flying through space and hitting the retina, but by the shock of minute *waves* against the retina.

Dip your finger into a basin of water, and cause it to quiver rapidly to and fro. From the point of disturbance issue small ripples which are carried forward by the water, and which finally strike the basin. Here, in the vibrating finger, you have a source of agitation; in the water you have a vehicle through which the finger's motion is transmitted, and you have finally the side of the basin which receives the shock of the little waves.

In like manner, according to the *wave-theory* of light, you have a source of agitation in the vibrating atoms, or smallest particles, of the luminous body; you have a vehicle of transmission in a substance which is supposed to fill all space, and to be diffused through the humors of the eye; and, finally, you have the retina, which receives the successive shocks of the waves. These shocks are supposed to produce the sensation of light. We are here dealing, for the most part, with suppositions and assumptions merely. We have never seen the atoms of a luminous body, nor their motions. We have never seen the medium which transmits their motions, nor the waves of that medium. How, then, do we come to assume their existence?

Before such an idea could have taken any real root in the human mind, it must have been well disciplined and prepared by observations and calculations of ordinary wave-motion. It was necessary to know how both water-waves and sound-waves are formed and propagated. It was, above all things, necessary to know how waves, passing through the same medium, act upon each other. Thus disciplined, the mind was prepared to detect any resemblance presenting itself between the action of light and that of waves. Great classes of optical phenomena accordingly appeared which could be accounted for in the most complete and satisfactory manner by assuming them to be produced by waves, and which could not be otherwise accounted for. It is because of its competence to explain all the phenomena of light that the wave-theory now receives universal acceptance on the part of scientific men.

Let me use an illustration. We infer from the flint implements recently found in such profusion all over England and in other countries, that they were produced by men, and also that the pyramids of Egypt were built by men, because, as far as our experience goes, nothing but men could form such implements or build such pyramids. In like manner, we infer from the phenomena of light the agency of waves, because, as far as our experience goes, no other agency could produce the phenomena.

Thus, in a general way, I have given you the conception and the grounds of the conception, which regards light as the product of wave-motion; but we must go further than this, and follow the conception into some of its details. We have all seen the waves of water, and we know they are of different sizes—different in length and different in height. When, therefore, you are told that the atoms of the sun, and of almost all other luminous bodies, vibrate at different rates, and produce waves of different sizes, your experience of water-waves will enable you to form a tolerably clear notion of what is meant.

As observed above, we have never seen the light-waves, but we judge of their presence, their position, and their magnitude, by their effects. Their lengths have been thus determined, and found to vary from about $\frac{1}{30000}$th to $\frac{1}{60000}$th of an inch.

But, besides those which produce light, the sun sends forth incessantly a multitude of waves which produce no light. The largest waves which the sun sends forth are of this non-luminous character, though they possess the highest heating power. A common sunbeam contains waves of all kinds, but it is possible to *sift* or *filter* the beam so as to intercept all its light, and to allow its obscure heat to pass unimpeded. For substances have been discovered which, while intensely opaque to the light-waves, are almost perfectly transparent to the others. On the other hand, it is possible, by the choice of proper substances, to intercept, in a great degree, the pure heat-waves, and to allow the pure light-waves free transmission. This last separation is, however, not so perfect as the first.

We shall learn presently how to detach the one class of waves from the other class, and to prove that waves competent to light a fire, fuse metal, or burn the hand like a hot solid, may exist in a perfectly dark place.

Supposing, then, that we withdraw, in the first instance, the large heat-waves, and allow the light-waves alone to pass. These may be concentrated by suitable lenses and sent into water without sensibly warming it. Let the light-waves now be withdrawn, and the larger heat-waves concentrated in the same manner; they may be caused to to boil the water almost instantaneously.

This is the point to which I wished to lead you, and which without due preparation could not be understood. You now perceive the important part played by these large darkness-waves, if I may use the term, in the work of evaporation. When they plunge into seas, lakes, and rivers, they are intercepted close to the surface, and they heat the water at the surface, thus causing it to evaporate; the light-waves at the same time entering to great depths without sensibly heating the water through which they pass. Not only, therefore, is it the sun's fire which produces evaporation, but a particular constituent of that fire, the existence of which you probably were not aware of.

Further, it is these self-same lightless waves which, falling upon the glaciers of the Alps, melt the ice and produce all the rivers flowing from the glaciers; for I shall prove to you presently that the light-waves, even when concentrated to the uttermost, are unable to melt the most delicate hoar-frost; much less would they be able to produce the copious liquefaction observed upon the glaciers.

These large lightless waves of the sun, as well as the heat-waves issuing from non-luminous hot bodies, are frequently called obscure or invisible heat.

We have here an example of the manner in which phenomena, apparently remote, are connected together in this wonderful system of things that we call Nature. You cannot study a snow-flake profoundly without being led back by it step by step to the constitution of the sun. It is thus throughout Nature. All its parts are interdependent, and the study of any one part *completely* would really involve the study of all.

Heat issuing from any source not visibly red cannot be concentrated so as to produce the intense effects just referred to. To produce these it is necessary to employ the obscure heat of a body raised to the highest possible state of incandescence. The sun is such a body, and its dark heat is therefore suitable for experiments of this nature. But in the atmosphere of London, and for experiments such as ours, the heat-waves emitted by coke, raised to intense whiteness by a current of electricity, are much more manageable than the sun's waves. The electric light has also the advantage that its dark radiation embraces a larger proportion of the total radiation than the dark heat of the sun. In fact, the force or energy, if I may use the term, of the dark waves of the electric light is fully seven times that of its light-waves. The electric light, therefore, shall be employed in our experimental demonstrations.

From this source a powerful beam is sent through the room, revealing its track by the motes floating in the air of the room; for, were the motes entirely absent, the beam would be unseen. It falls upon a concave mirror (a glass one silvered behind will answer), and is gathered up by the mirror into a cone of reflected rays; the luminous apex of the cone, which is the *focus* of the mirror, being about fifteen inches distant from its reflecting surface. Let us mark the focus accurately by a pointer.

And now let us place in the path of the beam a substance perfectly opaque to light. This substance is iodine dissolved in a liquid called bisulphide of carbon. The light at the focus instantly vanishes when the dark solution is introduced. But the solution is intensely transparent to the dark waves, and a focus of such waves remains in the air of the room after the light has been abolished. You may feel the heat of these waves with your hand; you may let them fall upon a thermometer, and thus prove their presence; or, best of all, you may cause them to produce a current of electricity, which deflects a large magnetic needle. The magnitude of the deflection is a measure of the heat.

Our object now is, by the use of a more powerful lamp, and a better mirror (one silvered in front and with a shorter focal distance), to intensify the action here rendered so sensible. As before, the focus is rendered strikingly visible by the intense illumination of the dust-particles. We will first filter the beam so as to intercept its dark waves, and then permit the purely luminous waves to exert their utmost power on a small bundle of gun-cotton placed at the focus.

No effect whatever is produced. The gun-cotton might remain there for a week without ignition. Let us now permit the unfiltered beam to act upon the cotton. It is instantly dissipated in an explosive flash. This experiment proves that the light-waves are incompetent to explode the cotton, while the waves of the full beam are competent to do so; hence we may conclude that the dark waves are the real agents in the explosion. But this conclusion would be only probable; for it might be urged that the *mixture* of the dark waves and the light-waves is necessary to produce the result. Let us, then, by means of our opaque solution, isolate our dark waves and converge them on the cotton. It explodes as before. Hence it is the dark waves, and they only, that are concerned in the ignition of the cotton.

At the same dark focus sheets of platinum are raised to vivid redness; zinc is burnt up; paper instantly blazes; magnesium wire is ignited; charcoal within a receiver containing oxygen is set burning; a diamond similarly placed is caused to glow like a star, being afterward gradually dissipated. And all this while the *air* at the focus remains as cool as in any other part of the room.

To obtain the light-waves we employ a clear solution of alum in water; to obtain the dark-waves we employ the solution of iodine above referred to. But, as before stated, the alum is not so perfect a filter as the iodine; for it transmits a portion of the obscure heat.

Though the light-waves here prove their incompetence to ignite gun-cotton, they are able to burn up black paper; or, indeed, to explode the cotton when it is blackened. The white cotton does not absorb the light, and without absorption we have no heating. The blackened cotton absorbs, is heated, and explodes.

Instead of a solution of alum, we will employ for our next experiment a cell of pure water, through which the light passes without sensible absorption. At the focus is placed a test-tube also containing water, the full force of the light being concentrated upon it. The water is not sensibly warmed by the concentrated waves. We now remove the cell of water; no change is visible in the beam, but the water contained in the test-tube now boils.

The light-waves being thus proved ineffectual, and the full beam effectual, we may infer that it is the dark waves that do the work of heating. But we clinch our inference by employing our opaque iodine filter. Placing it on the path of the beam, the light is entirely stopped, but the water boils exactly as it did when the full beam fell upon it.

And now with regard to the melting of ice. On the surface of a flask containing a freezing mixture we obtain a thick fur of hoar-frost. Sending the beam through a water-cell its luminous waves are concentrated upon the surface of the flask. Not a spicula of the frost is dissolved. We now remove the water-cell, and in a moment a patch of the frozen fur as large as half a crown is melted. Hence, inasmuch as the full beam produces this effect, and the luminous part of the beam does not produce it, we fix upon the dark portion the melting of the frost. As before, we clinch this inference by concentrating the dark waves alone upon the flask. The frost is dissipated exactly as it was by the full beam.

These effects are rendered strikingly visible by darkening with ink the freezing mixture within the flask. When the hoar-frost is removed, the blackness of the surface from which it had been melted comes out in strong contrast with the adjacent snowy whiteness. When the flask itself, instead of the freezing mixture, is blackened, the purely luminous waves, being absorbed by the glass, warm it; the glass reacts upon the frost, and melts it. Hence the wisdom of darkening, instead of the flask itself, the mixture within the flask.

This experiment proves to demonstration that it is the dark waves of the sun that melt the mountain snow and ice, and originate all the rivers derived from glaciers.

There are writers who seem to regard science as an aggregate of facts, and hence doubt its efficacy as an exercise of the reasoning powers. But all that I have here taught you is the result of reason, taking its stand, however, upon the sure basis of observation and experiment. And this is the spirit in which our further studies are to be pursued.

THE NATURAL HISTORY OF MAN.

A COURSE OF LECTURES BY A. DE QUATREFAGES.

TRANSLATED BY ELIZA A. YOUMANS.

II.—The Antiquity of Man.

GENTLEMEN: I shall to-day continue the Natural History of Man, which I have undertaken to give you entire. Those of you who were present at our first lecture know that it was devoted to the examination of a fundamental question. We inquired if all the men living upon earth, however they may differ among themselves, are of one and the same species; that is, if they are to be regarded as descended from a single primitive pair.

To answer this question, we appealed to science alone. We started with the principle that, so far as the body is concerned, man is an animal—nothing more, nothing less; that, consequently, all the general laws to which animals are subject bear upon him, and he cannot evade their dominion.

We then asked, not only of animals, but also of plants, What is meant by the word *species?* and we were led to distinguish species from *race.*

Without going into the details I then gave, this distinction is easily established. When two individuals of different species unite, the union is almost always infertile, and, if the first union is fertile, the offspring, either immediately or at the end of a few generations, will reproduce no more. So that, between two species, we cannot establish a third series of individuals, starting at first with a father and a mother taken from two distinct species. The examples I gave are known to you all. When we unite a jackass with a mare, an ass with a stallion, we obtain a mule or a hinny, and never a horse or an ass; and, to get mules, it is always necessary to have recourse to a jackass and a mare.

When, on the contrary, we take two individuals of two different races of the same species, whatever their differences of exterior conformation, the resulting individual is fertile, and may give birth to an intermediate series of individuals between the two races.

As examples, I took the different races of dogs, of sheep, of cattle. Whatever the skin, the color, the form, the proportions of the dog, he remains a dog; whatever the proportions, the figure, the color of horses or of oxen, they remain horses and oxen. So, when we cross a water-spaniel with a greyhound, a lap-dog with a Havana dog, the offspring are fertile, and we get what are called fertile mixed races.

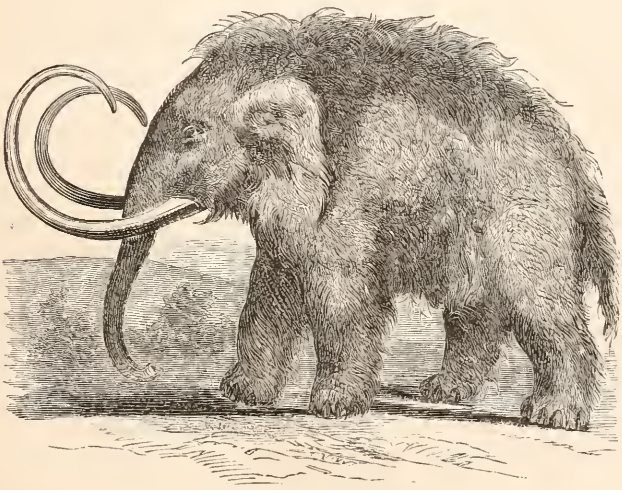
Now, when human beings unite with each other, whatever their exterior differences, whether they are white, or black, or yellow, these marriages are fertile. From this fact, verified a thousand times, we draw the conclusion that there is but one species of men, and that the differences existing between them are only differences of race. Again I say, in reaching this conclusion, we have never gone beyond science. I repeat this declaration, because, in all that I shall say to you, I wish you distinctly to understand that I never put foot outside the domain of science, where alone the scientific man can speak with authority.

The unity of the human species once demonstrated, many problems arise before us.

The first is that of the antiquity of man. Have men been always upon the earth? Did they appear at the same time with the other species of animals? Are they very ancient on the globe? Such are the first questions which present themselves to our minds.

Throughout all time have men lived on the earth? Many of you,

Fig. 1.



Extinct Elephant, or Mammoth.

doubtless, are already able to answer me. My brother professors of geology and paleontology have probably addressed you on these questions. I shall only recall to you the general facts bearing upon the case.

You all know what is the action of heat upon certain bodies. For example, you all know that water heated to a certain degree vaporizes; that if this vapor loses a certain quantity of heat, it is liquefied; that in losing still more, it forms a solid body—ice. This ice may become so solid, that in St. Petersburg they have been able to construct it into palaces, and have made cannons of ice that have been fired. You can understand that a sufficient quantity of heat will reduce all bodies to vapor, and that sufficient cold will solidify them.

Now, the facts of astronomy seem to prove that, of old, our earth, with all it contains, and all the materials that compose it, began as a vast, vaporous mass diffused in space. It was a globe of vapor. When the process of cooling set in, this mass became liquid, and, during periods of time which we cannot compute, it was only a vast mass of rocks and of matter melted by fire.

It is needless to insist on the fact that, at this epoch, on the surface of our globe, there were no living beings, and consequently no men.

The cooling progressing, there is formed a pellicle on the surface of the globe, and this pellicle goes on increasing in thickness. This is what we will call the primitive earth. On this primitive earth, during a long period, water could not exist in a liquid state, and consequently there were as yet upon our globe no living beings, for all these beings need water; and, of course, no men.

But the process of cooling continued. The water which was vaporized in the atmosphere fell in torrents on this crust which enveloped the globe; chemical reactions, of a violence of which we can form no idea, were produced. At this moment began the formation of what we call the earth of transport, and the globe entered upon what is called the Secondary epoch.

Strictly we may say that, from the moment the waters rested in a liquid state upon the surface of the earth, life might begin to manifest itself. In certain thermal waters of high temperature, we find confervæ—microscopic vegetables which are already organized and living. But no animal could yet live in this medium, for the heat would coagulate its albumen. Later, the cooling always progressing and the sea enveloping the greater part of the globe, more complex vegetables appeared. Soon animals, chiefly aquatic, made their appearance, and among them I would mention those gigantic reptiles you have sometimes seen represented in certain book announcements on the walls of Paris. Mammals—man—could not yet inhabit our globe.

As the cooling progressed, continents were formed by the upturnings of Nature. The time came when true mammals and birds, analogous to living species, appeared in their turn. This was the commencement of the Tertiary epoch. Then, very probably, man might have lived. We shall presently have to ask if he did not exist, at least in the latter part of this period.

The dislocation of the crust of the globe elevated the mountains, dug the valleys, sank the seas, formed the continents, and, toward the end of the Tertiary period, the globe presented a surface much resembling what we see now. Here commences the Quaternary period. This quaternary period presents to us a very remarkable phenomenon.

Up to this time, putting out of account the slight oscillations that have occurred, the globe seems to have cooled in a nearly uniform manner, from the time when it formed only a mass of vapor, down to the Tertiary epoch. With the Quaternary period came a moment wherein a cooling, perhaps sudden, but in any case very marked, showed itself and then disappeared.

At this moment, a part of the globe at least, and Europe in particular, was much colder than it is now. We have proof of this in the glaciers of the Alps. Instead of stopping at the place where they do now, these glaciers filled most of the Swiss valleys, descending even in the valley of the Rhone; and from one end to the other of these valleys enormous blocks of rock were transported by the glaciers, and

Fig. 2.

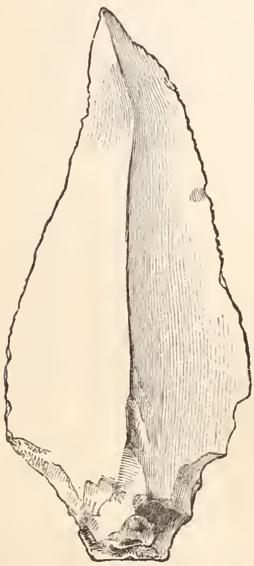
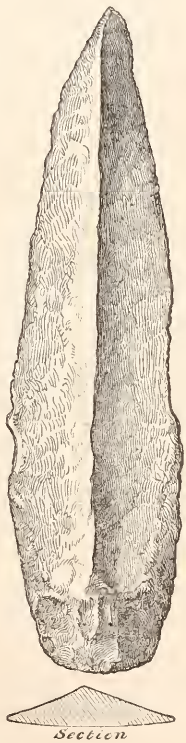


Fig. 3.



Arrow-shaped Flint Implements.

left on the spot. It is these which now constitute what we call erratic blocks.

During the Quaternary epoch, there lived in France very different animals from those which we find now. Among them I may refer to the great cave-bears, which were remarkable for their size and for their bulging foreheads. I will also mention the hyena. You know that now we have no hyenas, and that they are only found in countries much warmer than France. To the preceding species I will add the rhinoceros. I call attention particularly to an elephant, of which this is the picture (Fig. 1), and which we call the mammoth. This elephant, you see, is easily distinguished from species now living; by its size, first, for it is much larger than they; then by the form of its remarkably recurved tusks; finally and chiefly because, in place of the naked skin of the elephants we know, he was covered with a thick wool and very long hairs.

Of all this we are certain; for this elephant has been found preserved whole, with his skin and his hairs. At different times they have discovered in the frozen earth of Siberia the dead bodies of these animals. That country contains in such great numbers the tusks of these antediluvian elephants, to employ a vulgar expression, that the commerce in fossil ivory constitutes a considerable source of revenue, and the state reserves a monopoly of it.

I call special attention to this elephant, and we shall presently see why.

The Quaternary period ended as those that preceded it; and then began the present period. Since the time of its commencement, the continents, the flora, and the faunæ, have not undergone any considerable modifications.

Nobody has ever questioned the existence of man at the beginning of the present period, and some have even considered his appearance as the characteristic feature of this period. But did man exist before? To employ the common expression, were there antediluvian men? In other words, and to return to scientific language, is man the contemporary of those animal species among which appears the mammoth? May he be found, like the mammoth, in a fossil state?

Such is the question that has been often put, and which was long answered in the negative. Down to these later times, the most eminent men in Natural History, in Geology, in Paleontology, were all agreed on this point, and I need only state that Cuvier, in particular, never admitted the existence of fossil man.

To-day we are led by many well-ascertained facts to answer this question very differently. We are forced to admit that fossil man does really exist, and that man was contemporary with those species of animals I have been speaking of, especially with the mammoth.

This is certainly one of the most beautiful discoveries of modern times! The ground for it was laid by the establishment of a certain number of facts observed in England, in Germany, in France. But the honor of having brought decisive proofs, which convince everybody, belongs incontestably to two Frenchmen—to M. Boucher de Perthes, and to M. Edouard Lartet.

M. Boucher de Perthes, the eminent archæologist of Abbeville, while inspecting the excavations made in the earth around his native village, at Menchecourt, and at Moulin-Quignon, discovered stones fashioned in a peculiar manner, and the same form was constantly reproduced. It was soon evident to him that this circumstance was not accidental, but that these stones owed their form to human industry.

Now, these polished flints (Figs. 2 and 3), these stone hatchets (Figs. 4 and 5), were found in the earth associated with the bones of elephants; whence he concluded that the men who had fashioned them lived at the same epoch with those great mammifers long since extinct.

This conclusion, drawn by M. Boucher de Perthes, was at first vigorously contested. In particular, some of the men whose decisions have justly the highest authority on questions relating to the history of the earth, thought that the chipped flints and the bones of elephants

Fig. 4.

Fig. 5

Flint Hatchets.

were found together in the same bed because this bed had been altered. They said: A first bed was formed which enclosed the bones of elephants. On this bed, during the present period, men lived and have left these chipped flints as a trace of their presence. Then came a mighty tempest, which rolled and confounded together the hatchets and the elephants' bones. Hence we now find them side by side, although the bed to which they belong contains the remains of two perfectly distinct epochs.

It will be apparent to you that, if, in our day, men were buried in this bed of Menchecourt and of Moulin-Quignon, and, if a great storm should come and mingle these modern bones with the hatchets and bones of elephants, our grandchildren would find them all mixed together, and yet the men of to-day are not contemporaneous with the hatchets you see before you.

The objection was all the stronger for having been advanced, as I have said, by the highest authorities in Geology. This is why I attach such importance to the facts, for which we are indebted to M. Lartet, and which entirely refute these conjectures.

M. Lartet studied at Aurignac, in the south of France, a burial-place of these remote times. It is a grotto excavated in the side of a hill, at a height which is not attained by water-courses analogous to those of which we find the trace in the neighborhood of Abbeville. This sepulchral grotto at the time of discovery was closed by a slab taken from a bed of rocks at some distance from this point. In the interior were found the bones of seventeen persons, men, women, and children; and before the entrance were found the well-attested remains of a fireplace. There were traces of funeral repasts that the first inhabitants of our country were in the habit of making, and such as we sometimes find in our own day among certain European peoples. In the ashes of this fireplace were found bones bearing the trace of fire, and excrements of wild animals. These bones, scorched by the fire, bearing traces of the hand of man, were the bones of the bear and of the rhinoceros. The excrements were those of a species of hyena contemporaneous with the preceding animals. Here, consequently, man appears as eating the animals in question; as making his repast of those very animals whose contemporaneousness with him had been disputed.

M. Lartet crowned these beautiful researches by discovering in a cave, in the centre of France, a piece of ivory on which was unmistakably represented the very mammoth (Fig. 6) to which I have just called your attention. It is very evident that this picture could only be made by a man who lived at the same time with this elephant.

In view of M. Lartet's discoveries, we must admit the existence of fossil man, that is to say, the coexistence of our species with the lost species of animals of which I have spoken.

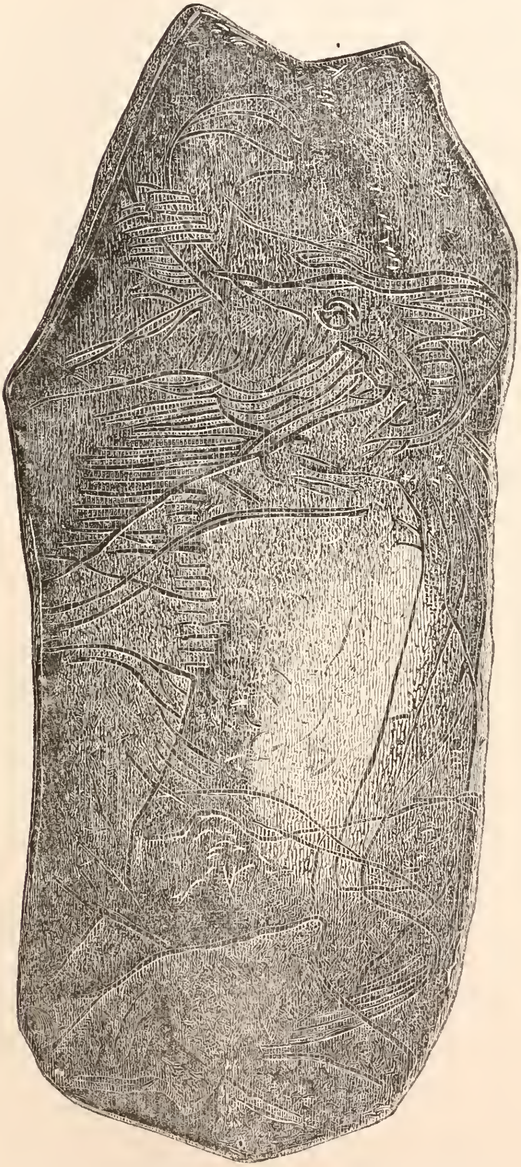
Since this epoch, besides, we have not only found traces of these primitive industries, but *débris* of jawbones, and entire crania. Hence we can judge of the characters which distinguished our first ancestors. Strange to tell, we find that these men who, even in France, warred with stone weapons such as I have shown you, against the elephant and the rhinoceros, have still at the present day in Europe descendants presenting the same characters.

So man lived in the Quaternary epoch. May we go further, and admit that he also existed during the Tertiary epoch? Was he contemporaneous, not only with the rhinoceros and mammoth, of which I have spoken, but also with earlier mammals?

The question is perhaps still premature. Some facts seem to indicate that it is so; but in such matters it is better to adjourn conviction than to admit opinions that are yet in doubt. Consequently, we shall regard the debate as remaining open.

After demonstrating that man goes back in geologic time to an epoch much anterior to that in which we formerly believed, we are naturally led to ask if it is possible to estimate in figures this antiquity of our species. We are obliged up to the present time to answer, No.

FIG. 6.



Sketch of Fossil Mammoth on ivory, found among Cave Relics.

We can perfectly establish relative epochs; but we cannot judge of the number of years that each of these epochs represents.

This, however, has been attempted. From calculations of the time required to form a bed of peat, some have attempted to compute the duration of certain periods of the age of stone, of the age of bronze, and of the age of iron.

But the results have been so discordant as to throw doubt upon the method. Then the accumulations of *débris* thrown up by torrents of the Alps have been studied, and, in particular, an accumulation of this kind known under the name of the cone of Tinnière. A railroad has cut through these materials, which have probably been accumulating ever since the commencement of the present epoch, and in the cut there have been found *débris* reaching back in one case to the Gallo-Roman epoch, in others to the Roman epoch—these to the epoch of iron, those to that of bronze, and, finally, to the epoch of stone.

As we know the duration of some of these periods, it has been thought possible by a simple proportion, taking account of the thickness of the beds, to go back to the epoch of the first formation of the cone. But here again, I repeat, the results are so uncertain that we cannot give them any serious confidence.

We cannot, then, give precise figures. Yet, from all these researches, and from archæologic facts not less demonstrated, it results that it is necessary to go back much farther than we have been accustomed to, to look for the advent of man upon the earth. Let me cite you just one of these proofs.

You were at the Universal Exposition—probably you entered the Egyptian Temple. At the bottom of the hall, facing the entrance, you saw a statue—that of King Cephren. This statue goes back something like four thousand years before our era. Consequently, it was sculptured about six thousand years ago. Now, you may know that the work was very difficult, for the stone of which it is made is very hard. The statue is remarkably perfect. From this, as well as from other data, we learn that in Egypt, six thousand years ago, civilization was already much advanced. We must, therefore, date back the origin of the Egyptians more than six thousand years. But we shall presently see that Egypt was not the first inhabited country. Man must have come there from his original home. Consequently, his first appearance on the globe will be found much more remote in time.

So we are now certain of the existence of Quaternary man; we already suspect the existence of Tertiary man, and it is precisely in our country that the discoveries which led to these conclusions were made.

SCRUTABLE PROVIDENCES.

WHEN, the other day, a juror in one of the Westfield suits refused to award damages against the steamboat company, on the ground that the disaster could have happened only by the direct will of God, and was simply an inscrutable Providence, the community heard him with a suppressed titter, which, if it implied tolerance for his convictions, implied equal contempt for his understanding. For it was patent to every mind but his own that a worn-out boiler must explode at the very instant when all conditions favored that catastrophe, and that the men who knew that that instant was imminent, yet hourly solicited travellers to a possible death, were morally guilty, not only of criminal neglect and deceit, but of murder.

But many candid men, who saw clearly the accountability of the Westfield owners and managers, shake their heads just now over what seems to them a really mysterious visitation of God—the Persian famine. And because all great and inexplicable calamities pain loving hearts, and sadden, if they do not obscure the faith of many souls, it seems worth while to look a moment at this subject of Inscrutable Providences.

Here is this case of the Persian famine. For unknown years the Persians have been cutting off their trees, and diminishing their rainfall thereby. Nay, not only has the removal of the forests decreased the supply, but it has wasted whatever rain fell. For the roots of the trees, and of all the innumerable shrubs and bushes and vines and ferns that thrive in their shadow, kept the ground open and held the water in countless natural wells for the use of the soil in droughts. But all the undergrowth dying when its protecting forests were felled, the scanty showers percolated into the streams at once, causing rare floods and frequent droughts. The droughts yielded no harvests, and no harvests were followed by pestilence, famine, and death. Now, for three years no rain has fallen on the blistered fields, and a nation apparently is dying. The very first drought was the kindly warning of Heaven against the violation of natural laws. Men were too heedless or too ignorant to accept it; and the sins of the fathers are to-day visited on the children, not in the vengeance of an awful Power, but in the discipline of relentless law. Is not this a Providence so scrutable that he who runs may read?

When, in Chicago, a night's fire undid a generation's toil, spreading misery and death broadcast, was that horror in the least degree inexplicable? Every man who, within thirty years, had put up a wooden house in a city whose familiar breezes were gales, and whose gales were hurricanes, solicited that rain of fire. They who, hasting to be rich, fell into the snare of cheap and dangerous building, digged, every man, a pit for his neighbor's feet as well as for his own. The inscrutable aspect of the calamity was that it had not come years before. And the providential lesson would seem to be that laws of matter are laws of God, and cannot be violated with impunity.

When the earthquake wellnigh swallowed up Peru, five or six years ago, men stood aghast at the mysterious dispensation. But Heaven has not only always declared that tropical countries are liable to earthquakes, but had taught the Peruvians through hundreds of years to expect two earthquakes in a century, travelling in cycles from forty to sixty years apart. The citizens of Africa have not only this general instruction, but that special warning which Nature always gives. A great light appeared to the southeast. Hollow sounds were heard. The dogs, the goats, even the swine, foresaw the evil, and hid themselves. But the simple men passed on and were punished.

Before the Alpine freshets come, the streams are coffee-colored. Even the tornadoes of the tropics, which are instantaneous in their swoop, so plainly announce themselves to old sailors, that they reef sails and save ship and life, while only the heedless perish. The simoom gives such certain and invariable warnings that the caravan is safe if it be wary.

Herculaneum and Pompeii were built too far up the mountain. And that the builders knew quite as well as the excavators of the splendid ruins know it now. But they chose to take the risk. And to-day their cheerful compatriots gather their heedless vintage and sit beneath their perilous vines still nearer to the deadly crater. St. Petersburg has been three times inundated, and after each most fatal calamity processions filled the streets and masses were said to propitiate the mysterious anger of God. Peter the Great, who built the city, was the successor of Canute. He ordered the Gulf of Kronstadt to retire, and then set down his capital in the swamps of the verge of the Neva. Whenever the river breaks up with the spring-floods, the trembling citizens are at sea in a bowl. Only three times has the bowl broken, so much money and skill have been expended upon it. But when a March gale shall drive the tide back upon the river, swollen and terrible with drifting ice, drowned St. Petersburg will be the pendant for burned Chicago.

Modern science has brought the world a fifth gospel. In it we read that God commands us to give him our whole heads as well as our whole hearts, for that we cannot know him nor obey him till we discern him in every minutest fact, and every immutable law of the physical universe, as in every fact and law of the moral. It is barely two hundred years since the great Cotton Mather preached a famous sermon called "Burnings Bewailed," wherein he attributed a terrible conflagration to the wrath of God kindled against Sabbath-breaking and the accursed fashion of monstrous periwigs! For years after his time the Puritan colonies held fasts for mildew, for small-pox, for caterpillars, for grasshoppers, for loss of cattle by cold and visitation of

God. They saw an Inscrutable Providence in all these things. But, when their children had learned a better husbandry and better sanitary conditions, the "visitations" ceased.

In the perfect providence of God there are no surprises. If there seem to be, it is that we have suffered ourselves to be taken unawares. We must work out our own salvation. The book of natural phenomena is opened wide before every man, and he is set to learn it for his own good. If he will not study it through reverence and love, he is taught it through pain. But the pain itself is the beneficence of a perfect law, and it is a constant testimony to the goodness and tenderness of God that calamity—not less than prosperity—is a Scrutable Providence.—*Christian Union.*

THE PHYSIOLOGICAL POSITION OF ALCOHOL.

By B. W. RICHARDSON, M. D., F. R. S.

IN whatever mode alcohol may be passed into the living body to produce modification of physical action, the changes it excites are remarkably uniform, and, other things being equal, the amount required to induce the changes is also uniform. Thus, I have found, by many researches, that the proportion of sixty grains of alcohol to the pound weight of the animal body is the quantity capable of producing an extreme effect.

The order of the changes induced is, in like manner, singularly uniform, and extends in a methodical way through all classes of animals that may be subjected to the influence; and, as the details of this part of my subject are the facts that concern us most, I shall expend some time in their narration.

The first symptom of moment that attracts attention, after alcohol has commenced to take effect on the animal body, is what may be called vascular excitement; in other words, over-action of the heart and arterial vessels. The heart beats more quickly, and thereupon the pulse rises. There may be some other symptoms of a subjective kind—symptoms felt by the person or animal under the alcohol—but this one symptom of vascular excitement is the first objective symptom, or that which is presented to the observer. I endeavored in one research to determine from observations on inferior animals what was the actual degree of vascular excitement induced by alcohol, and my results were full of interest. They have, however, been entirely superseded by the observations made on the human subject by Dr. Parkes and Count Wollowicz.

These observers conducted their inquiries on the young and healthy adult man. They counted the beats of the heart, first at regular intervals, during what were called water periods, that is to say, during periods when the subject under observation drank nothing but water; and next, taking still the same subject, they counted the beats of the heart during successive periods in which alcohol was taken in increasing quantities; thus step by step they measured the precise action of alcohol on the heart, and thereby the precise primary influence induced by alcohol. Their results were as follows:

The average number of beats of the heart in 24 hours (as calculated from eight observations made in 14 hours), during the first or water period, was 106,000; in the alcoholic period it was 127,000, or about 21,000 more; and in the brandy period it was 131,000, or 25,000 more.

The highest of the daily means of the pulse observed during the first or water period was 77.5; but on this day two observations are deficient. The next highest daily mean was 77 beats.

If, instead of the mean of the eight days, or 73.57, we compare the mean of this one day, viz., 77 beats per minute, with the alcoholic days, so as to be sure not to over-estimate the action of the alcohol, we find:

On the 9th day, with one fluidounce of alcohol, the heart beat 430 times more.

On the 10th day, with two fluidounces, 1,872 times more.

On the 11th day, with four fluidounces, 12,960 times more.

On the 12th day, with six fluidounces, 30,672 times more.

On the 13th day, with eight fluidounces, 23,904 times more.

On the 14th day, with eight fluidounces, 25,488 times more.

But as there was ephemeral fever on the 12th day, it is right to make a deduction, and to estimate the number of beats in that day as midway between the 11th and 13th days, or 18,432. Adopting this, the mean daily excess of beats during the alcoholic days was 14,492, or an increase of rather more than 13 per cent.

The first day of alcohol gave an excess of 4 per cent., and the last of 23 per cent.; and the mean of these two gives almost the same percentage of excess as the mean of the six days.

Admitting that each beat of the heart was as strong during the alcoholic period as in the water period (and it was really more powerful), the heart on the last two days of alcohol was doing one-fifth more work.

Adopting the lowest estimate which has been given of the daily work done by the heart, viz., as equal to 122 tons lifted one foot, the heart, during the alcoholic period, did daily work in excess equal to lifting 158 tons one foot, and in the last two days did extra work to the amount of 24 tons lifted as far.

The period of rest for the heart was shortened, though, perhaps, not to such an extent as would be inferred from the number of beats for each contraction was sooner over. The heart, on the fifth and sixth days after alcohol was left off, and apparently at the time when the last traces of alcohol were eliminated, showed in the sphygmographic tracings signs of unusual feebleness; and, perhaps, in consequence of this, when the brandy quickened the heart again, the tracings showed a more rapid contraction of the ventricles, but less power, than in the alcoholic period. The brandy acted, in fact, on a heart whose nutrition had not been perfectly restored.

It is difficult, at first glance, to realize the excessive amount of work performed by the heart under this extreme excitement. Little wonder is it that, after the labor imposed upon it by six ounces of alcohol, the heart should flag; still less wonder that the brain and muscles which depend upon the heart for their blood-supply should be languid for many hours, and should require the rest of long sleep for renovation. It is hard physical work, in short, to fight against alcohol; harder than rowing, walking, wrestling, carrying heavy weights, coal-heaving, or the tread-wheel itself.

While the heart is thus laboring under the action of alcoholic stimulation, a change is observable in the extreme circulation—that circulation of blood which by varying shades of color in exposed parts of the body, such as the cheek, is visible to the eye. The peripheral circulation is quickened, the vessels distended. We see this usually in persons under the influence of wine in the early stage, and we speak of it as the flush produced by wine. The authors I have already quoted report upon it in definite terms: "The peripheral circulation (during alcoholic excitement) was accelerated, and the vessels were enlarged, and the effect was so marked as to show that this is an important influence for good or for evil when alcohol is used."

By common observation the flush seen on the cheek during the first stage of alcoholic excitation is supposed to extend merely to the parts actually seen. It cannot, however, be too forcibly impressed on the mind of the reader that the condition is universal in the body. If the lungs could be seen, they, too, would be found with their vessels injected; if the brain and spinal cord could be laid open to view, they would be discovered in the same condition; if the stomach, the liver, the spleen, the kidneys, or any other vascular organs or parts could be laid open to the eye, the vascular enlargement would be equally manifest.

In course of time, in persons accustomed to alcohol, the vascular changes, temporary only in the novitiate, become confirmed and permanent. The bloom on the nose which characterizes the genial toper is the established sign of alcoholic action on vascular structure.

Recently some new physiological inquiries have served to explain the reason why, under alcohol, the heart at first beats so quickly and why the pulses rise. At one time it was imagined that the alcohol acted immediately upon the heart, stimulating it to increased action, and from this idea—false idea, I should say—of the primary action of alcohol, many erroneous conclusions have been drawn. We have now learned that there exist many chemical bodies which act directly by producing a paralysis of the organic nervous supply of the vessels which constitute the minute vascular circuit. These minute vessels when paralyzed offer inefficient resistance to the stroke of the heart, and the heart thus liberated, like the mainspring of a clock from which the resistance has been removed, quickens in action, dilating the minute and feebly-acting vessels, and giving evidence really not of increased but of wasted power.

The phenomena noticed above constitute the first stage of alcoholic action on the body; we may call it the stage of excitement; it corresponds with a similar stage or degree caused by chloroform.

If the action of alcohol be carried further, a new set of changes is induced in another part of the nervous system—the spinal system. Whether this change be due simply to the modification of the circulation in the spinal cord, or to the direct action of the alcohol upon the nervous matter, is not yet known, but the fact of change of function is well marked, and it consists of deficient power of coördination of muscular movement. The nervous control of certain of the muscles is lost, and the nervous stimulus is more or less enfeebled. The muscles of the lower lip in the human subject usually fail first of all, then the muscles of the lower limbs, and it is worthy of remark that the flexor muscles give way earlier than the extensors. The muscles themselves by this time are also failing in power; they respond more feebly than is natural to the galvanic stimulus; they, too, are coming under the depressing influence of the paralyzing agent, their structure temporarily changed, and their contractile power everywhere reduced. This modification of the animal functions under alcohol marks the second degree of its action. In this degree, in young subjects, there is usually vomiting, and in birds this symptom is invariable. Under chloroform there is produced a degree or stage of action holding the same place in the order of phenomena.

The influence of the alcohol continued still longer, the upper portions of the cerebral mass, or larger brain, become implicated. These are the centres of thought and volition, and as they become unbalanced and thrown into chaos, the mind loses equilibrium, and the rational part of the nature of the man gives way before the emotional, passional, or mere organic part. The reason now is off duty, or is fooling with duty, and all the mere animal instincts and sentiments are laid atrociously bare. The coward shows up more craven, the braggart more braggart, the bold more bold, the cruel more cruel, the ignorant more ignorant, the untruthful more untruthful, the carnal more carnal. "*In vino veritas*" expresses faithfully, indeed even to physiological accuracy, a true condition. The spirits of the emotions are all in revel, and are prepared to rattle over each other in wild disorder;

foolish sentimentality, extending to tears, grotesque and meaningless laughter, absurd promises and asseverations, inane threats or childish predictions impel the tongue, until at last there is failure of the senses, distortion of the objective realities of life, obscurity, sleep, insensibility, and utter muscular prostration. This constitutes the third stage of alcoholic intoxication. It is the stage of insensibility under chloroform when the surgeon performs his painless task.

While these changes in the action of the nervous system are in progress there is a peculiar modification proceeding in respect to the temperature of the body. For a little time the external or surface temperature is increased, especially in those parts that are unduly charged and flushed with blood. But it is to be observed that in respect to the mass of the body the tendency is to a fall of temperature. In the progress toward complete intoxication under alcohol, however, there are, as we have already seen, three degrees or stages. The first is a stage of simple exhilaration, the second of excitement, the third of rambling insensibility, and the fourth of entire unconsciousness, with muscular prostration. The duration of these stages can be modified in the most remarkable manner by the mode of administration; but whether they are developed or recovered from in an hour or a day, they are always present except in cases where the quantity of alcohol administered is in such excess that life instantly is endangered or destroyed. In the first or exhilarative stage the temperature undergoes a slight increase; in birds a degree Fahrenheit, in mammals half a degree. In the second degree, during which there is vomiting in birds, or attempts at vomiting, the temperature comes back to its natural standard, but soon begins to fall; and during the third degree the decline continues. The third degree fully established, the temperature falls to its first minimum, and in birds comes down from five and a half to six degrees; in rabbits from two and a half to three degrees. In this condition the animal temperature often remains until there are signs of recovery, viz., conscious or semi-conscious movements, upon which there may be a second fall of temperature of two or even three degrees in birds. In this course of recovery I have seen, for instance, the temperature of a pigeon which had a natural standard of 110° Fahr. reduced to 102°. Usually with this depression of force there is a desire for sleep, and with perfect rest in a warm air there is a return of animal heat; but the return is very slow, the space of time required to bring back the natural heat being from three to four times longer than that which was required to reduce it to the minimum.

In these fluctuations of temperature the ordinary influences of the external air play an important part as regards duration of the fluctuation, and to some extent as regards extremes of fluctuation.

These facts respecting fall of temperature of the animal body under alcohol were derived from observations originally taken from the inferior animals; they have been confirmed since by other observers, from the human subject. Dr. De Marmon, of King's Bridge, New York, has specially proved this fact in some instances of poisoning by whiskey in young children. In one of these examples the temperature of the body fell from the natural standard of 98° Fahr. to 94°, in another to 93½°.

Through all the three stages noticed in the above, the decline of animal heat is a steadily-progressing phenomenon. It is true that in the first stage the heat of the flushed parts of the body is for a brief time raised, but this is due to greater distribution of blood and increased radiation, not to an actual increment of heat within the body. The mass of the body is cooling, in fact, while the surfaces are more briskly radiating, and soon, as the supply of heat-motion fails, there is fall of surface temperature also; a fall becoming more decided from hour to hour up to the occurrence of the fourth and final stage, of which I have now to treat.

The fourth degree of alcoholic intoxication is one of collapse of the volitional nervous centres, of the muscular organs under the control of those centres, and of some of the organic or mere animal centres. It is true that, while the body lies prostrate under alcohol, there are observed certain curious movements of the limbs, but these are not stimulated from the centres of volition, nor are they reflected motions derived from any external stimulus; they are strange automatic movements, as if still in the spinal cord there were some life, and they continue irregularly nearly to the end of the chapter, even when the end is death.

Through the whole of this last stage two centres remain longest true to their duty, the centre that calls into play the respiratory action, and the centre that stimulates the heart. There is then an interval during which there are no movements whatever, save these of the diaphragm and the heart, and, when these fail, the primary failure is in the breathing-muscle: to the last the heart continues in action.

The leading peculiarity of the action of alcohol is the slowness with which the two centres that supply the heart and the great respiratory muscle are affected. In this lies the comparative safety of alcohol: acting evenly and slowly, the different systems of organs die after each other, or together, gently, with the exception of those two on which the continuance of mere animal life depends. But for this provision, every deeply-intoxicated animal would inevitably die.

It happens usually, nevertheless, that under favorable circumstances the intoxicated live: the temperature of the body sinks two or three degrees lower, but the alcohol diffusing through all the tissues, and escaping by diffusion and elimination, the living centres are slowly relieved, and so there is slow return of power. If death actually occurs, the cause of it is condensation of fluid on the bronchial surfaces and arrest of respiration from this purely mechanical cause. The animal is literally drowned in his own secretion. Such are the stages or degrees of alcoholic narcotism, from the first to the last. Let me add two or three observations.

In the first place, we gather that this agent is a narcotic. I have compared it throughout to chloroform, and the comparison is good in all respects save one, viz., that alcohol is less fatal than chloroform as an immediate destroyer.

The well-proven fact that alcohol, when it is taken into the body, reduces the animal temperature, is full of the most important suggestions. It shows that alcohol does not in any sense act as a supplier of vital heat, as is so commonly supposed, and that it does not prevent the loss of heat, as those imagine "who take just a drop to keep out the cold." It shows, on the contrary, that cold and alcohol in their effects on the body run closely together, an opinion most fully confirmed by the experience of those who live or travel in cold regions of the earth.

The conclusive evidence now in our possession that alcohol taken into the animal body sets free the heart, so as to cause the excess of motion of which the record has been given above, is proof that the heart, under the frequent influence of alcohol, must undergo deleterious change of structure. It may, indeed, be admitted in proper fairness, that when the heart is passing through this rapid movement it is working under less pressure than when its movements are slow and natural; and this allowance must needs be made, or the inference would be that the organ ought to stop at once in function by the excess of strain put upon it.

I cannot, by any argument yet presented to me, admit the alcohols by any sign that should distinguish them from other chemical substances of the exciting and depressing narcotic class. When it is physiologically understood that what is called stimulation or excitement is, in absolute fact, a relaxation, I had nearly said a paralysis, of one of the most important mechanisms in the animal body—the minute, resisting, compensating circulation—we grasp quickly the error, in respect to the action of stimulants, in which we have been educated, and obtain a clear solution of the well-known experience that all excitement, all passion, leaves, after its departure, lowness of heart, depression of mind, sadness of spirit. In the scientific education of the people no fact is more deserving of special comment than this fact, that excitement is wasted force, the running down of the animal mechanism before it has served out its time of motion.

It will be said that alcohol cheers the weary, and that to take a little wine for the stomach's sake is one of those lessons that come from the deep recesses of human nature. I am not so obstinate as to deny this argument. There are times in the life of man when the heart is oppressed, when the resistance to its motion is excessive, and when blood flows languidly to the centres of life, nervous and muscular.

In these moments alcohol cheers. It lets loose the heart from its oppression, it lets flow a brisker current of blood into the failing organs; it aids nutritive changes, and altogether is of temporary service to man. So far alcohol is good, and if its use could be limited to this one action, this one purpose, it would be among the most excellent of the gifts of Nature to mankind.

It is assumed by most persons that alcohol gives strength, and we hear feeble persons saying daily that they are being kept up by stimulants. This means actually that they are being kept down, but the sensation they derive from the immediate action of the stimulant deceives them and leads them to attribute lasting good to what, in the large majority of cases, is persistent evil. The evidence is all-perfect that alcohol gives no potential power to brain or muscle. During the first stage of its action it may enable a wearied or feeble organism to do brisk work for a short time; it may make the mind briefly brilliant; it may excite muscle to quick action, but it does nothing at its own cost, fills up nothing it has destroyed as it leads to destruction.

On the muscular force the very slightest excess of alcoholic influence is injurious. I find, by measuring the power of muscle for contraction in the natural state and under alcohol, that, so soon as there is a distinct indication of muscular disturbance, there is also indication of muscular failure, and if I wished, by scientific experiment, to spoil for work the most perfect specimen of a working animal, say a horse, without inflicting mechanical injury, I could choose no better agent for the purpose of the experiment than alcohol. But alas! the readiness with which strong, well-built men slip into general paralysis under the continued influence of this false support, attests how unnecessary it were to put a lower animal to the proof of an experiment. The experiment is a custom, and man is the subject.

It may be urged that men take alcohol, nevertheless, take it freely and yet live; that the adult Swede drinks his average cup of twenty-five gallons of alcohol per year, and yet remains on the face of the earth. I admit force even in this argument, for I know that under the persistent use of alcohol there is a secondary provision for the continuance of life. In the confirmed alcoholic, the alcohol is in a certain sense so disposed of that it fits, as it were, the body for a long season, nay, becomes part of it; and yet it is silently doing its fatal work; all the organs of the body are slowly being brought into a state of adaptation to receive it and to dispose of it; but in that very preparation they are themselves undergoing physical changes tending to the destruction of their function and to perversion of their structure. Thus, the origin of alcoholic phthisis, of cirrhosis of the liver, of degeneration of the kidney, of disease of the membranes of the brain, of disease of the substance of the brain and spinal cord, of degeneration of the heart, and of all those varied modifications of organic parts which the dissector of the human subject so soon learns to observe—almost without concern, and certainly without any thing more than commonplace curiosity—as the devastations incident to alcoholic indulgence.—*Condensed from the Popular Science Review.*

VESUVIUS.

GEOGRAPHERS say there are some two hundred volcanoes on the surface of the earth; of these one is situated on the continent of Europe—Vesuvius. This mountain has had a remarkable history, and is now an object of renewed interest, as it has been again in profound convulsion.

Vesuvius stands about 10 miles southeast of Naples, in Southern Italy. Seen from the city it is a mountain with two summits. That on the left is the peak of Somma, 3,747 feet above the sea; the peak on the right being the volcano itself, about 200 feet higher. Between the two summits is a valley at the entrance to which, on a plateau, is situated the Hermitage and the Observatory. The mountain stands on the plain of Campania, and has a base of some 30 miles in circumference.

Vesuvius was an active volcano in very ancient times, and then was in a state of repose for a long period. This is inferred from the fact that writers before the Christian era never alluded to it as in eruption, but do refer to the igneous character of its rocks, and to its "many signs of having been burning in ancient times." It awoke to great activity A. D. 79, and from that time to the present has been the scene of about sixty grand eruptions.

The sides of the mountain, as described by Strabo, were clothed with gardens and vineyards filled with luxuriant vegetation; beautiful farms and rich woods extended to its top, which was flat, barren, and slaggy. Its dangerous character was not suspected: villas were scattered over the sloping landscape; the cities of Herculaneum, Pompeii, and Stabiæ, were planted at its base, and were fashionable resorts for wealthy Romans.

A premonition of what was coming occurred in the year A. D. 63, in the form of a violent earthquake, which overthrew many houses; but its significance was of course not understood, and the houses were rebuilt.

The first great recorded eruption of Mt. Vesuvius occurred August 24th, in the year 79, and has been described by the younger Pliny in a letter to Tacitus. His uncle, the elder Pliny, was at the time in command of the Roman fleet at Misenum, and his nephew was with him. From this point they first descried the eruption. Rising from the top of the mountain they saw what appeared like a column of dense, black smoke, but which was in reality a mass of dust, ashes, stones, and vapors, the form of which was likened by Pliny to a tall pine-tree throwing out great branches at its top.

Struck with surprise at the new phenomenon, the elder Pliny, a man of philosophical mind, hastened to the shore, that he might examine it more closely. He disembarked at Stabiæ, and went to the house of his friend Pomponianus. Here he remained till evening, gazing at the spectacle, and trying to quiet the fears of those around him. The streaks of fire on the mountain he attributed to the burning of the woods and villages, and when he became weary of the spectacle retired to bed and fell asleep. Meanwhile the shower of stones increased fast in Stabiæ, and began to fill the streets and the courts of the villa. Pliny's servants became alarmed and aroused their master, who joined his friend Pomponianus and his assembled family. What follows is best described in the graphic words of the younger Pliny:

"They took counsel together as to whether they should shut themselves in the house, or whether they should betake themselves to the fields, for the houses were so shaken by the violent tremblings of the earth, which followed each other in quick succession, that they seemed to be torn from their foundations, turned to every point of the compass, and then brought back to their places. On the other hand, they feared outside of the city the falling stones, though they were light and dried up by the heat. Of these two perils they chose the latter. With my uncle the strongest reason prevailed over the weakest. In the minds of those who summoned him, one fear prevailed over another. They fastened pillows around their heads as a sort of shield against the falling stones. Day was breaking elsewhere, but around them the darkest night reigned, though lighted up by the conflagration, and all kinds of fires.

"They approached the shore in order to attempt to escape by the sea, but it was stormy and contrary. There my uncle lay down upon a blanket and asked for some cold water, of which he drank twice. Very soon the flames, and a sulphurous smell which preceded them, put every one to flight, and forced my uncle to get up. He rose, supported by two young slaves, and instantly fell dead. I suppose that the thick smoke arrested respiration and suffocated him. He had a naturally narrow, weak chest, often panting for breath.

"When the light reappeared—three days after the last that had shone for my uncle—his body was found uninjured, the clothing undisturbed, and his attitude was rather that of sleep than of death."

The materials ejected from the mountain consisted of scoriæ and ashes, and their quantity far exceeded its own bulk. The shower of ashes, dust, pumice, and stones, continued to fall for eight successive days, accompanied by torrents of rain, and the cities of Stabiæ, Herculaneum, and Pompeii, were entirely buried. Pompeii was situated several miles farther from the crater than Herculaneum, and was buried only in ashes and loose stones; while Herculaneum was entombed deeper, and in a much more consistent substance, which was evidently plastic, and appears to be composed of volcanic ashes cemented by mud.

The volcano then rested 124 years; the second eruption taking place A. D. 203; and the third, which was much more violent, occurred 269 years later, in the year 472. On this occasion the ashes fell over nearly the whole of Europe; they were transported to Constantinople, and even to Egypt and Syria. In 1036 there occurred a violent eruption, during which lava was for the first time ejected.

The eruption of Vesuvius in 1631 was of extreme violence, and was accompanied by great currents of lava, which flowed over the villages at its base on the side of the Bay of Naples. There were at the same time thrown out immense torrents of hot water, which wrought great desolation.

The eruption of 1779 is described by Sir William Hamilton as among the grandest and most terrible of these phenomena. White sulphurous smoke like heaps of cotton rose up in piles four times as high as the mountain, and spread about it to a proportional extent. Into these clouds, stones, scoriæ, and ashes, were projected to the height of at least 2,000 feet. On subsequent days columns of fire shot forth to full three times the height of the mountain. Masses of rock of great size were projected out of the crater, one of which measured 108 feet in circumference and 17 feet in height. Ponton says the jets of lava were thrown up to a prodigious height. A portion of the ashes and stones was drifted away to some distance; but the greater proportion of these, and nearly all the lava, still red-hot and liquid, fell upon the cone, on part of Monte Somma, and into the valley between them. The whole mass which thus fell, still vividly glowing, formed a continuous fiery expanse about two and a half miles in breadth, which, with the lofty column of fire issuing from the top, presented a magnificent but very terrific spectacle. The heat, radiating from this vast glowing surface, is said to have been perceptible at a distance of six miles all around.

In June, 1794, occurred a terrible eruption, which destroyed the town of Torre del Greco. A single stream of lava was estimated by Breislak as containing more than 46,000,000 cubic feet. A vent opened near the bottom of the mountain, 2,375 feet in length and 237 feet in breadth, which became filled with lava, and on the hardening of this presented a dike in every respect similar to the ancient basaltic dikes.

The eruption of 1822 broke up the whole top of the mountain, and formed an elliptical chasm about three miles in circumference, and supposed to be 2,000 feet deep. The principal cone tumbled in, with a terrible crash, on October 22d, and the following evening there began an eruption which lasted 12 days. The internal detonations of the mountain were described as terrific, while the ashes and dust were so great as to produce at noon in the neighboring villages a darkness deeper than midnight.

The eruption of 1855 presented a most imposing spectacle. We have referred to the valley or ravine between the two mountains, the first descent to which on the side of Vesuvius is a sheer precipice. A great stream of lava, about 200 feet in width, issuing from the crater, took the direction of this ravine, and on arriving at the edge of the precipice fell heavily over it, forming a magnificent fiery cascade about 1,000 feet in height. On reaching the valley beneath, it wended its way through the woods, consuming the trees in its course, and destroying several villages through which it flowed. A grander sight than this cascade of fire must have presented, it would be difficult for the human mind to imagine.

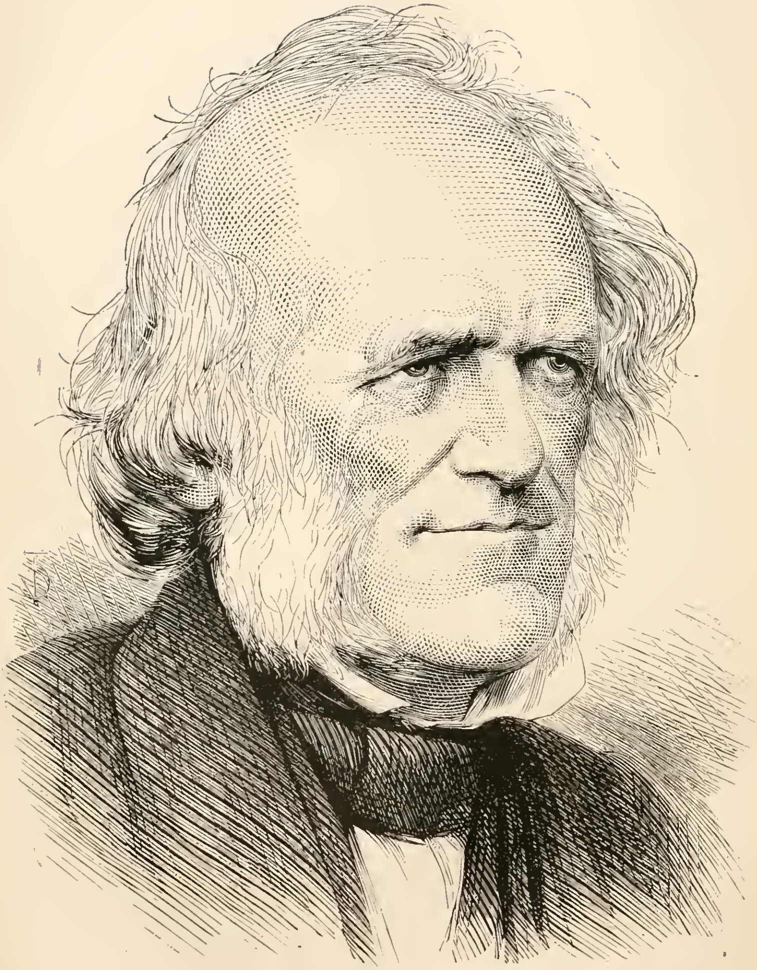
Monnier says that, "since 1850, springs of lava have opened near the base of the cone in the ravine which separates the two mountains; they are seen springing from the lava much as the water of rivers flows from a glacier. In 1855 and 1858 it rolled slowly through the ravine like the Thames in flames. To be really startling, the lava must be seen, not from above, but coming directly toward the spectator, as I saw it in 1855. Then it was no longer a river, but a burning, moving rampart. This wall was at least a mile wide and 20 feet high. It came slowly, irresistibly, covering the ground, burning the trees and houses; you could walk backward before it as a captain does before his company.

"The lava, as it issues from the crater of Vesuvius, is perfectly liquid, and glows with an intense white brilliancy, like that of molten silver; but, as it descends, it begins to cool at the top, and a quantity of broken slag is formed on the surface of the stream, becoming ere long a continuous coating. The speed of the current, very rapid at first, gradually slackens, until, on the level at some distance from the mountain, its progress is scarcely perceptible."

Vesuvius is much more active in modern times than in ancient; several grand eruptions having taken place within the present generation. The recent convulsion has been marked by the usual impressive features, but comparisons with former eruptions must be accepted with hesitation, for, where the imagination is so powerfully affected, and the data are so uncertain, the judgment may be much at fault. The following description of the present display was telegraphed from Naples, April 29th:

"The view of Mount Vesuvius from this city is now the grandest that has been witnessed since the year 1631. Many persons have taken advantage of the panic among the people of the towns which were threatened with destruction, to take whatever goods they could find, and the government has been compelled to order troops to those places to prevent the stealing of abandoned property. In this city the Bourse has closed, and business is almost entirely suspended. The people use umbrellas to protect themselves from the falling ashes.

"A sound as of thunder accompanies the discharges. The wind was blowing in this direction this morning, carrying dense clouds of



SIR CHARLES LYELL.

smoke and ashes over the city. The ashes were falling in the streets like snow, and reached a depth of two or three inches. The rumbling inside the volcano continued, but no fresh craters have opened, and the lava has ceased flowing.

"Showers of sand have succeeded the rain of ashes which was falling this morning. The eruption is now accompanied by fearful electric phenomena. Lightning darts incessantly from the summit of the volcano, and the quakings of the mountain are more violent and frequent. The thunder is continuous. Burning cinders, stones, and scoriæ, are falling fast and thick in the town of Massa di Somma, which is entirely deserted."

SIR CHARLES LYELL.

SIR CHARLES LYELL is now seventy-five years old. He took his degree in Oxford, in 1821, and commenced the study of law, but, influenced by Dr. Buckland, he soon left it for that of geology. His first original papers on this subject were published in 1826, and the first volume of his great work, the "Principles of Geology," was issued in 1830. He came to the United States in 1841, and again in 1845, and visited many localities for the purpose of scientific observation. He became president of the Geological Society in 1836, and again in 1850, and was honored with knighthood, for his success in science, in 1848.

Sir Charles Lyell not only ranks as the first of living geologists, but his name will always be closely linked with one of the most important stages in the development of the science. He has been a careful and extensive observer, but he has also eminently a philosophic cast of mind, leading him to the elucidation of principles, and he has accordingly done much to place this great science upon the sound basis of inductive philosophy. Of the extent of his labors in the various special departments of geological observation, it is unnecessary here to speak, but there are one or two great doctrines with the introduction of which into the science of geology his name will be connected, and to which it will be desirable here to refer.

In an able lecture before the Geological Society, in 1869, Prof. Huxley recognized three great systems of geological thought, which he denominates *Catastrophism*, *Uniformitarianism*, and *Evolutionism*. The first phase of thought historically was that of catastrophism. Prof. Huxley defines it as follows: "By catastrophism, I mean any form of geological speculation, which, in order to account for the phenomena of geology, supposes the operation of forces different in their nature, or immeasurably different in power, from those we at present see in action in the universe. The doctrine of violent upheavals and cataclysms in general is catastrophic so far as it assumes that these were brought about by causes which have now no parallel."

This was the earliest system of doctrine in geology, and was inevitable because of the narrow and false ideas concerning past time. Observation accumulated evidences of vast changes in the earth's crust; it was held that the world is but a few thousand years old; it was therefore concluded that the changes must have been on a stupendous scale, of which we have at present no experience.

There are geologists who still hold to this view, as there were those in the early history of the science who believed in vast time and slow changes. Hutton, in his theory of the earth, in 1795, put forth this advanced principle: "I take things such as I find them at present, and from these I reason to that which must have been." It, however, became the work of Sir Charles Lyell to elucidate and establish this doctrine, by extensive and critical investigations, as a broad and fundamental generalization of geological science. *Uniformitarianism*, or the theory which extends the present rate of terrestrial changes into the past, is a problem of geological dynamics, and involves the study of the totality of forces by which the earth's crust has been altered, and the rocky systems formed.

To work out so vast a subject on the basis of observation and immediate physical data was enough to task the largest capacity, and it is not surprising that Sir Charles Lyell was little disposed to venture into the more speculative questions of the science. Indeed, geologists early insisted on the necessity of limiting inquiry to the changes that have taken place since the formation of the earliest stratified rocks, and crucifying the propensity to pry into the more distant origin of the world. The English Geological Society tacitly forbade these speculations, and of this procedure Mr. Huxley says: "Uniformitarianism, as we have seen, tends to ignore geological speculation in this sense altogether. The one point the catastrophists and the uniformitarianists agreed upon, when this Society was founded, was to ignore it. And you will find, if you look back into our records, that our revered fathers in geology plumed themselves a good deal upon the practical sense and wisdom of this proceeding. As a temporary measure, I do not presume to challenge its wisdom; but in all organized bodies temporary changes are apt to produce permanent effects; and, as time has slipped by, altering all the conditions which may have made such mortification of the scientific flesh desirable, I think the effect of the stream of cold water, which has steadily flowed over geological speculation within these walls, has been of doubtful beneficence."

Mr. Huxley, in common with many other scientists, now holds that the progress of geological thought must carry us beyond uniformitarianism into evolutionism.

But Sir Charles Lyell is the farthest possible from being a narrow-minded partisan. His career offers one of the noblest examples of candor and sincerity, in abandoning old ground and embracing new views, that is afforded in the whole history of science. In the earlier editions of his works he accepted the current opinions in regard to organic species and the past course of life upon earth, but, after a half-century's study of the question, he became satisfied that these views are untenable, and in the tenth edition of his "Principles of Geology," published in 1867, he gave them up, and adopted the general view represented by Mr. Darwin. This great work he has again revised, and the eleventh edition has just made its appearance. All the later questions of this most interesting subject will there be found most ably and fully discussed. We subjoin the notice of the work just published by the *Saturday Review:*

The great work of Sir Charles Lyell has too long and too authoritatively held its place as a classic in the literature of science to call for, or even to admit, the expression of any estimate of its value. The number of editions it has gone through may be taken as sufficiently attesting the concurrence of public taste and conviction with the appreciative opinion of the more critical class of readers at home and abroad. It may be hoped that the wide and increasing circulation of so valuable a work has had, and is long destined to have, the effect of leavening the mass of educated thought with its sound, careful, and conscientious views of physical truth. While congratulating both the writer and reader upon the issue of the eleventh edition of the 'Principles of Geology,' we feel that our notice of its contents is almost of necessity restricted to those portions of the work in which the author has seen reason to amplify, to remodel, or to correct, what he had advanced in former impressions.

Within the last five years special attention has been drawn to the geological proofs of strongly-marked changes in the terrestrial climate during long periods of time. In face of the additional facts and corresponding theories which have thus divided the minds of geological inquirers, Sir Charles Lyell has seen fit to recast those chapters of his work which treated of the meteorology and climatic history of the earth's surface, with a view especially to insist upon the paramount influence exerted in this direction by the relative distribution and height of the land at successive periods. The balance of argument and research has been such in the mean while as to confirm him more and more in his conviction of the agreement and continuity of the forces at work through all the vicissitudes of the earth's surface, from the earliest to the most recent geological ages. It is hardly necessary, perhaps, to go further back, for the pedigree of the organic forms which for the most part chronicle and attest the laws of succession, than to that Miocene period in whose organic deposits the flora and fauna of all subsequent ages seem to have their ground and root. A superficial view of the local changes of climate which are proved to have taken place might have, and indeed has, induced the belief that causes no longer operative had been at work in remoter times. The existence of a subtropical Miocene flora near, and probably up to, the North Pole, with remains of the mastodon, elephant, rhinoceros, and cognate mammals as far north as the icy circle, might be taken to point to a revolution of a terrestrial, if not of a cosmical, kind from higher conditions of temperature. On the other hand, the dispersion in a southern direction of erratic blocks, evidently carried by ice-action, and striated or polished by glacial friction, was a proof of a cold climate extending much farther south than that of the present time, invading even the subtropical latitudes. Now, there can be absolutely no room for the hypothesis of any appreciable change, within Miocene times at least, in the total temperature of the earth, either from the sudden outburst of subterranean fires on the one hand, or from general cooling of the earth's mass on the other. At the same time, a large body of both organic and inorganic evidence supports the view that the climate of earlier geological periods, from whatever cause, had over wide regions been in excess of what it now is. Not only in the greater part of the Miocene and Eocene epochs did a vegetation like that of Central Europe in our day extend into the Arctic regions as far as they have been explored, and probably to the Pole itself, but in the Secondary or Mesozoic ages the prevalent types of vertebrate life indicate a warm climate and an absence of frost between latitude 40° north and the Pole, a large ichthyosaurus having been found in latitude 77° 10′ north. Carrying our retrospect back to the Primary or Palæozoic ages, we find an assemblage of plants which implies that a warm, humid, and equable climate extended from the 30th parallel of north latitude to within a few degrees of the Pole, while a still older flora, the Devonian, leads to a similar inference. Such, moreover, is the general resemblance between the whole invertebrate fauna of the Devonian, Silurian, and Cambrian rocks and that of the Carboniferous, Permian, and Triassic series, as to make it clear that a similarity of conditions as regards temperature prevailed throughout the whole of these six periods.

The idea of possible variations in the temperature of space traversed by our globe, started by Poisson, is promptly set aside by considerations long ago advanced by Mr. Hopkins. Nor is there much greater force, as Sir Charles Lyell amply shows, in the effect attributed by others to variation in the obliquity of the ecliptic. The latest calculations of Sir John Herschel conveyed in a letter to our author, in October, 1866, admit the possibility of a deviation of the earth's axis to the extent of three, or even four, degrees on either side of the mean. The sun's rays would thus be disseminated at intervals over a far broader zone than at present, around the Arctic and Antarctic Poles, with a corresponding shortening of the Polar night, and a diffusion of more genial warmth. Yet, on the other hand, a large deduction must be made, as Mr. Meech has shown, for the increased length of path, and the greater amount of atmosphere through which the calorific rays must pass in very high latitudes, not to speak of the greater prevalence of cloud in regions round the Pole. A truer cause of climatic change is to be sought in the effect of precession of the equinoxes, the revolution of the apsides, and, above all, the eccentricity of the earth's orbit. The great cycle of change due to precession would cause the different seasons of the Northern and Southern Hemispheres to coincide in turn, within 25,868 years, with all the points through which the earth passes in its orbit round the sun. Combining with this movement, that of the revolution of the apsides or "motion of the aphelion," as Herschel named it, reduces this term of years to about twenty-one thousand. Sir C. Lyell's explanation, aided by a new diagram, renders sufficiently clear the effects which would be produced upon climate by the successive phases of precession, especially when combined with increased eccentricity or distance from the sun. The difference between winter in aphelion and perihelion—the range of eccentricity extending, as he has shown, to 14,000,000 miles at some periods, instead of 3,000,000, as now—is set down by Mr. Croll as not less than one-fifth of the entire heat received from the sun. Some slight change in this direction since the year 1248 A. D. has been thought capable of actual proof by M. d'Adhémar, and of being verified by the observations of M. Venetz upon the decrease of Swiss glaciers prior to the tenth century, and their subsequent increase. An admirable table compiled by Mr. Stone shows the variations in eccentricity for a million years before 1800 A. D., with the number of days which would be added to winter by its occurrence in aphelion, which has been followed up for a million years more by Mr. Croll and Mr. Carrick Moore. From these figures there might appear to be a possibility of approximating to a date for the Glacial epoch; and Sir C. Lyell holds it "far from startling" that 200,000 years back might be fixed upon as about the period of greatest cold, when the excess of winter days amounted to 27.7. He had in his tenth edition speculated upon 800,000 or 1,000,000 years as nearer the Glacial epoch, but he feels compelled to narrow the time within the limit at which the principal geographical features of the continents and oceanic basins were approximately assuming their present form. Were the astronomical theory, however, to be relied upon as the basis for the solution of the problem, we ought to meet in the course of palæontological research with a series of Glacial periods perpetually recurring in the Northern Temperate Zone; supposing a large eccentricity by itself sufficient, apart from the coöperation of terrestrial causes, to intensify the cold of high latitudes. But no such evidence of violent revolutions is to be found in the flora and fauna of earlier periods. The continuity of forms, particularly in the class of reptiles, from the Carboniferous to the Cretaceous period, is an obvious fact opposed to the intercalation of intense glacial epochs. Another fact is, that many great cycles of eccentricity must have been gone through in the long centuries of the Carboniferous period, in which no break in the order of life is manifested.

The exhaustion of all other means of solution, joined to the mass of positive evidence accumulated by recent science, throws us more and more conclusively upon the idea to which Sir Charles Lyell has firmly held from the first, and which may be taken as the culminating point of his latest achievements in geology, that the predominant cause of the great changes in climate is to be found in the distribution and elevation of the land. The Glacial period may be traced to an excessive and abnormal accumulation of land around the Pole. There is absolutely no limit to the alternations which the surface of our globe may have, or indeed has gone through. There is hardly a spot of what is now land which has not been covered by the sea, probably not a space now covered by the ocean which has not been at some time, if not many times, dry land. In one epoch the land may have been chiefly equatorial, at another polar or circumpolar. At present we may readily divide the globe into two equal parts, the land hemisphere and the water hemisphere; the former of which exhibits almost as much land as water, or as 1 to 1.106; while in the latter the proportion of land to water, as made out by Mr. Trelawny Saunders, is only as 1 to 7.988. The general proportion of land to sea may be taken throughout the globe as 1 to 2½. Were the land, by the action of subterranean forces, its total amount being unchanged, now gathered together in masses along the equator and around the Poles alternately, such geographical changes would amply suffice, as Sir C. Lyell makes it his task to show, to explain the utmost vicissitudes which the climate of the earth has undergone. This course of reasoning by no means precludes such aid as may be brought in by independent *veræ causæ*, by the concurrence of the cold period induced by excessive piling of land around the Pole with wintering in aphelion, or at a period when the earth's axis was abnormally inclined. These causes, especially in combination, would greatly intensify what, after all, must remain the ruling and inherent principle of climatic revolutions. We have only to look at the present aspect of Greenland to satisfy ourselves what might become the state of the British Isles by a mere substitution of other local conditions under the same parallel of latitude. Were the Gulf Stream done away with, the equatorial continents which now form vast reservoirs of heat transferred to the Northern regions, and their snow-clad frozen surface swept by Polar currents, how far south would the ice-sheet cover the unsubmerged tracts of land, and the glaciers come down to the level of the sea? The chain of facts and reasonings by which Sir Charles Lyell binds together the phenomena which science and discovery contribute to this intricate problem forms one of the most characteristic features of his book. Every new link, and every additional degree of tenacity given to his argument, enhances the value of this standard work as a steadfast, clear-sighted, and consistent witness to the great law of uniformity and continuity in Nature.

The latest information acquired by deep-sea dredging has been incorporated by Sir C. Lyell into his remarks upon the temperature and shape of the bed of the ocean and its living inhabitants. In his chapter on ocean-currents he has also considered the latest-known results of experiments and observations made by Dr. Carpenter, Prof. Wyville Thompson, and Captains Spratt and Nares, upon the currents of the Straits of Gibraltar. The space allotted to this survey is not adequate to a full or critical discussion of the arguments for and against the existence of a permanent indraught. The balance of proof, however, is felt by Sir Charles to support his previously-expressed conviction that the inflowing movement is no permanent undercurrent caused by evaporation, but the result of the Mediterranean tide, which, slight as it is, runs alternately from east to west for several hours, its action being found more regular in the depths of the straits, where it is less affected either by winds or by the surface inflow. The difference of no less than twenty degrees between the temperature of the Mediterranean and the Atlantic, as well as the difference of four degrees between the deep-sea soundings of the western and central basins of the Mediterranean and of the Greek Archipelago, is explained by the existence of high submarine crests or barriers of rock bounding the sea to the west, and again dividing it into sections, as shown by the diagram in the present edition. Proceeding to the wider problem of ocean circulation arising out of the extreme cold found at great depths both in temperate and tropical regions, Sir Charles disputes the notion of these low temperatures being due to mere depth, the Mediterranean soundings of 13,800 feet having failed to reach a degree of cold below 55° Fahr. Yet the soundings taken at Aden, whither the cold water can only come from the Southern Hemisphere, lead to the belief that the whole of the equatorial abysses of the ocean are traversed, in some parts at least, by a continuous mass of water not much above 32° Fahr. That solar heat is in some way or other the primary cause of this great displacement, through the change in specific gravity from the cooling of water toward the polar zones, counterbalanced by a return, however slowly, of water from the equator to the Poles, may well take the place of more recondite theories, such as that exploded by Herschel, that the expansion of water by heat in the equatorial zone raises the level of the sea, and causes a flow down a gently-inclined plane toward the Poles. In the absence, however, of more extensive and accurate knowledge of the state of the ocean at great depths, or of its local direction and quantity of motion, in relation to the utter stillness found generally by the sounding-line to prevail in its great abysses, Sir Charles Lyell is too cautious and patient a reasoner to think the time ripe for a positive solution.

EDITOR'S TABLE.

LOOSE AND ACCURATE KNOWLEDGE.

IN explaining what we understand by science, in the first number of this monthly, it was stated to consist in accurate as contrasted with lax and careless thinking. We had not then space to show how a great deal of the knowledge that is truly recognized as scientific may be still so loose and imperfect as to be misleading. Let us, therefore, briefly consider this aspect of the case.

There are two stages in the history of science, and two states of mind among so-called educated people, which correspond to them. The first stage of all science consisted simply in recognizing the properties of bodies so as to identify them. The characters were made out which distinguished this thing from that, and one kind of effect from another. The first thing was to determine the *qualities* of objects, and this was the work in the early or *qualitative* stage in the progress of each science. But, qualities being ascertained, the next and inevitable step was to bring them under the operation of mathematics, which deals with the laws of quantity. First, it was asked, What are the properties or effects? and next, What are their degrees, or what quantities are involved in given results? This implies exact measurement, and is known as the *quantitative* stage of science.

For example, bodies, which burn and produce heat, have the property of combustibility; but the next question is, *How much* heat will different bodies produce in burning? It is a quality of vinegar to unite with soda, and this was ascertained in the qualitative infancy of chemistry, but how much vinegar will combine with a given amount of soda was only determined with the development of quantitative chemistry. It is a quality of animals that they exhale carbonic-acid gas in respiration, but, when this was known, it became necessary to know the rates of exhalation in the different tribes, and the variations of these rates in sex, age, activity, sleep, and disease. It is a quality of ideas that they cohere with each other, forming groups and trains by which thinking becomes a connected and orderly process; but it is also a fact that these cohesions are of unequal degrees of strength, and this gives rise to a kind of quantitative psychology, which is only imperfect because we lack the means of exact measurement.

Now, qualitative information is the first indispensable step in the growth of knowledge, and is just as truly "science" as the knowledge of quantities; but it is not the whole of science. Qualitative chemistry must precede and underlie quantitative chemistry, and so with other departments. But, to suppose that a mere knowledge of qualities may pass for science is an error leading to the worst practical consequences. Current scientific knowledge, however, is very much of this qualitative sort. As it was first in the order of development, because it is simplest, it is also most widely diffused for the same reason. This is one of the things that is meant in saying that people think vaguely and loosely, and reason wildly, upon subjects in which science is involved. For every thing in practical and applied science turns at last on the question, How much? It is not enough to know that a given substance will produce a given effect; we must know the degree or amount of effect before we can build upon it. It is this scientific smattering with qualitative notions that exposes people to all forms of plausible imposture. The skilful knave, with his new process and patent-right, practises on this half-knowledge of the community, and enriches himself at the expense of his victims. He is very candid, and would have them take nothing on trust. He will bring his idea to the test of experiment. They shall see for themselves, and need take nobody's word. "This arrangement will produce such an effect. I don't ask you to accept my statement, I will demonstrate it;" and with an impressive parade of fixtures, and much scientific talk, the alleged wonderful things are done. With those who have not thoroughly learned that every thing depends not upon effects produced, but upon their *quantities*, the next step of the unscrupulous patent-agent is easy. Having established himself in his customer's confidence, he does the rest by profuse asseveration and persistent lying. "The facts are proved; it is a new discovery; it will revolutionize the business, and somebody is going to make enormous profits—you had better have some of the stock." But the skilful speculator may go still further. If sharply met by the question of economy, or exactly how much is gained by his process, he may proceed to prove his claim on the spot. He may demonstrate experimentally and completely that his operation has the advantage by many per-cent. over those in use, while the project is still a worthless fraud: for it is possible in a small way, and with careful experiments, to produce quantitative results which cannot be realized on the manufacturing scale.

There is no end to the schemes that are palmed off upon the public in this way. A morning paper that has just come to hand has the following item:

> "Will water burn? And, if so, can burning water be used at a moderate cost for fuel? The public mind of Peoria, Ill., has been of late much exercised upon these questions. A stranger and a Yankee came to the city and claimed that, by burning mixed water and oil in it, he could heat a common cooking-stove red-hot in five minutes. The proportions were four gallons of oil to five gallons of water, and with this quantity the inventor declared that he could run a steam-engine for thirty days, heat twelve furnaces, or light a whole city with gas. The oil was worth 50 cents a barrel, and cooking, heating, and lighting, were thus to cost almost nothing. A stock company was started to push the enterprise, and it was found that 'by the aid of twelve gallons of oil two gallons of water could be evaporated.' It didn't promise overwhelming dividends. The corporation disembodied itself as fast as possible, and the inventor, packing up his gas-pipes and oil-cans, left Peoria, to enlighten and warm some other region."

How true this statement may happen to be, we do not know; but we do know that analogous cases are abundant.

These consequences are a natural result of superficial scientific teaching. A little science is now dispensed in all schools; but it is generally the qualitative rudiments that are easiest taught, and which serve only to make pedants of the pupils. A mass of the simpler facts are memorized as mere sensational acquisition, and there is very little training in principles, or scientific method. It is not to be expected that in general education students will possess themselves of all the higher qualitative data of science, so as to be able to meet any emergency with ready and accurate information. But, for protection from such impositions as we have here noticed, there should be such a cultivation of the scientific judgment as will guard against the grosser fallacies put forth by unscrupulous projectors.

THE QUESTION OF STIMULATION.

The article in our present number, on the physiological position of alcohol, by Dr. Richardson, an eminent physician of London, is the freshest exposition of the subject yet offered. Its author has made narcotics and anæsthetics a matter of special scientific study and physiological experiment; and, although his hypothesis of a "nervous ether" is regarded as fanciful, yet his statement of the way alcohol influences the system is independent of that speculation, and will be found instructive.

The evils that arise to individuals and to society, through the agency of alcoholic drinks, are universally admitted, but the question what is to be done to remedy them proves most difficult. It has been asked in this country and in England, for half a century, without eliciting any satisfactory reply, and the same question is being now very seriously proposed by the French. There seems to have been an enormous increase in the consumption of spirits in France, a great reduction of cost, and a deterioration of quality. In 1820, there were consumed 7,700,000 gallons of alcoholic drink; in 1869, it had risen to 21,500,000 gallons. In 1850, nine-tenths came from the distillation of the products of the vine, while in 1869 the vine furnished only three-tenths of it —the remainder coming from beet-root and grain. So a gallon of liquor, which in 1850 cost nine francs, sells to-day for two and a half francs. It is alleged that suicides and insanity have increased during this period in a rapid ratio.

To arrest this tendency of things, the French are fertile in projects. They would tax cheap liquors, they would extirpate the vine, they would make public drunkenness criminal, they would pledge men to total abstinence from—ever setting foot in a *café*.

But, what is more to the purpose, a society has been organized in Paris, embracing a large number of physicians and scientists, who propose to instruct the people by the press and lectures as to the evils which flow from the habitual use of alcoholic drinks. They will not insist on teetotalism or prohibition, but urge the substitution for the stronger liquors of such beverages as coffee, native wines, cider, and beer.

It is not to be disguised that the problem here proposed, and with which civilization is now confronted, is one of the most refractory that philanthropy has yet encountered. Slavery was a local and anomalous institution, based upon legislation, and, when the turf of moral suasion failed to dislodge it, the stones of war proved effectual. But the evil of intemperance cannot be terminated by burning gunpowder. The craving for stimulation and for stimulants, in one or another of their innumerable forms, is not a local, unusual, arbitrary, or statutory thing, but a rooted and universal passion of human nature. It is not confined to special communities, but pervades alike the civilized and uncivilized races all over the world; varying in different types of humanity, but common to all. Some races take to opium, others to hashish, others to alcohol. It is this deep basis of the propensity in human nature that gives to the subject its mystery and its perplexity.

The *rationale* of stimulation is indeed not so puzzling. Food builds up and maintains the vital activity of the whole animate creation in its working state, but that is not enough for man. He leads a life of high and complex feeling, subject to wide fluctuations, while his intellect furnishes him with the means of influencing his emotional states. He therefore seeks those agencies which act to arouse pleasurable emotion, and these are stimulants. Capable of appreciating the immediate pleasure, but incapable of realizing adequately the distant pain, the habit is formed, and use runs into abuse.

What, then, is to be done? Here logic is soon at fault, for the headlong reformer, who fixes his attention upon some special phase of the evil, and would eradicate it root and branch, is soon found to be himself involved in something not very unlike what he so zealously condemns—he, too, is an object of reformatory solicitude. One thunders against the whole tribe of alcoholic stimulants, from ethereal wine to acrid whiskey, and never touches, tastes, or handles them—the pipe will do for him. Another counter-blasts tobacco—content with abundance of strong coffee. Another decries all these together, inspired by the stimulus of concentrated potions of tea. Still another ingests perhaps only vegetables and water, and fulminates from the pulpit or platform against all these gross material indulgences, yet is lifted into the seventh heaven of enjoyment by the stimulating incense of flattery and applause which comes up from admiring auditors, and without which life would be "flat, stale, and unprofitable." Others get from music, pictures, theatres, fashion, novels, newspapers, or travel, a quieter form of excitement, which, though often running into dissipation, is less harmful than ordinary narcotic stimulation. How far the ballroom, the political campaign, or the religious revival, may be the equivalent of a drinking spree, we will not pretend to say, but that they are all marked by a common character—stimulation of pleasurable feeling carried to a pitch of excitement which ends in reaction more or less exhausting—is not to be denied.

As regards relief from the mischiefs of over-stimulation, alcoholic or otherwise, we have no reformatory nostrum to propose. And, when they are proposed, we shall do well to remember that the evil does not exist alone; it is part of the general imperfection of our nature, and the social state which accompanies it. Nor is it to be remedied alone; the evils that result from the craving for stimulants, and the gratification of it by dangerous drugs, will probably only be removed with the slow and general improvement of character and amelioration of social conditions. As soon as people know better their own nature and the true conditions of its unfolding, and begin to regard the subject with a more sacred respect, in proportion, we will venture to say, to the growth of a *scientific conscience*, will man become a higher law to himself, and the grosser vices of conduct may be expected gradually to disappear.

LITERARY NOTICES.

Corals and Coral Islands. By James D. Dana, LL. D. Dodd & Mead.

This book will be widely welcomed, not only for the interest of its matter and the elegance of its form, but because of the gratifying assurance it will afford to the numerous friends of its accomplished author that, although in shattered health, he still retains that wonderful power of versatile labor by which he has been distinguished in the world of science for the last 25 years. Prof. Dana went round the world, from 1838 to 1842, with the Wilkes Expedition, as geologist in the scientific corps. In this extended exploration, in addition to his geological work, he made a special and elaborate study of the zoophytes, and treated at length of corals, coral animals, and coral reefs. His reports upon these subjects were, of course, designed mainly for men of science, but in the present volume he has recast the statement, with the view to its more general usefulness. In his preface the author says: "The object in view, in the preparation of this work, has been to present a popular account of 'corals and coral islands,' without sacrifice of scientific precision, or, on the main topic, of fulness. Dry details and technicalities have been avoided as far as was compatible with this restriction; explanations in simple form have been freely added, and numerous illustrations introduced in order that the subject may have its natural attractiveness to both classes of readers." The object proposed has been very completely attained, and a volume produced which will be alike valuable to men of science and entertaining and instructive to general readers. Its illustrations are many and fine, and its manufacture is a credit to the publishers.

We have no room here to treat of the

contents of Prof. Dana's volume, but mean to do so in a future number; yet we cannot forbear quoting a pleasant passage referring to a man of whom much is now vehemently said, both in praise and disparagement:

"Our cruise led us partly along the course followed by Mr. Charles Darwin during the years 1831 to 1836, in the voyage of the Beagle, under Captain Fitzroy; and, where it diverged from his route, it took us over scenes, similar to his, of coral and volcanic islands. Soon after reaching Sydney, Australia, in 1839, a brief statement was found in the papers of Mr. Darwin's theory with respect to the origin of the atoll and barrier forms of reefs. The paragraph threw a flood of light over the subject, and called forth feelings of peculiar satisfaction, and of gratefulness to Mr. Darwin, which still come up afresh whenever the subject of coral islands is mentioned. The Gambier Islands in the Paumotus, which gave him the key to the theory, I had not seen; but on reaching the Feejees, six months later, in 1840, I found there similar facts on a still grander scale and of more diversified character, so that I was afterward enabled to speak of his theory as established with more positiveness than he himself, in his philosophic caution, had been ready to adopt."

Spectrum Analysis, in its Application to Terrestrial Substances, and the Physical Constitution of the Heavenly Bodies. Familiarly explained by Dr. H. Schellen, Director der Realschule I. O. Cologne. Translated from the second enlarged and revised German edition, by Jane and Caroline Lassell. Edited, with Notes, by William Huggins, LL. D. With numerous Woodcuts, Colored Plates, and Portraits; also, Angström's and Kirchhoff's Maps. 455 pages, 8vo. D. Appleton & Company.

In his late work on the sun, Mr. R. A. Proctor, author of "Other Worlds than Ours," says: "The reader is referred, for fuller details than there is here space for, to Dr. Schellen's work on 'Spectrum Analysis,' the English edition of which is now preparing for publication under the able supervision of Dr. Huggins. This work will be specially worthy of very careful study in all matters relating to the spectral analysis of the sun." This long-expected work, which has been so eagerly looked fo by those who desire a popular and authoritative exposition of this beautiful subject, has now appeared, and is republished in this country at half the English price. An able writer in the London *Spectator* thus speaks of it:

In the whole history of science there is nothing more wonderful than the discovery or invention (it would be difficult to say which is the more correct term) of spectrum analysis, and the sudden advance of the new method of research into a foremost position, among all the modes of scientific inquiry. If we take up at random any recent scientific work, whether on astronomy, or chemistry, or meteorology — nay, even though it treat of subjects like entomology, botany, and conchology, which seem as far as possible removed from optical problems—we cannot turn over its pages without finding more or less copious reference to the prismatic analysis of light. Yet, thirteen years ago, spectrum analysis had no existence whatever as a mode of scientific inquiry. It was a subject for research, not a method of research, and there were not a few who regarded it as a subject altogether intractable, while scarcely any believed that it would become the means of advancing our knowledge to any important extent.

The history of the sudden advance of this great problem into the position of a great solver of problems is full of interest. Not five years had passed from the day when Kirchhoff announced the true meaning of the dark lines in the solar spectrum, before Huggins and Miller were telling astronomers of the terrestrial elements existing in the stars. Then the great secret of the gaseous nebulæ was revealed by Huggins, and soon after the structure of comets began to be interpreted. Nor had chemists been idle in the mean time. In 1861, Bunsen and Crookes, by means of the new analysis, had detected three hitherto unknown elements, cæsium, rubidium, and thallium, and, in 1863, Reich and Richter had discovered a fourth new element, indium. The importance of the new mode of research in all problems of chemical analysis, as a delicate test for determining the presence of poisons, as a means of improving many processes of manufacture, and as an aid in almost every branch of scientific inquiry, became each year more clearly recognized. We have seen Sorby analyzing by its means the coloring-matter of plants, and the entomologist comparing the spectrum of the glow-worm and the fire-fly, or discussing the absorption-bands peculiar to the fluids of insects. The microscopist employs the powers ot the new analysis to solve problems which the magnifying powers of his instruments would be altogether unable to cope with. Nothing, in fine, seems too vast or too minute, too distant or too near at hand, for this wonderful instrument of research, which deals as readily with the mass of Sirius, a thousand times larger and a million times farther away than our sun, as with the ten-thousandth part of a grain of matter in a flame within a few inches of the spectroscopic tube.

It is, perhaps, not the least wonderful circumstance about the new analysis that it has already been made the subject of many volumes of scientific lore. A goodly library might be filled with the printed matter which has been devoted to spectroscopic analysis, either in works definitely directed to the subject, or else in chapters set apart for its treatment in works on other subjects. But the general public has undoubtedly not had occasion to complain, as yet, that the analysis has been too fully expounded to them. It cannot be denied, indeed, that hitherto the vaguest possible ideas have been entertained by many respecting the most powerful mode of scientific research yet devised by man. The work of the telescope or of the microscope all men can at once understand, even though the principles on which these instruments are constructed may not be thoroughly understood save by a few. But the case is very different with the work of the spectroscope. When the astronomer says that with a telescope magnifying so many times he can see such and such features in Mars or Venus or Jupiter, every one knows what he means; but, when the spectroscopist says that his instrument shows certain bright lines in the spectrum of a nebula, or certain dark lines in the spectrum of a planet, the general reader has to accept on trust the interpretation placed on such results by the observer.

It was to remove this difficulty that the present volume was originally written. Of its value in this respect we can have no higher evidence than the fact that Dr. Huggins named it to the two ladies who have translated the present edition as 'the best elementary work on spectrum analysis.' The translators—the Misses Lassell (daughters of the eminent astronomer who has just vacated the presidential chair of the Astronomical Society)—remark that the interest they derived from the perusal of this work 'suggested the idea of undertaking its translation.' Dr. Huggins agreed to edit the volume; and, accordingly, we find appended to the valuable text of Dr. Schellen many important (in some cases absolutely indispensable) notes by the English master of the subject.

The work thus translated is from the second German edition, which is not only much larger than the first, but is improved by the correction or omission of several faulty passages. It consists of three parts. The first describes the various artificial sources of high degrees of heat and light. The second relates to the application of the analysis to terrestrial substances. These portions of the work are extremely important, and, on the whole, they are well arranged; but, to say the truth, they are rather dry. Fortunately for the general reader, they occupy together little more than one-third part of the work, the remainder being occupied by the description of the application of spectrum analysis to the heavenly bodies. In this, the third section of the book, we have four hundred pages full of the most interesting matter. The investigations of astronomers into the nature of the sun's globe, and of those wonderful envelopes which surround him, are described with great fulness of detail, and illustrated by a fine series of drawings. The colored plates, representing the prominences as seen by Zöllner, Respighi, and Young, are especially interesting and suggestive, more particularly when the reader's attention has been directed to the scale of miles—or rather of thousands of miles—placed under each. Respighi, indeed, rejects mile-measurement altogether, and can be satisfied only by a scale of terrestrial diameters; so that, instead of showing how many thousands of miles would correspond to the height of the colored prominences, his scale tells us how many globes as large as our earth could be placed one above another, so as barely to reach to the summit of the solar flames.

The sections on the stars and nebulæ are full of interest, though Dr. Schellen is disposed to place somewhat more reliance on the researches of F. Secchi into the stellar spectra than is entertained by our leading spectroscopists. On dealing with meteors and their spectra Dr. Schellen lays a well-deserved stress on the labors of Schiaparelli, to whom science owes the recognition of the strange fact that meteoric rings are associated with comets. Nearly ten years have passed since Schiaparelli announced that 'the comet of 1862, No. III.' (a large and bright object) 'is no other than the remains of the comet out of which the meteoric ring of the 10th of August has been formed in the course of time.' Received with doubt for many months, this bold assertion gradually commended itself more and more to the attention of those who studied meteoric phenomena, until in 1866 the recognition of a corresponding agreement between the November meteor-ring and Temple's comet of that year removed all doubt as to the reality of the relation. On February 9th of the present year, the gold medal of the Astronomical Society was awarded to Schiaparelli in recognition of this important contribution to our knowledge.

The editorial work of Dr. Huggins adds considerably to the value of Schellen's treatise. In places, the author apportions somewhat incorrectly the merit due to various workers in the field of spectroscopic research; so that some of the notes in which Dr. Huggins refers to these points are, in reality, very necessary. But the work of the editor is yet more important in removing errors and explaining difficulties relating to scientific details.

Ancient America: in Notes on American Archæology. By John D. Baldwin, A. M. Harper & Brothers.

One of the great results of modern science is the power it confers of arriving at true interpretations of the past. Just in proportion as it discloses orderly relations in the events of Nature, and trains the human mind in the careful weighing of evidence, it enables investigators to turn backward and gather a knowledge, which was before impossible, of the ancient order of things. We owe to science, therefore, a history of man which is earlier than books—of civilizations which rose and passed away with no literature to preserve its memory. Fragmentary and most incomplete it assuredly is, and a host of questions arise in the inquirer's mind to which no answers can be given; yet a vast and constantly-increasing mass of facts is known, from which many valid conclusions are deduced of interest to the students of Nature and of Man.

Archæology, or the science of antiquities, searches for all the vestiges of human action in the distant past; the remains of architectural structures, of public works, carvings, inscriptions, coins, medals, heraldic symbols, workmen's tools, articles of use and ornament, and whatever can serve to throw light upon the state of man and society when they were produced. It matters nothing how apparently trivial are the relics of by-gone ages; they have interest for the archæologist because they are the results of art, industry, intelligence, and social organization, and become the measures of these conditions.

The book before us treats of the most interesting departments of American archæology. Its author published a volume in 1869 on the prehistoric nations, and now follows it with a popular compendious statement of what is known of the ancient monuments of North and South America, and the inferences they warrant as to the condition of the early inhabitants of our continent. For, whatever theory is adopted regarding the origin and career and relationship of the American races of men, one thing is certain: this continent was formerly the theatre of a people greatly superior to the Indian tribes. Many of the works that remain give evidence of high, though of course, indefinite antiquity.

One of the phases of ancient works which remain to us in great abundance is the mound-structures; the people who made them being known as the mound-builders. These are numerous in the Mississippi Valley—there being 10,000 of them in Ohio alone. One, in West Virginia, is 70 feet high, and 1,000 feet in circumference. They are truncated, and their summits are supposed to have been occupied by edifices—probably temples which have disappeared. Lines of artificial embankments remain which enclose from 100 to 400 acres, and evince a considerable degree of geometrical knowledge in their plans. Many articles, as vases, pottery, fragments of cloth, and copper implements, have been found in them, indicating considerable industrial skill. There is evidence that, since they were built, the rivers have changed their courses, and it is also a significant fact regarding their antiquity that the human skeletons found within them are in a state of decay so advanced that they crumble to pieces as soon as touched. Skeletons found elsewhere, and known to be 2,000 years old, are still compact, and comparatively well preserved. An interesting fact in regard to these aborigines is, that they knew something of mining. In the copper-mines of Lake Superior, old excavations for the extraction of the metal, 30 feet deep, have been discovered. Mining implements were found in the cavern, and trees 400 or 500 years old (as ascertained by counting their annual rings) stood upon the *débris*. Prof. Newberry, Geologist of the State of Ohio, informs us that he has found evidence of the ancient working of oil-wells and lead-mines.

The indications of civilization in Central America, Mexico, and Peru, are still more perfect. The author states that the great Peruvian roads of stone, lime, and cement, 25 feet wide, and with a strong wall on each side, and carried over rivers, marshes, and mountains, and as long as both our Pacific Railroads, make these boasted works of the nineteenth century dwindle into insignificance.

Mr. Baldwin's book is neatly and copiously illustrated, and it has the excellent defect of being too brief.

PROF. TYNDALL'S NEW BOOK.

The first volume of the "International Scientific Series" will be by Prof. Tyndall, on the "Forms of Water," and will treat of the mutations of this element in the great operations of Nature, especially in the phenomena of glaciers. We publish a short article from the advanced-sheets, which will give an idea of the lucid simplicity of the style in which it is written. Prof. Tyndall throws his statements into the direct colloquial form, as if he were talking to a young student beside him, and *showing* him the things he is talking about. There is true art here as well as science—the art of forcible, effective, vivid presentation by which words become pictorial to the imagination. Prof. Tyndall is as skilful in his manipulation of language as of his scientific apparatus, and he sets his successors in the International Series an example which it will be not easy for them to imitate.

While speaking of Prof. Tyndall, it may be proper to add that he intends visiting the United States in the autumn, perhaps early in October. He will come to see his friends (and he will find them numerous), and to get acquainted with our people; but it is not his purpose to exploit the country as a lecturer. He may probably give a few lectures, but he will embarrass himself by no previous engagements.

MISCELLANY.

CONCERNING ATOMS.

Dr. S. D. Tillman publishes in the *American Chemist* an able paper on "Atoms and Molecules," in which he reviews the present state of the question, and gives the reasons why we should still hold by the atom, notwithstanding the attempts made to get rid of it. Both sides of the question were early taken, on purely speculative grounds. The ancient philosophers, in their subtle reasonings on the constitution of Nature, asserted the existence of ultimate indestructible material atoms. Others, and notably Boscovich, at a later day denied the material atoms, and substituted for them what he termed centres of force. Modern chemistry, however, approached the subject from a different point of view. It was proved that the interior changes and reactions of matter are governed by definite mathematical laws, and it was inferred that material substances must therefore be made up of ultimate material units. The assumption was made, because it best explained the laws of chemical change. Still the tendency to resolve matter into force continues with many, who of course abandon the conception of atoms, and the theory that implies them.

Dr. Tillman shows that the facts of invariable weight which experiment establishes, of equal or multiple gaseous volumes, of specific capacities for heat, of the equilibrium of chemical forces, of isomeric transformations, and of uniformity, homogeneity, and constancy of structure, in the constitution of material substances, are all explicable only by the conception of indivisible and indestructible atoms.

WHAT BECOMES OF COMETS?

Prof. G. B. Donati, whose name is already famous in connection with comets, has just issued a paper on this subject from the Royal Observatory of Florence, which appeared in the *Evening Post* in full, and of which the following is the substance: He denies that any astronomer has recently seen a large comet, and affirms that none at all are visible at the present time. As for new comets, no astronomer can tell whether they will or will not appear. As to periodical comets, that of Biela, which completes its circuit round the sun in six years and nine months, is due next August. The earth and the comet of Biela travel different ways, and their paths cross each other at a certain point. A collision is, therefore, not impossible. The comet and the earth have, however, hitherto passed the point in question at very different periods. Should Biela's comet arrive, it would traverse the terrestrial orbit on August 26th; but on that day the earth would be distant from the comet almost half as far again as it is distant from the sun. As to whether any other comet may encounter the earth, Prof. Donati holds it to be possible, but infinitey improbable. "The comets," he says, "have masses so small that, if one of them were to approach to within even a short distance from the earth, the latter perhaps would have nothing to fear, and, in all probability, in such an event, the comet would become a satellite of the earth." As for the comet of Biela, he says there is great probability that it no longer exists; although it should appear every six years and nine months, it has not been seen since 1852. From 1826, the time of its discovery, to 1852, it appeared regularly. In 1846 the comet presented a most extraordinary appearance. Instead of appearing single, as was the case on all preceding occasions, it appeared double—that is, composed of two parts, separated by a distance of more than 100,000 miles. When it appeared in 1852, the separation was still more complete, the interval amounting to 1,200,000 miles. Its non-appearance in 1858 was attributed by some to its immersion in the solar rays; but in 1866 it should have reappeared in a position so far from the sun, that it would have been visible at night; but it was impossible to discover it. Nor is the comet of Biela the only one which has failed to appear when due. That discovered by Prof. De Vico at Rome in 1814, and which should return every five and a half years, has never since been seen. What becomes of them? Kepler held that they may be dissipated, and said that as the silk-worm consumes itself while spinning its cocoon, so comets may cousume themselves, and die while generating their long, interminable tails; and Newton thought that they might fall directly into the sun. But Donati conjectures that the material of Biela's comet has already fallen in part, and is still falling upon our planet. Prof. Schiaparelli, who has just got the gold medal of the London Astronomical Society for his study of comets, maintains that they are resolved into shooting-stars—meteors which traverse the earth's atmosphere. It is well known that on August 10th and November 13th many such falling stars are seen; and this is explained by supposing that the earth passes through two great belts or bracelets of meteoric matter, and draws some of the fragments or corpuscles toward itself. Prof. Schiaparelli has demonstrated that there are several comets which move round the sun, in the direction of these meteoric bracelets; and Prof. D'Arest has noticed that every year, on December 5th, shooting-stars are seen that irradiate from that part of the celestial dome in which the comet of Biela would appear, if it came at all. It seems probable that the comet of Biela forms part of a bracelet of cometic corpuscles which move round the sun. It may have here been exposed to a mechanical influence, which broke it into two parts, and it is quite possible that many other breakings may have taken place, reducing it to fragments so small as not to be visible, except as falling meteors.

FISH AS FOOD.

Those fish are most digestible which have least of the oily element in their composition. Rich or fatty fish are apt to disturb the stomach, and prove stimulant to the general system. Thirst and an uneasy feeling are frequently produced by them, and it is this, doubtless, that has led to the practice of drinking spirits with this class of food. Hence, the proverb, "Brandy is the Latin for fish." It is well, therefore, in selecting fish, to choose those that cook dry, and are freest from oily matter. The sooner a fish is cooked, after being taken from the water, the better it will be. There is a popular notion that, like butchers'-meat, fish is improved by being kept awhile before it is fitted for the table. This is a mistake. There is a white curdy matter, plainly visible between the flakes of freshly-boiled fish, which adds much to the flavor, and is highly nutritious. This is really a film of albumen, produced by the coagulation of the serous juices, contained in the muscles. If the fish is kept long before cooking, a large share of this is lost, and the flavor of the fish correspondingly impaired. Fishermen themselves say that fish, taken directly from the net to the kettle, are as different, in flavor and nourishing properties, from fish one, two, or three days old, such as are purchased in our markets, as "chalk is from cheese."

By drying, salting, smoking, and pickling, the digestibility of fish is greatly injured, though in some cases its savory and nutritive properties may be improved. The flesh of fish is more digestible boiled than fried, and for invalids should always be cooked in this way. That of the male fish is in most cases better eating than that of the female; and, in either case, it is at its greatest perfection for food at the period of the ripening of the milt or roe. After spawning-time, fish appear to get out of condition, their flesh becomes soft and flabby, loses flavor, has a bluish semi-transparent look after cooking, and eaten thus is sometimes productive of much evil.

If lobsters and crabs are fresh, well cooked, and eaten in reasonable quantity, they agree with most stomachs, though less digestible than fish. They sometimes, however, produce violent colic, nausea, giddiness, depression, and nettle-rash; these effects depending upon some peculiar susceptibility of particular persons. Lobsters are frequently sold insufficiently boiled, and in this state are not nearly so wholesome as when thoroughly cooked.

Of all bivalves that are eaten, oysters are the most easily digested, and the most nutritious; and they are more digestible raw than cooked. Cooking coagulates and hardens the albumen, and corrugates the fibrine, causing both to be less easily dissolved by the juices of the stomach. Raw oysters rarely disagree even with invalids or dyspeptics. Persons of a gouty habit, however, particularly if they have dyspepsia, are sometimes violently disordered by them; and they have been known to bring on convulsions when eaten by women soon after confinement.

Many of the sauces eaten with fish are very indigestible compositions, and often the fish itself is charged with ill-effects which are solely due to the sauce. Oyster-sauce is too often made so badly, that both sauce and oysters are unfit for food.

Fish is less satisfying to the appetite than meat, poultry, or game, and, as it contains a larger proportion of water, is obviously less nourishing. On the other hand, many persons pass through the season of Lent on a diet composed almost wholly of fish, without apparent diminution of strength; and whole villages may be found on the coast, where fish almost entirely takes the place of butchers'-meat, the inhabitants at the same time being noted for their health and vigor.

TEMPERATURE OF THE BODY IN HEALTH.

In the healthy human adult, the body being at rest, and the temperature of the surrounding atmosphere about 60° Fahr., the average temperature in the axilla is 98.4°, in the rectum 99.4° and that under the tongue is intermediate, or about 98.9°. The average healthy temperature is not absolutely identical in every individual, but may vary from 97.75° to 99°. It is slightly higher in infancy and old age than in adolescents and adults. In the same individual also there are certain slight variations in the temperature consistent with health, some of which deserve to be mentioned. In the first place, there are diurnal variations of temperature constantly occurring in healthy persons, which must be kept in mind in reference to the diurnal variations so common in febrile diseases. As a rule, the daily minimum is about daybreak, or between 2 and 8 A. M. After this a rise begins, and continues until late in the afternoon, or to between 4 and 9 P. M. These daily fluctuations are somewhat greater in children than in adults; but in any case they rarely exceed 1° Fahr., and any variation in excess of this is very transient. Secondly, it is well known that muscular exercise increases the heat of the body, while repose tends to its reduction. The differences, however, resulting from this cause, are chiefly observed in the extremities. The temperature, in health, of the hands and feet, is often much below that of the trunk and internal parts. There may be a difference of 20° Fahr. or more between the temperature of the feet and that under the tongue. The effect of exercise is to raise the temperature of the extremities to that of the trunk. It produces little change—not more than an elevation of 1° Fahr. in the temperature of internal parts, as, for example, under the tongue, and even this elevation ceases on the cessation of exertion. Thirdly, the ingestion of food causes a slight rise of temperature. The effect of a full meal is to hasten the normal diurnal rise, or to postpone its fall; but the elevation of temperature resulting from food rarely amounts to 1° Fahr. Fourthly, the temperature of the human body is influenced to the extent of 1° or 2° by that of the surrounding atmosphere. Brown-Séquard found a rise of atmospheric temperature from 46.4° to 85.1° Fahr., to raise the bodily temperature from 97.9° to 100.22° Fahr. When the temperature of the atmosphere exceeds that of the normal standard of the human body, the temperature of the body occasionally exceeds the range compatible with health. It is also to be noted that young children and persons of advanced age have less power than adults of resisting external cold—the temperature of the body being more easily and considerably reduced by it in the former case than in the latter.—*Murchison.*

IMPURITIES OF WATERS.

There are certain abnormal conditions of waters, arising from natural or artificial causes, that are not very clearly understood, and which present interesting features for study and investigation. The water of Jamaica Pond, near Boston, affords a somewhat remarkable illustration of such changed condition, or sickness from natural causes, at the present time.

This pond, which is situated at a comparatively high elevation, has one small feeding-stream, and an equally small outlet; it receives no artificial drainage, and is not in a thickly-settled locality. Its water is still supplied, through pipes, to many citizens, and also to the neighboring towns of Brookline and West Roxbury. During the winter of 1866, after two seasons of drought, this water first exhibited the peculiar condition which it presents again this winter, also after two seasons of severe drought.

The water is not perfectly clear, and does not become so by standing; it is cloudy, but not colored; its color and taste are decidedly offensive, resembling water containing putrefying animal matter; these conditions are more evident when the water is heated, and are retained after evaporation to a small volume. Ordinary analysis shows the difference between the common condition of this water and its present peculiar state to be as follows: one United States gallon of each contains—

	Normal.	Abnormal.
Organic matter...........	1.36 grains.	2.33 grains.
Mineral matter...........	2.41 "	2.56 "
Total weight of impurities	3.77 "	4.89 "

By filtration, through paper, the water becomes clear and brilliant, the odor and taste of the filtered water being natural; and it is possible, in this way, to separate the offensive matter from the water and retain it for examination. This substance, which gives odor, taste, and additional weight to the impurities, consists of organized and vegetating bodies, which, as seen with the lens, are short, white threads, somewhat like conferva in form, but the threads are very short and perfectly white, differing in these respects from the green or brown confervoid growth of the summer months.

The water of this pond at present exhibits the natural balance between the animal and vegetable life below the surface, disturbed or destroyed. Crustaceous animalculæ, common in the water usually, are not to be found, while there is an extraordinary growth of subaqueous vegetation, of a low order of organized forms, emitting a repulsive odor.

The cause of this change in a large body of potable water, hitherto one of the purest, may be found in the excessive and protracted droughts of the two past seasons, modifying the growth of subaqueous vegetation, and allowing an offensive kind to predominate. And the water will, undoubtedly, recover its normal condition, with the change of seasons and an increased flow from the deep springs affording supplies to the pond, as it did in the spring of 1866 after the former disturbance.

An instance of peculiar condition, caused by artificial means, is that of the water in a manufacturer's well, yielding an abundant supply, but situated about three hundred feet below a brewery, on a hill-side. In this case, after the brewery had been in operation for two years, this well-water, quite unexpectedly, developed a fungous growth of enormous size and quantity. I took from the water in the well several individual plants, which were found floating on the surface, that were each literally nearly as large as a man's head, and, in the month of August, they increased so rapidly as to close the large iron outlet pipe, having a diameter of six inches.

These fungi, when placed in a dilute alcoholic solution, in a warm room, increased in size, producing acetic acid rapidly, and were true vinegar-plants (mother); they evolved a very offensive odor when decaying, and soon rendered the well-water unfit for use. The source of the germs of these plants was traced directly to that part of the brewery where returned empty ale barrels were washed and steamed before being refilled, and where the drainage was not perfect, although the entire floor was paved with bricks laid in mortar My attention has been called to many other cases of a similar nature, but to none where the cause and effect were so marked as in this well, the water being naturally calcareous, hard, and free from organic matter.—S. Dana Hayes, in *American Chemist.*

A MARKED MAN.

A man has lately turned up in Europe, whose attainments, both lingual and dermal, are exciting no small amount of wonder. Linguistically considered, he perhaps has numerous equals, though it is said that, besides Greek, his native tongue, he speaks Arabic and Persian fluently, French, Spanish, Italian, German, and English, with various degrees of ease and accuracy. But his other attractions are truly extraordinary, though chiefly for their showy superficiality; in which respect, after all, he doesn't differ so very much from a good many other famous people. The man is tattooed from head to foot, there not being a square inch of skin on the whole surface of his body that is not covered with tattoo-marks. His story is, that tattooing was inflicted on himself and two others in Chinese Tartary, as a punishment for acts against the government; that one of his companions died; the other was made blind, and is now living in Hong-Kong, while he had succeeded in making his escape. The man has a fine physique, and, stripped, appears as if his whole body were closely enveloped in a richly-woven web of Turkish stuff. Closer inspection, however, resolves this appearance into a great variety of figures, mostly of plants and animals, that have been pricked into the skin in colors of blue and red. Altogether there are some 384 such figures, representing apes, leopards, cats, tigers, eagles, storks, swans, men, women, elephants, lions, crocodiles, snakes, fish, snails, fruit, leaves, flowers, etc., while on the hands are certain inscriptions, said by Prof. Müller to belong to the language of Burmah. The marking appears to have been done with the juices of plants, as there are no traces of enlarged lymphatics, such as are often produced when tattooing is done with pulverized charcoal, or gunpowder. Then the instrument with which this man was tattooed, and which he brought away with him, is split like a steel pen at the tip, so that fluid substances could easily be taken up by it.

CONSANGUINEOUS MARRIAGES AND IDIOCY.

Dr. Mitchell, of the Edinburgh College of Physicians, says of idiocy and its relations to marriages of consanguinity, that in more than sixty per cent. of the cases of idiocy occurring in the British Isles the condition is acquired, not congenital, and is due to one or other of the numerous accidents to which children are liable. He disapproves of unions of near relations, but states that proof is wanting that any evil resulting from them is dependent on a mysterious influence intrinsic in the consanguinity itself. His objections to marriages of blood-relations proceed rather from a consideration of the increased risk in such unions of the transmission of morbid peculiarities. Thus, if a deaf-mute is married to a person in possession of the faculties of speech and hearing, the chances of having a deaf-mute child will be as 1 to 135; but, if deaf-mutes intermarry, the chances of having a deaf-mute child rise to 1 in 20.

Speaking of the causes which produce idiocy after birth, Dr. Mitchell points out that purely intellectual exercise, in excess, is more detrimental to children than purely emotional exercise in excess, but the reverse holds true in the case of adults. In children as well as in grown-up persons, disorder of the moral faculty, as a rule, precedes intellectual disorder, and overteaching of pupils is first apparent in change of character. Prolific causes of idiocy are scarlet fever, whooping-cough, and measles, diseases to which thirty per cent. of all the idiots and imbeciles in Great Britain are due.

TESTS OF IMPURE WATER.

In its provisions for securing to consumers a sufficient supply of pure water, the public health bill, now before the English Parliament, thus defines what will be considered as polluting liquids:

1. Any liquid containing in suspension more than three parts by weight of dry mineral matter, or one part by weight of dry organic matter, in 100,000 parts by weight of the liquid.

2. Any liquid containing in solution more than two parts by weight of organic carbon, 1, or .03 by weight of organic nitrogen, in 100,000 parts by weight of the liquid.

3. Any liquid which exhibits by daylight a distinct color, when a stratum of it 1 inch deep is placed in a white porcelain or earthenware vessel.

4. Any liquid which contains a solution, in 100,000 parts by weight, more than two parts by weight of any metal except calcium, magnesium, potassium, and sodium.

5. Any liquid which, in 100,000 parts by weight, contains, whether in solution or suspension, in chemical combination or otherwise, more than .05 part by weight of metallic arsenic.

6. Any liquid which, after acidification with sulphuric acid, contains, in 100,000 parts by weight, more than one part by weight of free chlorine.

7. Any liquid which contains, in 100,000 parts by weight, more than one part by weight of sulphur, in the condition either of sulphuretted hydrogen or of a soluble sulphuret.

8. Any liquid possessing an acidity greater than that which is produced by adding two parts by weight of real muriatic acid to 1,000 parts by weight of distilled water; or—

9. Any liquid possessing an alkalinity greater than that produced by adding one part by weight of dry caustic soda to 1,000 parts by weight of distilled water.

PERMANENT PHOTOGRAPHS.

The difficulty with photographs is, that they fade; the *desideratum* is to give them stability. Mr. W. H. Sherman, of Milwaukee, has been experimenting for some time past with a view to this object, and claims to have reached the result sought. His object was to introduce an unchangeable pigment of some kind into the print by deposition from solution, and he succeeds with the bisulphide of mercury (vermilion). The process and its explanation are as follows: "A solution is prepared, composed of hyposulphite of soda and a mercurial compound in such proportions that the bisulphide of mercury is slowly deposited, the deposition being almost entirely suspended until the print containing the unreduced chloride of silver is added to the solution. The withdrawal of hyposulphite to dissolve the chloride causes the deposition of the bisulphide to take place in the print." Pictures obtained in this manner resist strong reagents in a way that gives promise of great permanence, while they have a rich tone, and a novel and fine effect. Mr. Sherman has been experimenting a good deal on the precipitation of vermilion, and finds the color of the product powerfully affected by light.

THE SUN'S ATMOSPHERE.

Dr. Janssen, the French astronomer, in a letter to Prof. Newton, of Yale College, an extract from which is published in the *American Journal of Science and Arts*, says of the sun's atmosphere: "My observations prove that, independently of the cosmical matter which should be found near the sun, there exists about the body an atmosphere of great extent, exceedingly rare, and with a hydrogen base. This atmosphere, which doubtless forms the last gaseous envelope of the sun, is fed from the matter of the protuberances which is shot up with great violence from the interior of the photosphere. But it is distinguished from the chromosphere and the protuberances by a much smaller density, a lower temperature, and perhaps by the presence of certain different gases." Janssen proposes to call this the "coronal atmosphere," as he considers it to produce a large portion of the phenomena of the solar corona.

SCIENTIFIC ADVANCE IN GERMANY.

Prof. Virchow, in his address before the Congress of German Naturalists, states some facts which show what progress freedom of discussion has made in Germany since the beginning of the present century. "Not perhaps at the dead of night, but still beneath the veil of secrecy, a handful of *savants* assembled for the first time at Leipsic, at the invitation of Oken. In fact, in 1822, no considerable body of men could come together in Germany, in answer to a public invitation, with the permission of the civil authority. They could not discuss among themselves scientific questions, no matter how unconnected with the political and national questions of the day. Add to this that other fact, that, if I am not mistaken, it was only in 1861, at the Congress of Naturalists at Spires, that the names of the Austrian members could be made public, and then we can appreciate the tremendous change that has been brought about in Vaterland." In the same address Dr. Virchow pays a well-earned tribute of honor to French *savants*. He opposes also the suggestion that has been made by certain German professors, that *brevets*, or honorary memberships of French Academies, etc., held by German scientific men, should be sent back, for the reason that a distinguished French botanist had recently declined the honor of being made an associate of the Natural Science Academy of Leipsic.

ACTION OF SEWAGE-GAS ON LEAD PIPES.

Dr. Andrew Fergus states that lead soil-pipes are often found corroded and even perforated in positions which justify the belief that the destructive agent is sewer-gas. The corroding action always takes place from within, and is generally confined to the upper surface of the pipe most frequently in those situations where it lies in an horizontal position, though vertical pipes and the upper surfaces of bends are sometimes affected. Among the diseases he has observed as resulting from this state of things, typhoid fever, diphtheria, scarlet fever, and diarrhœa, are mentioned.

COOLING AND VENTILATION OF RAILWAY-CARRIAGES.

An ingenious contrivance for excluding dust and cooling the air of railway-carriages in hot countries is described in a late number of *Engineering*. It consists of an arrangement attached to the under side of the carriage, into which air is admitted and made to pass between layers of material that are kept constantly wet by a supply of water from above, and that present a large evaporating surface. By this means all dust is arrested in the chamber, and the air cooled before it enters the interior of the carriage. The windows of the car are so arranged that thorough ventilation is secured and the accumulation of moisture prevented. The appliance is now in use on several railways in India, and is found to be of great value. The average reduction of temperature secured by it is about 15° Fahr., with an evaporation of six gallons of water per hour. With a larger amount of water it is said that a reduction of 30° may be readily obtained.

CONSCIOUSNESS AFTER DECAPITATION.

M. Heindrich, who filled the office of headsman in Paris for fifty-four years, has lately died, after officially cutting off the heads of 139 criminals. He appears to have been a man of some cultivation; and had sufficient interest in his business, it is said, to attend the lectures of Velpeau, in order to obtain a knowledge of the exact position of the "vital joint." He also made various improvements in the construction of the guillotine. A visitor once asked him if he thought the separated head retained consciousness after it had fallen into the basket. Without giving a direct reply, he related several instances which went to support an affirmative answer. On one occasion he said a woman's head made a faint effort to spit at him; and he also spoke of violent contortions occurring in the muscles of Orsini's face—a phenomenon that has been observed in the faces of others immediately after decapitation. It is the opinion of the *Lancet* that these movements are reflex, and not at all of a conscious nature. They are probably due to the sudden loss of a large amount of blood, which here, as elsewhere, gives rise to convulsions. The mere blow must stun, and, before recovery takes place, the flow of blood from so many large vessels would be sufficient to produce perfect unconsciousness.

FOSSIL FLOWERS AND INSECTS.

A fauna and flora of the Eocene period have been dug out of the rocks by M. Munier-Chalmar, of the French Geological Society. He exhibited before it crustacea, insects, and flowers, in a wonderful state of preservation. The minutest details of the delicate organization of these vegetable and animal species are preserved with great nicety and fidelity. The flowers retain their calix and corolla, and some of the stamens still have their anthers. M. Munier exhibits some which are yet buds, others just blown, and still others with their petals all gone, and nothing left but the ovary. We may still observe the soft appearance of the insect larvæ, and can even discern the nerves of the budding wings of the nymphæ. Among the insects M. Munier recognizes a familiar domestic bug, in which may be seen the glands which secrete the mal-odorous liquid peculiar to those insects. Finally, among the crustacea, he has found a new species, in which we may study the minutest details of the masticatory apparatus.

A PHOSPHORUS-LAMP.

The following is a description of a safety-lamp, employed by the watchmen of Paris, in all magazines where explosive material is stored: An oblong phial of the whitest and clearest glass, containing a piece of phosphorus about the size of a pea Pour in some olive-oil, heated to the boiling-point, until the phial is two-thirds full, and then seal it up hermetically. To use it, remove the cork, allowing the air to enter the phial, and then recork it. The whole empty space in the bottle will then become luminous, and the light obtained will be equal to that of a feeble lamp. As soon as the light grows weak, its power can be increased by uncorking the phial, and allowing a fresh supply of air to enter. Thus prepared, the phial may be used for six months.

EFFECTS OF TRAINING.

The *Lancet*, in a short article on "training and its risks," *à propos* of the recent university boat-race, says: "We could mention numerous cases in which the reserve force of the system has been so forestalled by amateur oarsmen that not only specific vascular disease, but physical decrepitude, has declared itself long before the meridian of life. Within the last few days we have seen a list of cases in which, besides premature ill-health, even death itself was induced by the constant practice of rowing, followed by the tremendous final struggle. It is not only that the transition from customary to athletic regimen, and *vice versa*, has evils of its own, even in the case of professional watermen, but such evils are aggravated for the university amateur, who has so often to proceed from hard rowing to hard reading."

PHYSIOLOGICAL ACTION OF CAFFEINE.

According to Prof. Aubert's estimate, roasted coffee contains only about one-fourth per cent. caffeine; and, if so, it is not easy to account for the exciting effect of the infusion. The action of caffeine upon the spinal cord is analogous to that of strychnine, but far weaker. It notably augments palpitation of the heart. Artificial respiration arrests its mortal effects. Caffeine also produces transitory paralysis of the pneumogastric nerve. Dr. Nasse supposes that the action of the infusion of coffee is to be attributed, not to the caffeine alone, but to empyreumatic matter.

THE DEEPEST WELL.

The Germans claim the deepest hole that has ever yet been bored into the earth. It is situated near a small village about twenty-five miles from Berlin. The boring was commenced in 1867, and stopped last year, at a depth of 4,170 feet. The diameter of the hole at the top is 15½ inches. For the first 284 feet the drill passed through solid gypsum, when a bed of quite pure rock-salt was struck, the under side of which had not been reached when the boring ceased. Careful observations of the temperature at various depths are now being made, which will be placed before the public when completed.

PHYSICAL CONDITION OF CENTENARIANS.

In a paper lately read before the London Anthropological Society on the physical condition of centenarians, Sir Duncan Gibb gives an interesting account of the examination of six persons who had severally reached the age of one hundred years. He found the organs of circulation and respiration in a condition more approaching to the prime of life than old age. None of those changes which usually mark the age of seventy were observed; and, in nearly all, the special senses were unimpaired, and the intelligence perfect, which shows at least the complete integrity of the nervous system.

ARROW-HEADS IN NEW JERSEY.

Dr. Charles G. Abbott, writing in the *American Naturalist* on the "Stone Age in New Jersey," states that stone arrow-points of every variety are found at numerous points throughout the State, and that a reference to the drawings of arrow-points in Nilsson's "Stone Age in Scandanavia," and Lubbock's "Prehistoric Times," shows that whatever they have illustrated, either from the north of Europe or Terra del Fuego, is also to be met with in New Jersey. These arrow-heads are shaped from a great variety of minerals, but those made of various forms of quartz are the most abundant.

HONORS TO PROF. DANA.

At the meeting of the Geological Society of London, for February 16th, the president, Mr. Joseph Prestwich, presented for transmission to Prof. Dana, of New Haven, what is regarded as the highest honor the Society can confer, namely, the Wollaston gold medal, which had previously been voted by the council to this distinguished scientist. Prof. Dana's labors were spoken of in the highest terms; his numerous important contributions to almost every branch of geological science being characterized as remarkable, both for learning and skill of presentation.

COPPER IN ORGANIZED STRUCTURES.

Besides its wide-spread diffusion in the inorganic world, copper is also a frequent constituent of plants and animals. It is almost constantly found in flour, straw, hay, meat, eggs, cheese, and other articles of food, and also in sea-weed. In the animal kingdom, it occurs in the blood of certain mollusks and crustaceans, and is likewise found in the blood and tissues of many of the higher animals—in proportionally large quantity in the liver and kidneys.

M. Duclaux has lately discovered it in cacao-beans. The proportion is greatest in the outer covering or husk, although the inner parts, of which chocolate is made, also contain a notable quantity. Dr. Craig, of the Army Medical Museum, Washington, has quite recently found traces of copper in oysters; not in sufficient amount, however, to account for the green color which they sometimes present.

MAGNETIC VARIATIONS.

The last word about solar influence is uttered by Carl Hornstein, of Prague, who, summing up the results of an immense number of observations, says that the variations of each of the three elements of terrestrial magnetic force, declination, inclination, and horizontal intensity, have a period of about 26½ days. This periodicity can hardly be explained, except by the influence of the sun.

COLD IN GERMINATION.

The cold of winter is said by M. Duclaux, of the Paris Academy of Sciences, to be necessary for the germination of certain vegetable grains, and for hatching the eggs of the silk-worm. His researches in this matter he proposes to continue and to extend, so that the effects of cold may be ascertained to the greatest possible degree of exactitude.

NOTES.

A remarkable case of reproduction of the elbow-joint after resection is given by the *British Medical Journal.* The subject was a weakly girl, aged 13, whose elbow had become fixed in a faulty position, after inflammation. On account of this, and of disease of the bone, resection or removal of the joint was performed. The piece of bone removed was one and a third inch long in front, and two and a half inches behind; the articular portions of the bones of both arm and forearm being thus taken away. The child recovered, with power of moving the elbow between the angles of 60 and 113 degrees; rotation, however, was impossible. Two and a half years after the operation, the child died, and, on examination, a new elbow-joint was found, having its articular surfaces covered with cartilage, and provided with a synovial membrane.

The *Engineer* says that the oxyhydric light has not proved a success in Paris, and it has been discontinued in the public lamps on the Boulevard des Italiens. It is not generally known that a carburating apparatus is always employed in conjunction with oxygen, which adds to the complication of the apparatus as well as the cost of the light. There are but few, remarks *Le Gaz*, who will consent to have installed in their houses two meters, two regulators, a carburator, and two distinct systems of pipes. For this reason alone the system was certain to fail, even if the alleged economy were proved which has never been the case.

A simple mode of distinguishing with certainty between apparent and real death is given by Dr. Ars-Drouet, of the Paris Academy of Medicine. It consists in fastening a bandage, handkerchief, or cravat, etc., around the forearm, just below the elbow, or around the leg below the knee. If the patient still lives, the subcutaneous veins become inflated, swollen, and bluish under the skin; but, if life is extinct, there will be no change in the appearance of these veins.

From a statement made by Dr. Günther, in the January number of the *Magazine of Natural History*, it would appear that the national collection which in the year 1858 contained 480 species of snakes, represented by 3,990 examples, possesses now 920 species, represented by 5,500 examples. The number of typical specimens is 366, the total number of species of snakes known at present being calculated at about 1,100.

The perfect fossil skeleton of a man has just been discovered in a cavern near Meudon, France, by Dr. Rivière, who sends a communication on the subject to the French Geological Society. The skeleton was in an inclined position, and in the attitude of repose: the legs were partially bent, and the one rested on the other. A necklace made of shells and perforated teeth was found upon it.

Experiments with petroleum as a fuel in the puddling-furnace are said to have been attended with great success in France. The experiments were made under many varying conditions, and were conducted by practical and reliable men. It is asserted that, for convenience, efficiency, and, above all, for the superior quality of iron produced, there is nothing that equals petroleum in this manufacture.

In a paper read before the Iron and Steel Institute of England, Mr. J. Head states that, while there is as much heating-power in a pound of average coal as is necessary to produce 17 pounds of puddled bar-iron, there are few furnaces where more than one pound of iron is brought out to one pound of coal consumed.

If a sailing-ship be provided with a screw-propeller, the latter will revolve when the ship makes way; and it is proposed to apply the power thus obtained to operating a magnetic apparatus, which would furnish a far brighter signal-light than any oil-lamp.

The tannate of quinine has been substituted for the sulphate by Dr. Listach, of Bona, Algeria. Having employed the tannate in numerous cases, he found that it produced neither headache, nor deafness, nor singing in the ears, ordinarily produced by the sulphate. Unlike the latter, also, it possesses no bitter taste, nor does it cause over-excitement in nervous females.

M. Smith has written a paper, for the French Geological Society, on the carcasses of mammoths found in Siberia, with their flesh and integument preserved. He maintains that these animals were essentially arctic (like the musk-ox), that they found a grave in their native home, and that they were not drifted to Siberia by currents, as some have thought.

A new process for water-proofing leather consists in the exhaustion of the air from the pores of the leather, and then filling them up with a substance which unites with and adheres to the fibre, thereby strengthening without impairing the elasticity of the material, while at the same time it is rendered impervious to moisture.

In 1804, when Sir Humphrey Davy was but twenty-six years old, Dr. Dalton, the famed originator of the atomic theory, consulted him as to the best mode of preparing his lectures, and afterward described him as "a very agreeable and intelligent young man, the principal failing in whose character as a philosopher is that he does not smoke."

To distinguish benzole, which is made of coal-tar, from benzine, which is made from petroleum, Brandberg recommends that a small portion of the substance under examination be poured upon a little piece of pitch in a test-tube, when, if the liquid is benzole, it will immediately dissolve the pitch to a tar-like mass, while benzine will scarcely be colored.

A distinguished physiologist makes the assertion that about the heaviest tax on the memory is that imposed by the profession of the pianist. Rubenstein lately played by heart a piece which, according to actual count, contained but ten less than sixty-three thousand notes!

Bread made with sea-water is recommended for patients suffering from dyspepsia, phthisis, and scrofula. Those who have tried it testify that it is "extremely pleasant" to the taste.

The use of anæsthetics in veterinary practice is highly spoken of by an experienced veterinary surgeon of London.

An aching tooth has been extracted from the jaw of a member of the British Odontological Society, the dental canal cleansed, and the decayed portion cut away; and then the tooth was replaced in its socket, as in the case of artificial teeth. In two weeks, it is said, the tooth was serviceable.

M. Barety, member of the Biological Society of Paris, describes an interesting case of sweating, confined to the right side of the face. The curious phenomenon occurred at the outset of a fatal meningitis (inflammation of membranes covering brain and spinal cord), and lasted an hour.

During the last ten years, 2,778 photographs of the sun have been taken at the Kew Observatory. It is now announced that the almost continuous photographic record of the state of the sun's disk thus obtained is soon to be brought to a close.

Hallwachs has found that both green and red colored carpetings frequently contain arsenic. He asserts that the brilliant dark-red colors, now so popular, contain enormous quantities of this poisonous substance, burning with the blue flame of arsenic, and giving its characteristic garlic odor.

It has been found that the clothes fitted to new recruits in the English army soon become too small across the chest, and too tight around the neck, owing, it is stated, to the increased development given by gymnastic and military exercises.

Lithofracteur is rapidly replacing powder as a means of removing obstructing wrecks. Two charges of fifty pounds each recently accomplished on a sunken wreck what would have required tons of gunpowder, and much difficult labor.

In South America are found earthworms that oftentimes attain a length of 40 inches, and which have a circulatory system of great perfection. They are found to possess hearts composed, like those of the higher animals, of a soft auricle and of a very muscular ventricle.

The fossil horse is found among the tertiary and quaternary formations in Ecuador, showing that this continent possessed that animal previous to the Spanish settlement, though he became extinct.

At Chatham, England, there is a man who regularly refuses to have his children vaccinated, and will not pay the fines. The Anti-Vaccination Society support his wife and family while he is in prison.

The Popular Science Monthly has been well received by the press, and the project is cordially commended, as the following extracts will show:

"We think it is not too much to say that this is the best first number of any magazine ever published in America."—*New York World.*

"This is just the publication needed at the present day, when people are beginning to wake up to the importance of knowing something of the grand and beautiful processes of Nature, and of the thousand departments of scientific knowledge, the study of which strengthens and elevates the faculties, and opens up so many new sources of intellectual enjoyment."—*Montreal Gazette.*

"The new journal will meet with a deserved popular success, for the field is an open one, and The Popular Science Monthly is equal to the occasion; it is beyond comparison the best attempt at journalism of the kind ever made in this country."—*Home Journal.*

"The initial number is admirably constituted. It opens fittingly with a paper by Mr. Herbert Spencer which we commend most earnestly to all thoughtful men. With the improvements that will come by experience, we look to see The Popular Science Monthly a periodical of superlative merit, and a thorough success."—*New York Evening Mail.*

"The initial number amply fulfils the promise of its conductors, and, by the vigor and breadth of its discussions, no less than by the interest of the topics chosen, claims the public support and patronage. Scientific discovery in all departments moves forward so rapidly, and opinions, if it must be confessed, shift with such surprising readiness, that there is need of a full and well-conducted periodical to record the changes."—*Boston Journal.*

"The Popular Science Monthly, conducted by Prof. Youmans, and published by the Appletons, is a new-comer in the periodical field, and one for whose success we cannot but wish earnestly. In our opinion, the right idea has been happily hit in the plan of the new monthly. There is a positive need for such a journal as this, and we hope that the large number to whom its appearance must be welcome will see that it is a success from the start."—*Buffalo Courier.*

"This is a highly-auspicious beginning of a useful and much-needed enterprise in the way of publication for which the public owe a special debt of obligation to Messrs. D. Appleton & Co."—*Boston Gazette.*

"A journal which promises to be of eminent value to the cause of popular education in this country. It is to be hoped that an experiment of such unquestionable public utility will meet with support in accordance with its merits."—*New York Tribune.*

"We have not met a new acquaintance in the literary world which we can welcome more heartily than we do this new monthly. It meets a want which has long been felt by the friends of popular learning in our country.—*Lockport (N. Y.) Daily Union.*

"The articles selected from the leading foreign periodicals are of great value—particularly Mons. A. De Quatrefages's instructive and suggestive lecture on the Natural History of Man. The success of this periodical, so much needed and so well edited, may be taken for granted."—*Philadelphia Press.*

"This new enterprise appeals to all intelligent seekers for truth, all lovers of knowledge, all friends of investigation, and all who are interested in the laudable effort of diffusing that information which is best calculated to expand the mind, and improve the conditions and enhance the worth of life."—*Golden Age.*

"Messrs. D. Appleton & Co. have certainly carried out one of the memorable 'happy thoughts' of these times, in preparing The Popular Science Monthly. It is just what is wanted by the curious and progressive mind of this country, and ought to be widely circulated."—*New York Evening Post.*

"That there is a place for The Popular Science Monthly no one can doubt who has watched the steady increase of interest in scientific investigation manifested in this country, not only by a select class, but by the entire community. The success of a periodical of this nature, if it is rightly conducted, cannot for a moment be doubted, and, in this respect, we would say that, if the managers of this one will only continue as they have begun, they may be assured of a circulation at once large and appreciative. Prof. E. L. Youmans, who is the editor, has made arrangements with the leading scientific periodicals of Europe, so that he can publish papers of special interest from their advance-sheets among his selected articles."—*New York Times.*

"This new magazine, in our estimation, has more merit than the whole brood which have preceded it."—*Oswego Press.*

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CORALS AND CORAL ARCHITECTURE.

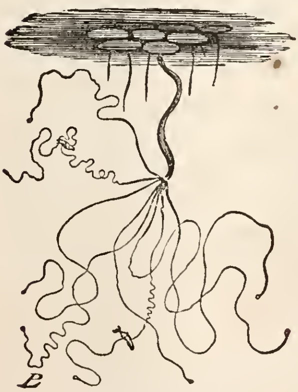
By ELIAS LEWIS, Jr.

THERE are forests and gardens in the depths of the sea. Stately, tree-like structures inextricably branched, and a multitudinous shrubbery, delicate in form, and crowned with brilliant perennial blossoms, constitute a world of life and beauty in the obscurities of the ocean, where the eye of man but rarely penetrates.

But what kind of life is that which produces such wonderful growths? The similarity of the appearances to a garden was too striking not to suggest an answer, for what but vegetal forces can produce growing branches covered with flowers? And so Theophrastus, the old Greek botanist, described these sea-structures as of vegetal origin, and this opinion prevailed for 2,000 years. It began at length to be suspected that the old notion was wrong, and in 1751 Peyssonnel sent to the Royal Society an elaborate memoir, in which he maintained that these ocean-forests are really formed by little animals. This, as a matter of course, was indignantly disputed, and was pronounced by the great Réaumur too absurd to be discussed. To ascribe to "poor, little, helpless, jelly-like animals" the skill and power necessary to build such stately and beautiful structures, looked like a wanton appeal to human credulity, and the point was hence warmly controverted. Linnæus, however, proposed a compromise. He would admit the animal, but would not deny the vegetable. He therefore assumed that these little toilers of the sea were of an intermediate nature, and named them *zoophytes*, animal-plants. But the coral-polype is now known to be as truly an animal as a cat or a dog. The apparent flower is a little sac-like creature, and the wreath of colored petals its arms or tentacles. These are arranged around its circular mouth to seize and draw in the food upon which it lives and grows, while the structures which it produces are not perishable wood but enduring stone.

But, lowly organized and apparently insignificant as these animals are, the part they play in the operations of Nature is in the highest degree imposing. Not only do they produce these exquisite arborescent forms, but they build gigantic structures with caverns, grottoes, and mighty arch-work, and raise rocky walls, which rival in extent and massive grandeur the noblest mountain scenery upon the land. Though these constructions proceed but slowly, yet in numbers that are inconceivable, and through ages that are incalculable these tiny beings have been engaged in the work of rock-manufacture, until they now rank with earthquakes, the rising and sinking of continents, and other stupendous agencies by which the crust of the globe has been shaped. Multitudes of islands, hundreds and thousands of feet above the surface of the sea, and multitudes of others sunk thousands of feet below it; stony reefs, along which the navigator sails hundreds of miles; the sheet of rock through which Niagara is slowly cutting its way, and extensive beds of limestone scattered over the continents—all have a common origin—all have been extracted from sea-water and secreted by animals low in structure, and chiefly by these jelly-form polypes, many kinds of which are so minute as to be hardly visible to the naked eye. Living, working, multiplying, and dying like ourselves, building blindly but grandly in the final result, perhaps here also not unlike ourselves, these humble creatures illustrate the method of Nature, and their works and ways are of inexhaustible interest. Their instructive story has just been told by Mr. Dana, with the fascination of romance and the fidelity of science, in his charming book on "Corals and Coral Islands." In the present brief presentation of some of the facts of the subject we shall chiefly follow Prof. Dana, and we are indebted to the courtesy of his publishers for the accompanying illustrations from his work.

Fig. 1.



Fresh-water Hydra.

The animal kingdom is divided into several sub-kingdoms, one of which comprises numerous species of animals termed *Radiates*, because their parts are arranged radially round a centre. One division of the radiates is known as *polypes*, and they have the faculty of secreting a stony frame or skeleton, which is termed *coral*. The polypes are the most important coral-making animals, but this substance is produced also by other radiates, by some of the lowest tribes of mollusks, and a kind of coral is made by lime-secreting sea-weeds.

There is a group of radiates termed *Hydroids*. One of these, the fresh-water hydra, is represented in Fig. 1, as it is often seen attached to the under surface of a floating leaf. Prof. Dana says: "It is seldom over half an inch long; it has the form of a polype, with long, slender tentacles, but no special organs except a mouth and tubular stomach. Like the fabled hydra, if its head be cut off, another will grow out, and any fragment will, in the course of a short time, become a perfect hydra, supplying head or tail, or whatever is wanting, and hence the name given to the genus by Linnæus."

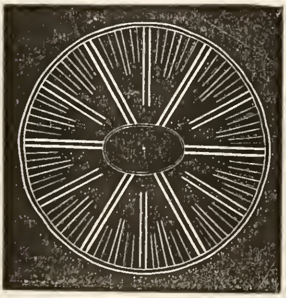
FIG. 2.

Plumularia; a Coral Sprig made by Hydroids, not more than the fiftieth of an inch long.

Some of the hydroids are coral-makers. Fig. 2 represents the kind of work done by one of them. It certainly looks like a plant, and, in allusion to its delicate plumes, it is called *Plumularia.* Along the branches are minute cells (indicated by the fine dots in the woodcut), each of which was the seat of one of the little hydra-like animals (in this case not more than the fourth of a line long), and usually with short tentacles spread out star-like.

"We will now pass to the true polypes. These may be divided into those which secrete coral and those which do not. The latter

FIG. 3.



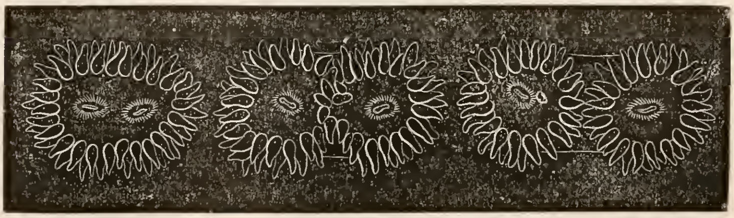
An Horizontal Section of a Polype showing the Internal Arrangement of the Folds and Compartments.

FIG. 4.

Coral from the West Indies, showing the Structure of the Cells.

have soft, leathery bodies, and live attached to stones and other substances upon the sea-bottom, by a basal, sucker-like disk. They have the power of locomotion by contraction and expansion of the muscles of the disk. But the coral-making polypes are fixed to the stone which they create, and which is part of themselves. The polype is the living part of the coral, the gelatinous mass which

FIG. 5.

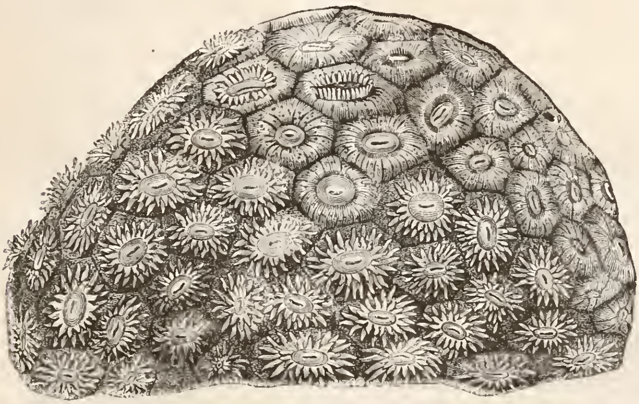


Multiplication of Polypes by Spontaneous Fission.

fills the radiating cells upon the coralline surface. It consists of a sac or stomach, and an enveloping membrane. An opening from the stomach outward is the animal's mouth. This is surrounded by tentacles, which by their motion aid in bringing to it currents of water in which floats its food, and of the solid matters of which it constructs its calcareous skeleton." In the polype, the stomach or digestive sac, with its appendages, constitutes the whole animal. Into the stomach the sea-water passes freely, and carries the digested food through the internal cavities. There is no other circulation of fluids.

Fleshy folds or partitions extend from the upper to the lower end of the animal, and give to the polype the appearance of a little balloon of tissue-paper crumpled up. These radial folds in the animal's structure are illustrated in Fig. 3, page 260, which is an ideal sectional view of one of this class of animals. The radiating partitions or folds are seen to be arranged in pairs. In the coral-secreting polypes these pairs are six or five, or multiples of six or five. The space between each of these partitions opens into the tubular tentacle at the top of the animal. The tentacles of the polypes moving freely and with con-

Fig. 6.



Coral from the Feejees, called *Astrææ*, from the Star-shaped Cells.

siderable muscular strength, seem sufficient to supply the animal's wants, but it has a formidable armature in the stinging barbs which cover its tentacles, mouth, and stomach, and which produce torpor and death in any small animal brought in contact with them. These are called *lasso-cells.* The cells in which the lasso or barbs are located measure from $\frac{1}{350}$ of an inch to $\frac{1}{5000}$ of an inch in length. From these the lasso is projected, inflicting, in some species, upon even a human hand, painful and serious injury. Owing to this peculiarity of certain jelly-fishes, they have been appropriately named *sea-nettles.*

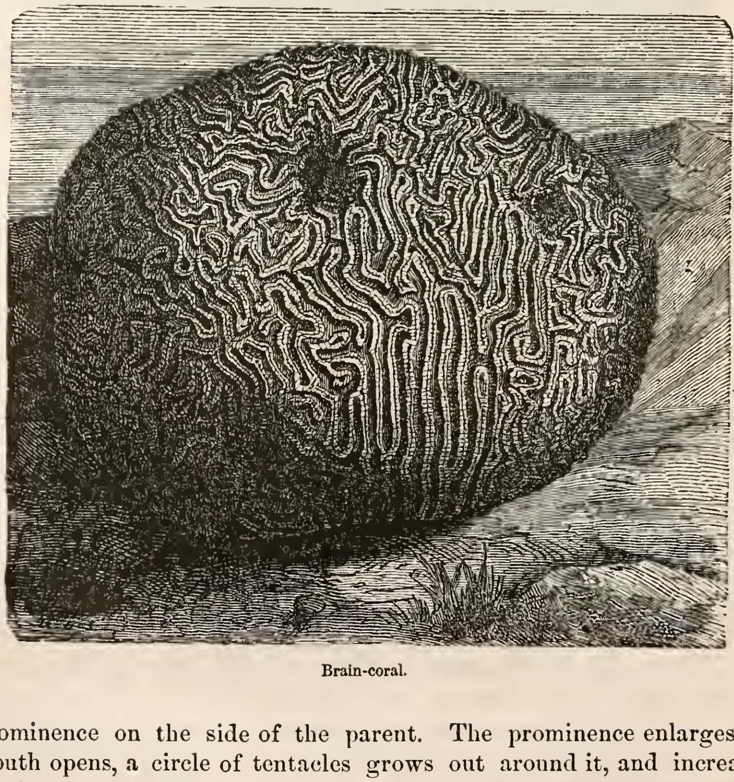
Between the fleshy partitions of the polype's body are thin, stony plates. These, with the other hard portions, make up the coral skeleton, and are wholly secreted by the polype. Fig. 4, page 260, represents a group of polypes (*Phyllangia Americana*) from the West Indies, and illustrates well the radial structure of the cells.

The secretions occur around and underneath the polype, never in its interior, which would interfere with its functions. It constructs its skeleton by secretion, as an oyster does its shell, or as the tissues of a vertebrate animal do its bones; an act wholly involuntary in both cases.

Therefore, when we speak of the labors or architecture of the coral animal, we do not imply outside mechanical work as the bee in constructing its comb, but simply the operation of a vital function. "This process of secretion," says Prof. Dana, "is one of the first and most common of those that belong to living tissues. It belongs eminently to the lowest kinds of life. These are the best stone-makers, for in their simplicity of structure they may be almost all stone, and still carry on the processes of nutrition and growth."

The young polype in the reef-building species arises by a process of budding from the parent animal. It was from this curious operation that early observers strengthened their argument in favor of the vegetable nature of corals. "The bud," says Dana, "commences as a slight

Fig. 7.

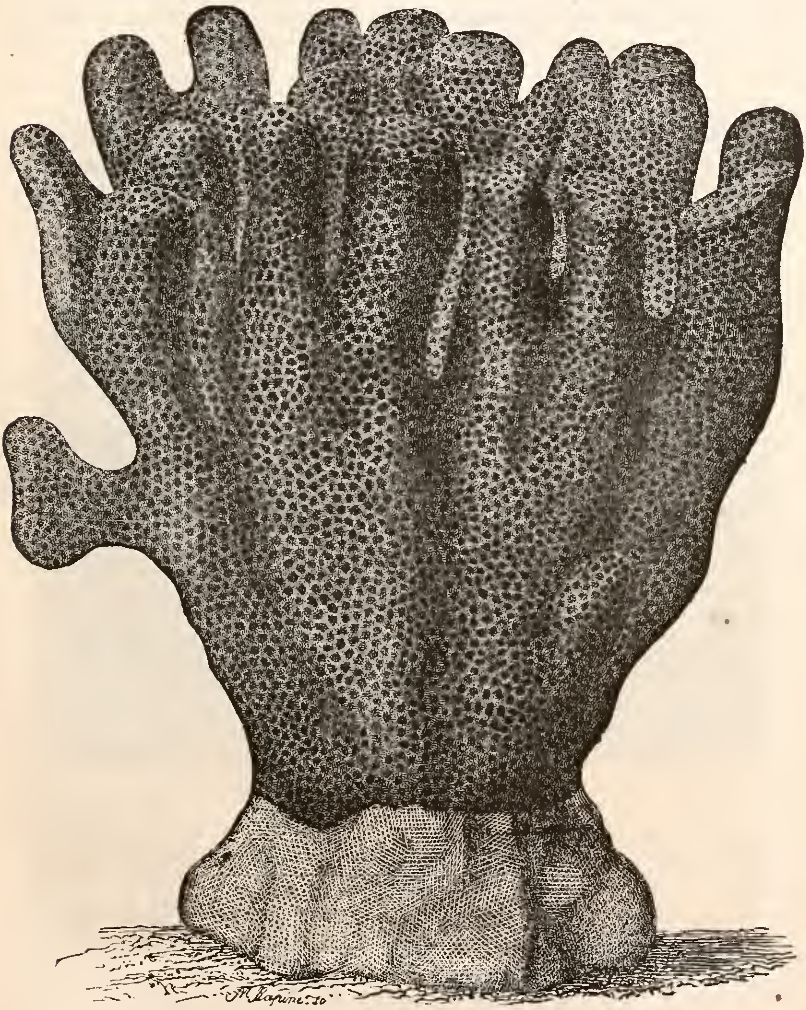


Brain-coral.

prominence on the side of the parent. The prominence enlarges, a mouth opens, a circle of tentacles grows out around it, and increase continues until the young finally equals the parent in size. Since in these species the young do not separate from the parent, this budding produces a compound group."

From this it is obvious that, while the polypes exist as individuals, they are nevertheless connected by intervening tissues which form a thin sheet of animal matter covering the surface of the coral, and through which fluids circulate. This sheet of animal matter unites the polypes, but does not destroy their individuality. The budding process

Fig. 8.



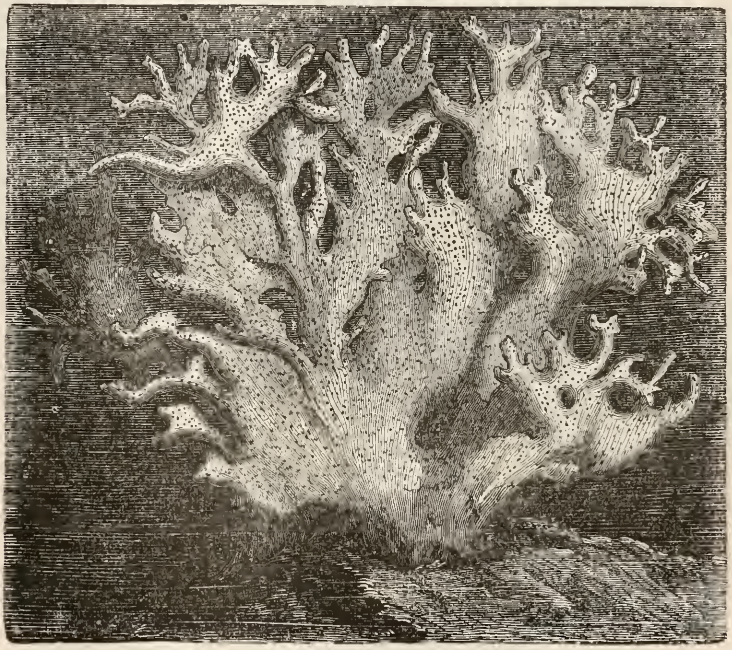
Porites from the Feejees; Cells exceedingly small.

takes place in some species by a spontaneous division of the parent polype. So that in the same cell a new polype forms side by side with the old one (Fig. 5, page 260), and begins an individual life, but the results are essentially the same.

The reef-building corals comprise all those with a stony skeleton, yet the great work is carried on mainly by a few of the principal groups. Of these the following are the most conspicuous and familiar:

The *Astræas*, so called from their star-shaped cells (Fig. 6, page 261). They grow in huge hemispherical masses, often twenty feet or more in diameter. The *brain-coral*, covered with meandering furrows and ridges resembling cerebral convolutions (Fig. 7, page 262). The masses are large, and are shaped like the astræa. The *Porites*, often branched,

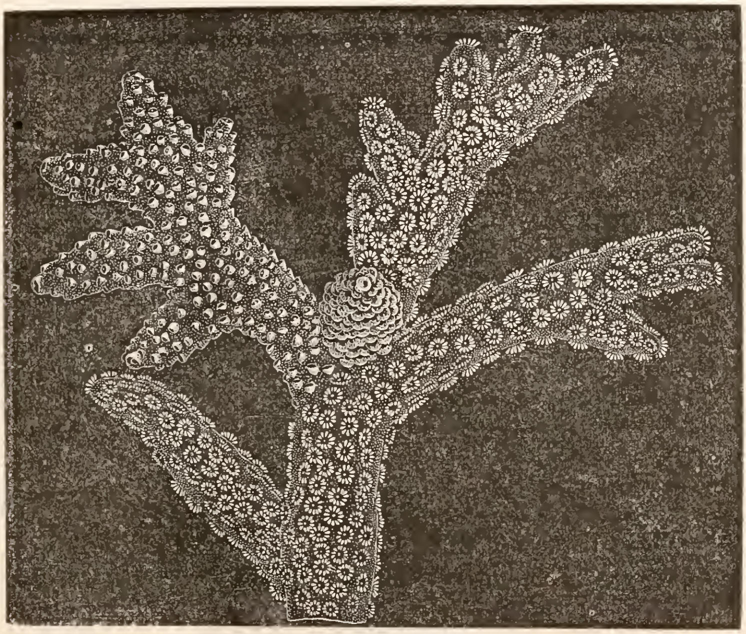
Fig. 9.



Millipores; Coral secreted by Jelly-fish (Acalephs).

sometimes massive and covered with exceedingly minute cells, are represented in Fig. 8, page 263. Other species are branching or lamellar, as the *Millipores* (Fig. 9), which contribute largely to the material of the West-India reefs. The animal, however, in this case, is not a true polype, but belongs to the group of *acalephs*, or jelly-fishes. Then there are the beautifully branched, tree-like *Madrepores* (Fig. 10, page 265). Fig. 11, page 266, represents one of the most beautiful of the corals produced by the *alcyonoid* polypes. Almost all of these are flexible, and sway with the moving waters. Some kinds are too flexible to stand erect, and they hang from the coral ledges, as in the coral caves, in gorgeous clusters of scarlet, yellow, and crimson. All these corals are covered with cells, and each represents the dwelling place of an individual polype. In some of these the diameter of the expanded rays or tentacles of the polype is about one-eighth of an inch; in others, as the astræa, nearly an inch. The rays, when expanded, closely resemble the petals of flowers, and coral flowers is, with many persons, a more familiar term than "rays," and equally expressive. The astræas have sometimes nearly a hundred petals or tentacles to a single animal. Others, as madrepores and porites, have twelve rays each; in

Fig. 10.



Madrepore; branching from Lateral Buds.

still other species a larger or smaller number is found. The rays or tentacles readily fold inward over and into the animal's mouth, and upon a slight jar of a mass of coral the waving tentacles close, and all motion or evidence of life disappears from its surface.

The number of polype-cells upon some species of coral is immense. A dome of astræa, twelve feet in diameter, with a cell to each half-inch of its surface, would contain 100,000 individuals. Prof. Dana remarks that a porites of the same size would number 5,500,000 polypes. But Agassiz states that he has estimated 14,000,000 individuals in a mass of porites not more than twelve feet in diameter.

Notwithstanding the enormous mass of some coral formations, they are dead and deserted throughout, excepting a thin crust upon the surface. This, in different species, may vary in thickness from $\frac{1}{8}$ or $\frac{1}{16}$ of an inch to half an inch, and constitutes the living portion of the coral where the work of growth goes on. The inner or dead portions constitute the stony mass on which new material is secreted, but is no more essential for that purpose than a rock or a sandy shore. Prof. Dana observes that, if the living portion could be separated, it would form a hemispherical shell about half an inch thick. As the higher orders of trees increase in size by additions of new wood at the outer margin of the trunk, long after the heart-wood is dead, so the coral is alive and grows only on its surface.

It is obvious that the increase of the coral will continue without

Fig. 11.

Alcyonoid Polypes; "gayest and most delicate of coral shrubs."

limit except from surrounding conditions. Thus, if the dome reaches the surface of the water, the polypes die, and growth ceases in that direction; but it may increase in diameter, forming some remarkable structures, which we will presently notice. But, if the coralline mass be continually sinking by a subsidence of the land on which it rests, the conditions of growth continue, and reefs of tremendous mass and thickness are formed.

The dead coral is always more or less porous, until the pores and polype-cells are filled by comminuted substance or the infiltration of carbonate of lime. Aided by chemical changes, the mass becomes solid coral-rock, and finally compact limestone, with few traces remaining of the coral structure. In many of the branching, tree-like corals the stems are formed nearly solid as they grow, and are of great strength. In some of the massive species the surface cells occupied by the living animals are very shallow, measuring from one-sixteenth to one-fourth of an inch in depth. Underneath the polype is a floor or partition of coral secreted by the animal, and which separates the new from the old cell. Hence many corals, when split vertically, show a coarse cellular structure. In the life-and-death process of the polypes, animal matters remain confined in the old cells.

As the coral masses increase in size, it is evident that there must have occurred a simultaneous increase in the number of polypes. This fact is the more interesting, when it is known that a great coral dome may have arisen from a few, or perhaps from a single parent individual. During the long period of its growth, reaching through thousands of years, how enormous is the number of builders of it that have lived and died!

The rate at which corals grow is an interesting question, but not fully determined, for want of sufficient data. A single mass standing in clear water would increase more rapidly than corals in a reef. If at the rate of an inch in six years, a dome 20 feet in diameter would require about 1,400 years. Some species seem to grow more rapidly than this, but the increase of reefs is slower, notwithstanding additions from shells and other sources. On a coral-plantation, as a reef may be called, a portion is always unproductive. There are barren areas on the reef where sands or sediment destroy the polypes, and retard its growth. The investigations of Prof. Agassiz, at Key West, indicate a growth of about six inches in 100 years. He says: "If we allow twice that rate of growth, not less than 7,000 years would be required for the formation of the great reef at that place, and hundreds of thousands of years for the coral growths which form the peninsula of Florida."

After a careful estimate, Prof. Dana concludes that the growth of reefs, from increase of their corals, may be from $\frac{1}{44}$ to $\frac{1}{80}$ of an inch per year, and adds that, "whatever the uncertainties of calculation, is is evident that a reef increases with extreme slowness." It is a reasonable calculation that more than 1,000,000 years have elapsed since the foundations were laid of some of the great Pacific reefs.

An opinion prevailed formerly that the different species of corals occur in a reef in a uniform order of superposition—that each flourishes at certain depths of water, and not above or below that plane. The general fact is known that no important reef-building coral grows at a depth greater than 120 feet. Above that plane, all the work of coral architecture is carried on. Prof. Agassiz supposes that the range of different corals in depth is in part limited by pressure of the waters. At 32 feet depth, the animal is under a pressure of two atmospheres, and of more than four atmospheres at 120 feet. In this connection he states that the astræas occur at the bottom of the reef. Next in order, the brain-coral, porites, madrepores, and on the surface the light, branching varieties which are the shrubbery of the coral world. This arrangement may occur where the bottom on which the reef stands is immovable, or has remained without change of level since the reef commenced. But how it could occur in a coral mass 2,000 feet thick, growth being limited to a depth of 120 feet, is not entirely obvious. In order to explain the enormous depth of coral-reefs upon the submerged lands of the Pacific, it is necessary to consider the further well-established fact, first suggested by Charles Darwin, that the lands and ocean-bed have gradually subsided. The subsidence has been often at the same slow rate that coral-reefs have increased by upward growth. It seems inevitable from this that the builders are at work on the upper portions of the reef; certainly it is here only that the work of elevation can go on. Summing up this subject, Prof. Dana says: "Reef-building corals of the different groups *grow together promiscuously* at different depths up to low-tide level. The largest astræas, mæandrines (brain-coral), porites, and other kinds, have been seen by the author, constituting the upper part of the growing reef." The coral polype flourishes only in the belt of warm waters which lies in and near the tropics. A temperature lower than 68° Fahrenheit is fatal to them. The great reefs abound and grow with greatest vigor in the zone of greatest heat.

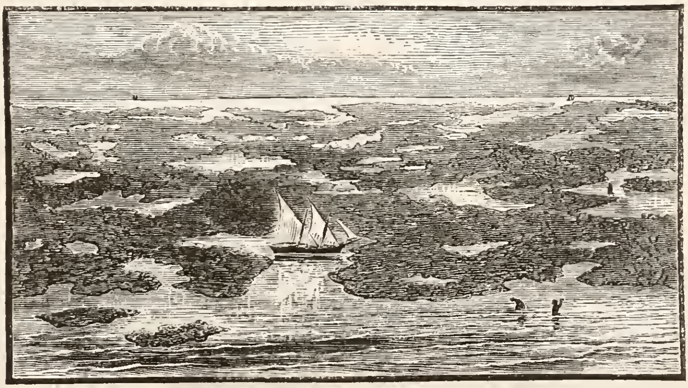
Surrounding most of the tropical islands are two principal reefs, one fringing the shore; the other, called the barrier-reef, lying seaward, sometimes more than 15 miles from the land. The intervening space is often filled with minor reefs and a gorgeous wealth of coral vegetation.

Here lie immense platform-reefs, a shell of coral covering the bottom beneath the shallow waters. These together make up the coral-reef ground of the island. West of the two larger Feejee Islands are 3,000 square miles of reef-ground. New Caledonia has a reef along its western shores a distance of 250 miles. The great Australian barrier, lying east and northeast of that island, forms a broken reef, 250 miles in length. On these outer reefs the waves forever break, and here, where the plunge of the surf is most furious and persistent, the polypes flourish with greatest vigor, and open their many-colored petals to the life-giving waters, as do thirsty flowers to the welcome rain. On every dead space delicate moss-like and lichen-like corals quickly form their thin, hard crusts.

Outside the reefs there occurs, in many places, a coral growth alike curious and interesting. In isolated patches are found immense mushroom-shaped masses called coral-heads. One is described by Whipple, cited by Dana, standing in water 50 feet deep, near Turk's Island. Its trunk is about 15 feet in diameter, supporting a tabular mass 100 feet in diameter, the top being bare at low tide. When these corals reach the surface, growth in that direction ceases, but may continue indefinitely around the margins. Thus, in many places, the tops of adjacent trunks have joined together, forming a coral floor resting upon arches and pillars built without axe or sound of hammer. In some parts of the reef-region, such united coral-heads cover large areas. A magnificent scene would be presented should the waters recede and leave bare these arches and columns. The ruins which "sentinel the desert" would not rival them in grandeur. To thread their avenues and sounding aisles would be the labor of a lifetime.

The illustration, Fig. 12, after a sketch by Prof. C. F. Hartt, in his "Geology of Brazil," is of an area of the sea off that coast, abounding in coral-heads similar to those described. "The corals," says Prof. Hartt, "grow in the open sea, and often rise 40 or 50 feet, and form what the natives call *chapeiroes* (signifying 'big hats').

FIG. 12.



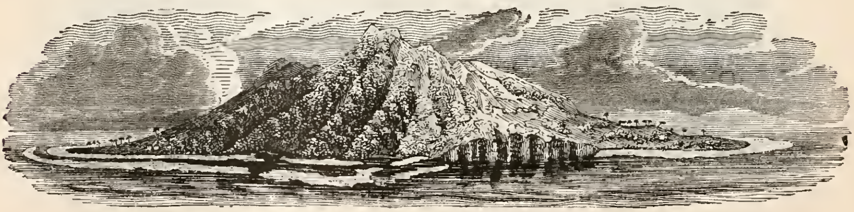
Coral-heads off the Brazilian Coast.

They are abundant on one part of the coast over an area of 40 square miles. A vessel running on the top of one of these chapeiroes would remain perched like a weathercock on the top of a tower, to the great amazement of the captain who finds deep water all around." Inside the outer or barrier reef the water is smooth as in an inland bay. If free from sediment, and not freshened by discharge from rivers, it is the paradise of the smaller corals. The beautiful fungia lie with innumerable shells upon the bottom. The feathery and fan corals grow in clusters, and, amid their delicate plumes, fishes, which rival them in gayety, glide through the transparent water.

It is a peculiarity of coral-reefs that the outer side is usually nearly perpendicular, while the inner side is a gentle declivity. The cause of this may be better understood if we follow the development of the reef from its beginning. Upon a shore of sand or rock, and at a depth of less than 120 feet, the reef-builders attach themselves and commence to grow. The reef rises, but, as before remarked, corals grow most rapidly in the purest waters, and thus it is that reefs often seem to crowd against the waves without and assume a wall-like aspect. But, owing to the wash of the land within, and the discharge of streams in some instances, the polypes are less healthy and their growth more precarious. These causes modify the form of the reef. But, however modified, the reef fringes or encircles the land (Fig. 13). We have already remarked that coral-reefs can attain no greater thickness than about 120 feet, unless there occurs with their growth a simultaneous subsidence of the land on which they rest; but, with that coincidence, the growth of the reef may continue so long as the subsidence goes on.

It is obvious that, with this sinking of the land, the area of the island must diminish, the sea and its accompanying corals gradually encroaching upon its shores. At last the land disappears. Then we have a lake or *lagoon* over its former site, surrounded by coral-reefs—for the builders have not been at rest. All the features of coral growth continue, but the land with its wealth of vegetation is buried. A coral floor has formed over it. This is the history of hundreds, perhaps thousands of former islands in the Pacific alone; and the great reefs, from which the surf sends up an incessant wail, are the monuments of this ocean-cemetery.

Fig. 13.



High Island, with Barrier and Fringing Reef.

The encircling reefs, with the lagoon, are called an *atoll*, which is only another name for a coral-island. This effect is well shown in Fig. 14, page 271.

Moreover, the force of waves and lifting-power of water have broken fragments of coral and coral-rocks, and thrown them upon the reef. The mass may have been already weakened by the perforations of innumerable boring worms and mollusks which burrow in the reefs. Thus in places beaches have been formed 10 or 12 feet in elevation above the ocean. They are composed of coral sand made fine and drifted by waves and winds, fragments of shells, bones of fishes, and other matters drifted thither by the sea.

The beauty of the completed atoll must be given in Prof. Dana's words: "When first seen from the deck of a vessel, only a series of dark points is descried just above the horizon. Shortly after, the points enlarge into the plumed tops of cocoa-nut trees, and a line of green, interrupted at intervals, is traced along the water's surface. Approaching still nearer, the lake and its belt of verdure are spread out before the eye, and a scene of more interest can scarcely be imagined. The surf, beating loud and heavy along the margin of the reef, presents a strange contrast to the prospect beyond. There lie the white coral-beach, the massy foliage of the grove, and its embosomed lake with its tiny islets. The color of the lagoon-water is often blue as the ocean, although but 10 or 20 fathoms deep, yet shades of green and yellow are intermingled." In some instances there is a ship-channel through the reefs into the lagoon, in others only a shallow passage, in others none at all.

Fig. 14.

Coral Island, or Atoll.

By a series of soundings, we have some idea of the depth of water near the ocean-side of many of the great reefs.

Seven miles from Clermont Tonnerre, of the Panmotus group, bottom was not found at 6,870 feet. From another point of the same island, only 1,500 yards from shore, the lead touched at 2,100 feet, then dropped off (probably from a projecting coral), and descended 3,600 feet without finding bottom. In another instance, about a cable's length from the island of Ahii (Peacock Island), in the same group, the lead struck at 900 feet, fell off and touched bottom at 1,800 feet. Off Whitsunday, 500 feet from the shore, no bottom was found at 1,500 feet. Deep soundings in the immediate vicinity of coral-islands is almost universal. Should these submerged islands of the Pacific be again elevated until their gigantic coral crowns should be lifted above the waves, an immense area of the Pacific would be converted again into an archipelago, not indeed of verdure-covered land as before, but of hills and mountains of coral-rock, bristling with crags, sublime with precipices and stupendous walls.

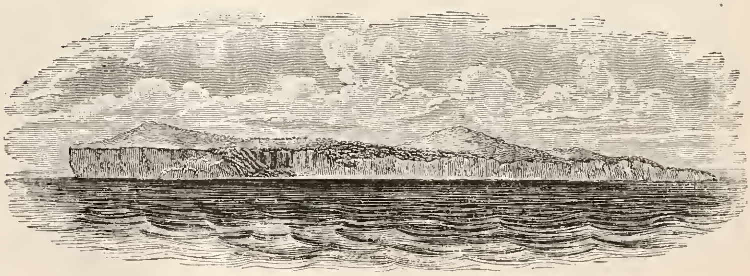
The great coral-bearing area of the Pacific is about 12,000,000 square miles in extent, nearly as large as the continent of Africa, or of Europe and North America combined. It extends from the southern side of the Hawaiian Islands to Pitcairn's Island to the southeast, thence 2,000 miles broad and 6,000 miles in length to the Pelew Islands, north of New

Guinea in the Polynesian seas. In this area are 204 islands, very few of which are high or with land still above the sea. Southward of this area are many mountainous islands, or with highlands, surrounded with reefs, evidently beyond the line of greatest subsidence.

The evidence is satisfactory that the depressed area has gone down, in comparatively recent geologic time, many thousands of feet, and yet the subsidence may have been less than the elevation of lands elsewhere; for we have the elevation of the Rocky Mountains, Andes, Alps, and Himalayas, modern events in geologic history. It is more than probable that great subsidence in one section is correlated by elevations elsewhere. And the depression of the Pacific area may correspond to the elevation of northern lands which probably caused the cold and glaciers of the glacial age. The movement was one of those great secular changes of the earth's crust which dates far back in its history.

There is evidence that the Pacific subsidence has ceased, or nearly so, and that local elevations have long since commenced. In about 40 instances, Pacific coral-islands have been elevated since reefs were formed upon them. Many of these elevations are a few feet only, others, a few hundred feet; as many as 600 feet in one or two instances. These elevated masses of coral-rock have the perpendicular walls and configuration before described. Metia, or Aurora Island (Fig. 15), is one of the Paumotu group; its walls of coral-limestone are 250 feet high, and resemble the Palisades on the Hudson.

Fig. 15.



Metia, or Aurora Island.

Along the outer margins of the elevated islands are deep caverns, showing, by their contour, the wearing and wasting action of waves. The Bermudas are remarkable for their caverns; the coral-made land being in places 260 feet above the level of the sea. On the island of Oahu, the Rev. John Williams entered one by a descent of 20 feet, and wandered a mile in one of its branches. Innumerable openings presented themselves on all sides. The roof, a superb stratum of coral-rock, 15 feet thick, was supported by stalactitic columns, and thickly hung with stalactites.

We cannot dismiss this subject without considering the coral-island, or completed atoll, in its relations to life. Upon an area so limited and so uniform, there may be much beauty, but little variety. On many of them there are less than a dozen species of plants, and not an animal higher in the scale than fishes, except a few migratory birds. Twenty-nine species of plants were found upon one island. There, as elsewhere, on the dry rocks, black lichens grow in patches. The germs of this class of plants seem to be present everywhere within the geographical limits of life. On some of the more favored islands are some tropical birds, a few rats and mice, and perhaps other animals introduced by man. The drift of the sea may convey to it various organic germs.

The coral-made land is ocean-born; its palm-groves were planted by the waves; and here too is man, savage, swarthy, unclothed, filthy, barbarous. With him degradation is an inheritance, and physical conditions hold him with relentless grasp. With occasional surfeit, he is in danger daily of starvation. He is driven to infanticide in self-defence. The taste which adorns our New-England landscapes can never develop here. In the land of the elm and the oak, rather than beneath the shade of the pandanus and the cocoa-nut palm, we must look for the conditions which mould manhood in the common struggle for life.

We quote again, and lastly, from Prof. Dana's work: "A coral-island, even in its best condition, is but a miserable place for human development, physical, mental, and moral. There is poetry in every feature, but the natives find this a poor substitute for the bread-fruit and yams of more favored lands. How many of the various arts of civilized life could exist in a land where shells are the only cutting instruments—fresh water barely enough for household purposes—no streams, nor mountains, nor hills? How much of the poetry and literature of Europe would be intelligible to persons whose ideas had expanded only to the limits of a coral-island, who had never conceived of a surface of land above half a mile in breadth—of a slope higher than a beach, or of change in seasons beyond a variation in the prevalence of rain?"

Such are coral-islands—beautiful gems of the ocean; delightful as a subject of study, equally in their aspects and development, their geological importance and in their relations to life.

THE PHYSIOLOGY OF EMOTION.

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THE object of this paper is, to examine the physical accompaniments of mental action, and, chiefly, to discuss the nature of the feelings or emotions which accompany the various conditions of body and mind; in fact, to lay down the theory that feeling (or emotion, which is another name for high and complex feeling) is the state which accompanies the excitation of a nerve centre or centres, being pleasant or painful according to the condition of the centre, or the intensity of the excitation.

Supposing this view to be correct, there is no need to allot one place in the brain to the intellectual and another to the emotional portion of the mind, neither can we discuss them apart. The intellectual or idea function, the thinking and working function of the mind, may be supposed to depend on the intercommunication of the nerve cells or centres of the entire hemispheres, carried on by means of the nerve-fibres, this interaction being accompanied by a feeling or emotion peculiar to the centres acting, but which varies according to their physical state at the moment of excitation, or that produced by the excitation itself.

That the cells, which in their aggregation make up what we call nerve-centres, vary immensely in their endowments and qualities, is a fact which probably few will dispute. We have centres of vision, centres of hearing, centres of taste and smell: the nerve-cells which form the intellectual centres of one who comes of a long line of educated and cultivated forefathers will differ from those of a descendant of Bushmen, even before they have been submitted to the influence of education. But, besides the special quality or endowment which each cell possesses, that quality which constitutes one a cell and centre of vision, as distinguished from another which is a centre of hearing, there is in each a varying state or condition on which depends its efficiency, its power of perceiving more or less accurately that which is presented to it, or of communicating with other centres of idea or motion. This condition will be influenced by a number of circumstances—by due nutrition, by heat or cold, rest or fatigue; but, according to it will be the efficiency or non-efficiency of the cell-function: by it, moreover, will be regulated, as I conceive, the pleasure or pain experienced when the cells are called into action. When the condition is sound and healthy, the function of the cells will be duly performed, and, in the due performance, pleasure, not pain, will be experienced. In other words, the supply of nerve-force being ample, the cells will energize pleasantly: when the nerve-force is insufficiently produced, or by action is exhausted, the energizing will be attended with proportionate pain.

It may be a question whether "nerve-force" is the best term to apply to the condition I have spoken of. It is one which opens up the many controversies which exist, and have existed, as to the nature of force, the relations of the various physical forces, and of these to the forces which we see at work in living animals. While, on the one hand, some shrink away from the very name of force, and will none of it, as a metaphysical entity to be relegated to the schoolmen along with that other metaphysical entity, the "mind" itself, on the other, it is to be feared that men have imagined that the study of mental phenomena has, at length, attained to the rank of the exact sciences, because they have placed nerve-force in the same category and correlated group as light, heat, gravity, and electricity. "Animal combustion," says Mr. Bain, "maintains nervous power, or a certain flow of the influence circulating through the nerves, which circulation of influence, besides reacting on the other animal processes, muscular, glandular, etc., has, for its distinguishing concomitant, the mind. The extension of the correlation of force to mind, if at all competent, must be made through the nerve-force, a genuine member of the correlated group." It may be interesting to see in what way another distinguished philosopher connects the forces of purely physical phenomena with those of life and animal movement. In his work on Heat (p. 499), Prof. Tyndall writes: "The grand point, permanent throughout all these considerations, is that *nothing is created.* We can make no movement which is not accounted for by the contemporaneous extinction of some other movement. And, how complicated soever the motions of animals may be, whatever may be the change which the molecules of our food undergo within our bodies, the whole energy of animal life consists in the falling of the atoms of carbon and hydrogen and nitrogen from the high level which they occupy in the food to the low level which they occupy when they quit the body. But what has enabled the carbon and the hydrogen to fall? What first raised them to the level which rendered the fall possible? We have already learned that it is the sun. It is at his cost that animal heat is produced and animal motion accomplished."

When I speak of there being in each nerve cell or centre a condition, varying within certain limits, according to which it is capable of energizing more or less readily and pleasantly, I am far from intending to convey a notion of any metaphysical entity, even if I use the term "nerve-force." It is not possible to separate this force in kind from that which is the special property of the cell. Each cell, as it lives its life in our bodily organization, as it grows to maturity, and fades in its decay, separates and selects from the blood, by a molecular metamorphosis, that which it requires for its function as an idea-cell, a hearing, or a sight cell, but it separates it in varying quantity and quality, and, having separated it, parts with it again, according to the demands made upon it. So this force, specialized by the various portions of the human brain, exists in every cell and centre, in greater or less degree, and upon the condition of its existence depends, it would seem, the pleasure or pain experienced when the part is called upon to act.

A cell, when it sets in action other cells, or other organs of the body, appears to deprive itself of this force, and in time to become exhausted, so that rest and repose are necessary for its renewal. If it be too metaphysical to talk of the conversion of bodily heat into force, and of force into muscular motion, it is, nevertheless, a fact of observation that a nerve-centre becomes exhausted by over-excitation and over-action, and, being exhausted, becomes incapable of energizing till its power or force is renewed by rest or food. In the following observations I shall try to illustrate the theory that a nerve-cell is called into action by stimulation applied to it from without, and that, according to its special quality, it will then energize and act upon other cells or structures. The *amount* of action, and the feeling attending it, depend on the condition in which it is at the time. And this condition will vary in proportion to its rest, nutrition, and heat, and also in proportion to the strength of the stimulation and the length of time during which it is carried on.

The first question is, By what method are we to gain any information upon these points? Absolute proof of what I have asserted is not to be expected; were it forthcoming, we should have learned it long ago. We shall have to apply the methods of observation and experiment, and, of these, observation will aid us most. We can observe the phenomena of Feeling in infants from the commencement of life, in children, in adults, in the aged. From mere sensations we can trace the dawn of what are called Emotions, or, to use an older terminology, Passions. We can observe them also in the lower animals, and in the varieties, so to speak, of man—in the savage, the insane, the idiot. And, in observing the feelings, we are compelled also to observe the outcome of them in the shape of bodily and facial motion, which is often the only evidence of their existence. Also, we shall observe the same individual under the various conditions of hunger and repletion, of sleep or want of sleep, of cold or heat, of health or disease. And we shall see how all the phenomena, which our inductive observation can collect, agree or disagree with the laws laid down by those who have by experiment investigated the physiology of the nervous system. From one method—dissection of the actual brain—we shall not learn much. When the action is over and the force departed, the actual structure teaches us little about the working. The greatest discoveries have been made by experimenting on living animals.

If we observe the life of an infant, we find it spent chiefly in sleeping, its short waking-time being principally occupied in feeding, in accumulating the material for its structural and functional growth. Its acts consist of sucking, crying, and kicking, and of using to some extent its eyes and ears. It does not at first see any thing as an object; it merely undergoes the subjective sensation of light; its retina and sensory ganglia are stimulated by light; and, if the light be too bright and the stimulation too strong, it testifies the pain experienced, by contracting the eyelids and crying. On the other hand, it is pleased by being brought before a lighted candle or other gently-stimulating light. The acts very soon indicate pleasure or the reverse, and we know whether the child is pleased or not long before it can tell us. It is pained by cold or hunger or bodily suffering, by a too vivid light, by a loud or harsh sound, as it shows by crying, by movement of its body and facial muscles. Its pleasure is denoted by laughing, kicking, and corresponding movement and expression of face. It derives pleasure also from excitation of its centres of motion, from being tossed, dandled, and rocked, while rough and violent movements cause no less pain and discomfort. We see, then, in such a child, manifestations of a very considerable amount of feeling—feeling which is at this stage entirely bodily, or at the most sensory, arising from the exercise of the senses.

A little later, and we find that the child can discriminate between the voice and face of its mother or nurse and those of a stranger, deriving pleasure from the one and pain from the other, and evincing memory. It remembers what it sees and hears, and what it experiences; and as the original events were pleasant or painful, so are the recollections of them, as we learn from the manifestations it exhibits. We know nothing of a child's inner life except from these manifestations, for it tells us nothing. All we learn is from its *facta*, its acts; it does not yet talk, and, when it commences, its talk is only of concrete objects. It has no abstract terms or generalizations in its vocabulary.

If we trace the development of this child, we see how its pleasures and pains, which at first are entirely corporeal, merge by barely perceptible degrees into mental feelings, and how these expand from mere feelings into the emotions of adult life. Its feeling is being perpetually evoked by every thing that it sees and hears. By turns it displays anger, fear, pain, or delight, and the feeling called up by one object is only to be allayed by the substitution of another, which, stimulating another centre, will by such stimulation rouse another feeling. If we look at a boy of three years, healthy and strong, whose sleep and appetite are good, and whose nerve-centres are full of force, we see that his whole waking-time is employed in the keen enjoyment of spending his nerve-force in incessant motion and play. There is no work in him: his life is all active amusement, emotive movement. He exhibits rage, terror, jealousy, wonder, vanity, love, the desire for action; and these emotions are fully developed and unmistakably exhibited. Here, then, we have the emotional part of our nature apparently full-grown, while the intellectual is yet in its early infancy. We know that it is in vain to reason with such a child: we control and manage him. These feelings are all expansions of the self-feeling which is plainly seen to be the feeling of the entire bodily organization. The child at first derives pleasure or pain from that which affects its bodily sensations, from the light or the color which pleases its sense of sight, from the song which gratifies its ear, from the warmth which is grateful to its skin, from the food which satisfies its stomach; and it extends its likings to those persons or things which minister to its comfort, its dislike to such as cause it discomfort, and so it displays its love, its hate and fear. These feelings are all reflected upon and through the medium of the body in facial and other movements. As the nerve-centres in which this self-feeling resides are roused and excited, so, according to the centre stimulated and according to the degree of stimulation, we have a corresponding series of movements as the result. There is a direct outcome of action, a direct conversion of force into motion, so to speak; without this we should not know that such stimulation had taken place.

How motion immediately follows the application of a stimulus to the centres is especially shown at this time of life. There is no deliberation, no delay; the action, the demonstration of joy, or sorrow, or resentment, or approval, is instantaneous. The motor centres respond to the stimulus as immediately as the pupil responds to the light, and the reflex action of the one is as purely physicial as that of the other. A child at this age possesses ideas formed from the memories of sensations and their associations, but its ideas are few, and it does not link them into chains of reasoning. Its intellectual processes are scanty, and so it comes to pass that the excitants of its nerve-centres are for the most part external events and sights, which at once result in bodily or facial demonstration rather than in internal mental action.

If mankind had stopped at the level of a child, if the higher and more complex emotions did not exist, it is not likely that various seats of emotion would have been mapped out in the brain. Emotion in children and animals is manifestly so much more a bodily excitation, the bodily movement follows so immediately as the result, that we do not confine it to a mental phenomenon as we do the higher emotions of man. But physiologically there seems to be no line of demarcation between simple feelings and the highest emotions. Before we examine the adult as we see him in the educated and refined inhabitant of the cities of Europe, we may pause and consider the various intermediate stages which carry on the succession from the child upward. There is the savage of all grades of savagery, from the Earthman to the stoical brave of North America who scorns to exhibit emotion of any kind. Many travellers have told us how like the tribes of Africa are to children, how they display emotion in a similar manner, how they instantaneously respond to a stimulus, whether it call forth joy, anger, or grief. Then there is the uneducated and unenlightened pauper of many an agricultural district of our own land, and there is the idiot, and the insane, whose self-feeling is predominant, whose whole life is centred in self, as much as is the child's. If after these we consider adult and educated man, we shall see that his sensations, feelings, and emotions, each mental state, in fact, which is called up in his brain, may be, and for the most part are, attended with muscular movement voluntary or involuntary, indicating the pleasure or pain which accompanies the mental stimulation. The amount of movement will often be the measure of the amount of force extricated and emitted from the centre on the application of a stimulus.

The first thing we notice is that most of the emotions of man are the same in kind as those of children, or even the inferior animals, the same in kind, though varying in complexity and specialty, according to the infinite variety of the acquirements of the human brain. The emotion of admiration, awe, and wonder, which fills our breast on seeing some marvellous spectacle or hearing some great news, what is it but the wonder which we see depicted in the animal when it sees for the first time something entirely novel and strange? I once saw a leveret meet face to face a young dog in a covert. Probably neither had previously encountered such an object. They stood for a moment transfixed with surprise; this, changing in the hare to fear, caused it to turn and fly; the dog, not quite so timorous, pursued, his wonder being converted, by the leveret's flight, into the emotion of pursuit. The animal's emotions we recognize by its motions; we could not otherwise assert that it experienced emotions at all. Its brain, when stimulated, at once converts its force into motion. And, if we strictly analyze the feelings and emotions of man, we shall find that here also action or motion of some kind is almost invariably the concomitant of emotion —at any rate, when this is at all intense, or, as we rightly say, *powerful.* With regard to many of our feelings and emotions, this is at once apparent. If some sudden disaster occurs to a man, his countenance, probably his limbs, will denote his terror, grief, or anger. He is said to be devoid of feeling, if this be not the case. His mode of speech, his tone of voice, is affected by it, and he may be led into immediate and violent action, so involuntary that it may almost be called automatic. On the other hand, pleasant sights and news will produce corresponding traits in countenance and movements of limbs. The latter will be less marked than those set in motion by pain or grief, inasmuch as a pleasant stimulus will set up less violent action than one that is painful.

When we look at the simple emotions and feelings of man, we find him exactly on a par with the child or the animal. A violent stimulus produces at once violent, or at any rate manifest, action, facial or other. There is a conversion of nerve-force into muscular movement, directly following a stimulus, whether this be one exciting bodily pain, as a blow, or mental, as a shocking sight or piece of news But, when we examine the mind of man in its highest development we find in the highly-intellectual individual certain emotions, which are clearly the feelings corresponding to the very complex ideas acquired and organized by years of culture and training. We read of the Ethical Emotion, or moral sense; of the Æsthetic Emotion; of other emotions arising out of the Intellect. But all these appear to illustrate and to be illustrated by what I have said concerning the simple emotions. Here, instead of a single and simple idea-centre which, when excited, at once responds in outward bodily movement, we have an extremely complex chain of ideas. The training and preparation of years, as well as previous organization, are required to bring about in the brain that complex series of ideas which represents a knowledge of the fine arts, and which is presupposed when we speak of experiencing æsthetic emotion. Instead of a single and lowly-endowed centre, such as we may find in children or animals, we have a coördinated and complex chain of high centres, which, when excited, respond not in immediate bodily movement accompanied by bodily feeling, but in deliberate action, the result of reflection; in intellectual, rather than bodily movement. For the activity of thought must be due to a stimulus applied to the intellectual centres, no less than the activity of body: and not only the activity of thought, but action in thought, the desire for action of body which would become action, did not some other reflection intervene, must also be set down as an outcome of nerve-force emitted by some centre or centres, which have been set in motion by a stimulus. Repressed action, whether in thought alone, or in the clinched hands and quivering lips of suppressed passion, must be taken as an emission of force. The complex coördination of ideas arrived at after years of study and experience, which causes the connoisseur the keen delight experienced when he gazes at a rare Rembrandt etching or a matchless coin, must include within itself the feelings belonging to it. The uninitiated cannot feel the delight, because he possesses not the ideas. We cannot suppose that the feeling resides in one part of the brain, and the ideas in another; rather would it appear that the stimulation of the ideas by the sight of the object causes the feeling. The ideas exist in the brain as knowledge, but when called into action we have the feeling of pleasure or pain which is special and appropriate to such a group of ideas, in addition to the knowledge and the ideas themselves. It may be said that emotions are so varied that they must require a special organization; that the emotion of delight just named is something totally different from such a feeling as self-denial. But we must remember that ideas are formed in the educated mind into large and complex groups—associated ideas, as they are called—and that these act as units, just as groups of muscles always act together; and the association of the one, when established, cannot be disjoined, any more than that of the other. Consequently, stimulation of such a group of ideas calls it into action, and then arises its special feeling, depending in degree upon the amount of the stimulation and the nerve-force extricated in the process. And these very complex emotions may be reduced by analysis to much simpler feelings—to feelings of self-advantage or self-detriment, the pleasure or pain which is at the bottom of all feeling, of all stimulation of the nervous system strong enough to cause feeling to come into consciousness. Looking upon the whole conscious brain as self, its feeling varies from self-good to self-ill; its various and special portions, groups of nerve-cells and nerve-centres, being stimulated into special feelings which are yet all of them resolvable into the simple elements. If we look at the phenomena of insanity we shall see this illustrated by the fact that the feelings and delusions of the insane always have reference to self.

I have traced the higher emotions up from the mere bodily feelings, nay, even from the sensations of the special senses, and have affirmed that they all vary according to the amount of stimulation which each centre receives, while their quality depends on the special properties of the centre or centres. The phenomena of two of the senses, at any rate, confirm this view. One person hears a sound which another cannot. This is because the centre of hearing in the deaf person is not sufficiently stimulated by a sound, the vibrations of which are too slow for him, though not too slow for the other to perceive. Similarly, some people cannot recognize redness as a color. On analyzing the color red, we find it to be the color at one end of the spectrum, an inch of which gives the smallest number of waves of light, and to this amount of stimulation some eyes are insensible, just as the eyes of all men are insensible to the rays beyond red, which we discover by the galvanometer, though they do not excite our optic centres as light. As no two persons feel alike, so no two see or hear alike. The centres of sight and hearing of one man are stimulated by vibrations which fail to excite those of another. There may be colors and there may be harmonies all around us in the universe, of which we know nothing, but of which the more sensitive organs of what are called the lower animals may be keenly conscious. It may be that these animals are only by us called dumb because we ourselves are deaf.

The stimuli, then, which excite the nerve-centres of man, produce various feelings and emotions according to the quality and properties of the centre excited. But, as I have said, the feeling will vary according not only to the quality of the centre, but also according to the condition it may happen to be in at the time, or that to which it may be brought by the stimulation it experiences. To elucidate this, we must consider what we know of the physiology of nerve-structures and their functions.

When studying the physiology of nerve-action as we see it in animals, children, and men, and the pathology as we see it in various nervous disorders, as acute insanity, *delirium tremens*, and the like, we soon become aware of the fact that the well-being of the entire nervous system depends mainly on its renovation during a state of repose; and that for the higher portion of the brain, at any rate, this state of repose and rest is synonymous with healthy sleep. Round the phenomena of sleep, and its causes and conditions, are grouped many of the problems which have to be solved by the physiologist who has to investigate the action of the nerve-centres, and the physician who has to cure their disorders. The state or condition of a nerve-centre, which I have called the force, will be dependent upon the amount of rest and sleep which it enjoys, supplemented by two other restorers of force, food and warmth; which must also be taken into consideration.

Observation teaches us that all animals sleep after a certain period of bodily fatigue, which varies according to the individual, the young requiring sleep more quickly than the old, and a larger amount. If the fatigue be great, nothing can keep a child or even a man awake. When refreshed by sleep, when the force is again accumulated in the brain, we wake spontaneously, or are awakened by trifling stimuli, as sounds or light. This alternation of sleep and waking is the normal state of health, and absence of sleep is something abnormal: it is a disorder, and must lead to further disorder if prolonged. Sleep is not necessary for the renewal of force in every centre. In very severe muscular exercise mere cessation for a time recruits our force, and enables us to begin again; but for the higher work of the brain sleep is indispensable, and all brain-work, and indeed life itself, must cease, unless by this the force is renewed.

So much does observation teach us of the reparation of the force of the brain during sleep. Experiment, however, enables us to state the physiological condition of the brain in sleep, and so to analyze further the production and expenditure of this nerve-force. In sleep, as we have seen, it is produced and accumulated; in active waking hours it is expended. In sleep, the arterial circulation of the brain falls to a certain point, and metamorphosis consequently is reduced to a minimum. When the brain is acting, even in dreams, the blood-flow increases both in arteries and veins. To promote sleep, we seek to diminish this arterial current; until this is done, sleep comes not. The two things which chiefly produce sleep in a healthy man or animal are fatigue and food. After a hearty meal, or after great fatigue endured for many waking hours, it will be difficult to rouse him from sleep, and when roused he will be torpid and inactive, and will fall back into sleep easily. His brain will be emptied of blood, and ordinary stimuli, as light, sound, and movement of others, will not bring back the blood to his brain: moreover, his blood will contain less oxygen. When sufficient hours have been passed in sleep, slight stimuli are enough to wake him, such as a trifling noise or a light; nay, he may wake or seem to wake "of his own accord." The blood returns to the brain highly oxygenized, and the brain is alive and energetic, ready to expend in action the force it has accumulated in the period of its rest.

Now, be it observed, this force is accumulated by the brain in sleep, when the blood-supply is at its minimum and contains the least oxygen. Oxidation of brain, then, implies expenditure, not accumulation of force. Stimulation of brain increases the blood-flow and activity, *ubi stimulus ibi fluxus.* But this activity cannot go on long, and material for new work cannot be provided, unless the blood-flow be reduced to the sleeping-point, and the oxygen in the blood cease to be consumed.

In the creation and restoration of nerve-force, food and heat are to sleep both the supplement and the complement; without all these the full energy of brain-life cannot manifest itself, except for a very limited time, and each will vary in amount according as the other two are supplied in greater or less quantities. To resist the cold of a northern climate, the Esquimaux consumes at a meal that which would feed a Hindoo for a month. If he did not, the bitter winter would bring to him, no less than to the animals hybernating around him, sleep from which he would not wake again. The intense desire for sleep felt by persons exposed to great cold is closely akin to that produced by overwhelming fatigue: the whole nerve-force is consumed in either case and cannot be replaced. In those suffering from cold, the loss may be met by warmth or by food; in those worn out by fatigue, sleep alone is the restorer. How completely the brain is upset by cold we may learn from the striking narrative of the Arctic voyager Dr. Kane,[1] who tells us, after a journey of eighty or ninety miles over the ice at a mean temperature of minus 41°.2: "We were quite delirious and had ceased to entertain a sane apprehension of the circumstances about us." "Our strength failed us, and we began to lose our self-control. . . We fell half-sleeping on the snow. I could not prevent it. Strange to say, it refreshed us. I ventured upon the experiment myself, making Riley wake me at the end of three minutes; and I felt so much benefited by it that I timed the men in the same way. They sat on the runners of the sledge, fell asleep instantly, and were forced to wakefulness when their three minutes were out."

The fact, that pleasure and pain depend on fatigue and the consumption of this nerve-force, is closely connected with two other phenomena: one, that the stimulation of any nerve-centre, if repeated, loses somewhat of its effect; the other, that the same stimulus, if prolonged or intensified, may cause every variety of feeling from

[1] "Arctic Explorations," i., 198.

pleasure to extreme pain. The first phenomenon is expressed in the language of every-day life, when we say there is nothing that we may not "get used to." We get used to sights, to sounds, to tastes, to smells, to the endurance of bodily pain. It may be stated as an almost constant fact that the same thing repeated, the centre again stimulated with the same stimulus, always loses somewhat of its effect, and consequently less force is expended. We endure the excitation better and feel less fatigued, whatever it be. If by any chance, however, through illness or other cause, our stock of force becomes lessened, we find that we cannot so well endure our habitual stimuli, and they become painful instead of pleasant. Our feelings, then, are regulated partly by the amount of stimulation, partly by the condition in which our centres are when stimulated; and that which applies to pain applies also to pleasure. Pleasurable excitations when repeated lose their charm, or they fail to please us when a disordered liver or a headache makes us dismal.

The second phenomenon is different. Although an excitation repeated loses its effect, yet an excitation prolonged without cessation passes from pleasure to pain without this process ever being reversed.

There is no voluntary action, whether mental or bodily, which does not in time cause fatigue; but it will be found that actions accompanied with direct emotion fatigue the soonest. Almost all bodily or mental processes are accompanied by some amount of feeling or emotion. They are pleasant to us or distasteful; we may be wearied of doing them, or wearied by doing them, according as the mind or the body is fatigued. In either case the process is the same, though the centre which experiences the discomfort is different. The pleasantest occupations or amusements may cause such sheer bodily fatigue that we can do them no longer, and to attempt it causes pain. It would appear that every thing carried to this point—to the extent of exhausting the nerve-force of the centre stimulated—causes discomfort or pain, which is only to be removed by cessation of the particular stimulus, and the substitution of another, stimulating other centres, or by the rest of the whole nervous system. This brings me to the consideration of another point, namely, that violent stimulation of a centre exhausts the nerve-force, not of that centre only, but of the whole nervous system. A terrible shock may so use up the nerve-force that the individual falls senseless, or, short of this, he may yet be so paralyzed with fear or grief that he loses all muscular power, or he may be so violently moved that the great exertions which he makes only last for a short time. We all know that for a long-sustained muscular effort the mind must be tranquil, and free from emotion, and the muscular movements must be regular and even, and free from spasmodic and violent action. How it is that the nerve-force of the whole system is poured out in this or that form of emotion, or idea, we see, but cannot trace the process.

Nevertheless, it is a fact that two great displays of force cannot co-exist; violent muscular exertion and intense thought cannot go on together; the thinker sits, or stands, abstracted, motionless. The man who is rowing or running a race cannot command his thoughts; ideas come and go through his mind, but he cannot keep up a continuous current of mental work. His force is being expended on bodily movement.

What is the answer to those who say they believe that emotions reside in this or that part of the brain? We may object, first, that every attempt to locate emotions has signally failed, from the days of Gall, Spurzheim, and Combe, to those of Schroder van der Kolk. Some have separated the seat of emotion from the seat of the consciousness thereof, and have placed the latter in the sensory ganglia. Others have placed emotions in the hemispheres alone, and so would deny every thing of the kind to those beings which have no cerebral hemispheres; yet we see considerable emotional feeling manifested by such creatures as the ant and the bee.

Secondly, by an analysis of emotions we may perceive that there is no real line of demarcation between them and mere feelings of a much lower order, and that one and the other belong to the *action* of the moment, and not to any past or future time. If we are watching, say, a splendid sunset, we experience a feeling of intense delight as the heavens are lit in gorgeous color. The following day we may recall the scene, but we do not feel the pleasure. We remember the pleasure, but it remains, like the scene, only as an idea, it is not now a feeling. Now, few, I presume, would assert that the perception of this sight resides in one part of the brain, and the feeling attending it in another. If this were so, we ought to be able to excite the feeling by means of the idea preserved in the memory; but this we cannot do. The original stimulation causes the pleasure, and this vanishes, never again to return. It is only in complexity that the highest emotions differ from this simple feeling; they involve more ideas, more acquisitions, previously laid up, but the effect of the immediate stimulation is the same; this it is which, according to its intensity, causes the pleasure or pain. The same may be said of pain experienced; we may recall the memory of it, but this is not the same thing; even the memory may be distressing and saddening, but this is different from the acute pang which we suffer at the first shock.

The brain is a sealed book far more than some of the other organs of the body, as the lungs and heart; but, if we could inspect it at work, it is not probable that we should be able to note those molecular changes, which, nevertheless, we believe to take place when mental action is going on. What we should see, however, would be alterations in the circulation of the blood. We should see that the whole circulation, or portions of it, would be affected by mental excitation, by the stimulation of the various cells or groups of cells, which we call nerve-centres. We should see that a piece of news, a disaster, an impending trouble or difficulty, causes a man to lay awake at night, and we should know that he lies awake because his brain circulation, either through the whole or in parts of his cerebral hemispheres, is higher than admits of sleep. There is an extrication of force going on in the shape of thought, there is a flow of blood going to the excited part. We cannot see all this, however, but we can and do see how emotion causes the face to flush and the pulse to quicken, how those who lie awake suffer from heat of head and suffusion of eyes, how emotion increases the lachrymal secretion, the lacteal, and others. And when we say that emotion does these things, we merely mean that something or other has stimulated the brain into producing these phenomena, and that along with the stimulus the feeling of grief or shame or anger coexists.

If all this be true, it may perchance throw some light upon many of the phenomena of disordered mind and brain: it may help us to understand why, with almost the same delusion, e. g., that the newspapers are writing about him, one man will be exultant, another angry, another depressed; it may explain why the same man is at one time maniacal, at another melancholic. Lack of force may account for the wretched feeling of the hypochondriac and the hysterical, for the mental pain which many feel when they are below par: and a proneness to part with force, to convert it into action, may be the condition of the centres of those who are excitable and impulsive, a condition analogous to that brought about in certain centres by such drugs as strychnia, by such diseases as epilepsy and convulsions, or evidenced by such an affection as stammering.—*Fortnightly Review.*

A GIANT PLANET.

By RICHARD A. PROCTOR, F. R. A. S.

WE propose to give a brief sketch of what is known respecting the noble planet Jupiter. He is the giant of the solar system, himself the primary of a scheme of orbs whose movements resemble in regularity the motions of the planets round the sun. Much has been discovered during the last few years—nay, even during the last few months—to render such a sketch interesting.

We must, in the first place, dispossess ourselves of the notion, not uncommonly entertained, that Jupiter is one of a family of orbs, nearly equal in dignity and importance, and comprising the Earth and Venus, Mars and Mercury, among its members. This idea still prevails, because in our books on astronomy we commonly see a set of concentric circles at regularly-increasing distances, assigned as the paths of the several planets of the solar system. And besides, there yet remains, in the modern teaching of astronomy, a perceptible trace of the ancient astronomical systems, in which Saturn and Jupiter, Mars, Venus, and Mercury, played parts of equal importance.

Let it be carefully remembered, then, that the four planets which circle nearest the sun—the family of which our earth is a member—differ in all their characteristics from the outer family (also consisting of four planets) to which Jupiter belongs. The whole of the inner family—the whole of the space within which its members travel—could be placed between the paths of Jupiter and his next neighbor Saturn, with a clear space many millions of miles wide on either side. The actual area between the paths of Jupiter and Saturn exceeds nearly thirty times the whole area within which the four lesser planets pursue their paths. And, when we consider the dimensions of the four inner planets, we find a like disproportion. Four circles representing these orbs can be enclosed within a circle representing Uranus, the smallest of the four outer planets; yet even this circumstance does not adequately represent the enormous disparity between the two families of planets; for, in fact, the volume of Uranus exceeds the combined volume of all the inner planets upward of thirty times. We might adduce many other illustrations of the complete dissimilarity between the inner and outer families of planets; but what has been already stated will suffice for our present purpose. It will be evident that, in considering the members of one or other family, we must be prepared to meet with relations which differ not merely in degree, but in kind. We may thus, at the outset, dismiss from our thoughts the idea that the planet Jupiter is necessarily to be regarded as an inhabited world merely because the only planet we are actually acquainted with is inhabited. The latter circumstance may be an excellent reason for regarding Mars or Venus as the abode of life; but the analogy can no more be extended to Jupiter than to the fixed stars, which certainly are not inhabited worlds. We must, in fact, consider the physical habitudes of Jupiter independently of all conceptions based upon terrestrial analogies. Studied thus, he will be found, as we conceive, to hold a position in the scheme of creation differing considerably from that which has been assigned to him, until of late, in treatises on astronomy.

It is necessary briefly to state the dimensions, mass, and general characteristics of the planet, before proceeding to discuss its probable physical condition.

Jupiter has a diameter exceeding the earth's rather more than ten times, and a volume exceeding hers 1,230 times. It is not far from the truth to say that Jupiter's dimensions exceed the earth's in very nearly the same degree that those of the sun exceed Jupiter's. But his mass, though gigantic compared with the earth's, does not altogether correspond to his bulk, for it exceeds the mass of the earth only three hundred times. So that, if the disk our astronomers see and measure actually represents the true globe of the planet, his substance must be, on the average, much less dense than that of the earth. In fact, while the earth's density is nearly six times as great as that of water, the density of Jupiter (*thus judged*) would exceed that of water by barely one-third. This vast globe rotates, in less than ten hours, on an axis nearly upright or square to the level in which the planet travels. This rapidity of rotation—so great that points on the planet's equator travel twenty-seven times as fast as points on the terrestrial equator—results in a considerable flattening of the planet's globe; insomuch that the polar diameter is less than the equatorial by about a twelfth part, or by fully 7,000 miles. And it may be remarked in passing, that this circumstance—the fact, namely, that the poles of the planet are drawn in, as it were, 3,500 miles as compared with the equatorial regions, or 1,750 miles as compared with the mid-latitudes in either hemisphere—affords a striking illustration of the enormous amount of energy really represented by the rotation of Jupiter. It may also be added that the velocity with which points on Jupiter's equatorial zone are carried round, exceeds the corresponding velocity in the case of all the planets in the solar system, and is nearly six times greater than the equatorial velocity of the sun himself. It amounts, in fact, to about 7½ miles per second.

We do not propose to consider here at any length the system of satellites over which Jupiter bears sway; but this preliminary sketch would be incomplete without a few words on the subject. It is worthy of notice that, although our earth in some sort resembles the outer planets in being accompanied by a satellite, yet the relation which our moon bears to the earth is altogether different from that which the satellites of the outer planets bear to their respective primaries. Our moon is by no means a minute body by comparison with the earth, and compared with Mars or Mercury she may be regarded as having very respectable dimensions. We may, indeed, look upon the moon as a fifth member of the inner family of planets—a member inferior to the rest, doubtless, but still not so far inferior to Mercury as Mercury is inferior to the earth. In the case of the outer planets, however, and especially in Jupiter's case, moons hold an utterly subordinate position. Taking the accepted measurements, we find the largest of Jupiter's moons less than the 16,000th part of its primary as respects bulk, while its mass or weight is less than the 11,000th part of Jupiter's.[1]

[1] It is not uncommonly stated in our text-books of astronomy, that the density of Jupiter's moons is far less than Jupiter's density; and Lardner goes so far as to say that "the density of the matter composing these satellites is much smaller than that of any other body of the system whose density is known." But this is a mistake. All the satellites, save one, are of greater density than Jupiter, and that one—the innermost—is denser than Saturn, Uranus, or Neptune.

So that these orbs may fairly be regarded as bearing the same relation to their primary that Jupiter himself bears to his primary—the sun. It will be seen presently that this consideration is an important one.

But the great interest of the study of Jupiter resides in the fact that, being the nearest of the outer family of planets, the aspect of his globe supplies the best available means of determining the condition of the giant orbs constituting that family.

The first feature which strikes us in the telescopic aspect of the planet is the presence of a series of belts, lying parallel to the planet's equator. Usually the equatorial regions are occupied by a broad, bright belt, of a creamy-white color, and bordered on the north and south by copper-colored belts. Beyond these, again, lie alternate bright and dark belts, the dark belts growing more and more bluish in hue as the pole is approached—while the poles themselves are usually of a somewhat decided blue color in telescopes adapted to display such features to advantage. There are commonly two or three dark belts on each hemisphere.

Now, before inquiring into the peculiarities presented by these belts, and into the remarkable changes which have been noted lately in their general aspect, it may be well for us to consider briefly what such belts seem to imply. That they are due to peculiarities in the planet's atmosphere is admitted on all hands. And it has been usual to compare them with the trade-wind zones and the great equatorial calm zone on our earth. The bright belts, according to this view, are regarded as zones where for the time clouds are prevalent, the dark belts being regions where the comparatively dark hues of the planet's surface are brought into view. And then it has been deemed sufficient to point out that the parallelism of the zones is due to the extreme rapidity of the planet's rotation.

But, setting aside the fact that the trade-wind zones and the great equatorial calm zone on our earth are, in reality, little better than meteorological myths, it must be regarded as a remarkable fact that, in the case of a planet so far away from the sun as Jupiter is, there should be a supply of clouds so abundant as to form belts discernible from the earth. Jupiter is rather more than five times farther from the sun than the earth is, and receives from him about one twenty-seventh part of the light and heat which falls upon the earth (equal surface for equal surface). Making every allowance for the possibility pointed out by Prof. Tyndall, that some quality in Jupiter's atmosphere may prevent the solar heat from escaping, and so cause the climate of the planet to be not very different from the earth's, yet the direct heat falling on the planet's oceans cannot be increased in this way—nay, it must be rather diminished. It chances, indeed, that the very quality by which the earth's atmosphere retains the solar heat is unquestionably possessed by Jupiter's atmosphere. When our air is full of aqueous vapor (invisible to the eye), the escape of heat is prevented, as Tyndall has shown, and thus the nights are warmer than where the air is dry. Now, in Jupiter's atmosphere there is much water, for observers, armed with that wonderful instrument, the spectroscope, have recognized the very same dark bands upon the spectrum of the planet which appear in the solar spectrum when the sun is low down, and therefore shining through the lower and denser atmospheric strata. The spectroscopist knows that these bands are due to the aqueous vapor in the air, because Janssen saw the very same bands when he examined the spectrum of a powerful light shining through tubes filled with steam. So that there is the vapor of water—and that, too, in enormous quantities—in the atmosphere of Jupiter. But though we thus recognize the very quality necessary for an atmosphere which is to retain the solar heat, our difficulty is not a whit lessened; for it is as difficult to understand how the invisible aqueous vapor finds its way thus into the planet's atmosphere, as to understand how the great cloud-masses are formed.

Aqueous vapor in the atmosphere, whether its presence is rendered sensible to the sight or not, implies the action of heat. Other things being equal, the greater the heat the greater the quantity of watery vapor in the air. In the summer, for instance—though many imagine the contrary—there is much more of such vapor in the air than there is in winter, the greater heat of the air enabling it to keep a greater quantity of the vapor in the invisible form. In winter, clouds are more common, and the air seems moister; yet, in reality, the quantity of aqueous vapor is reduced. Now, it cannot but be regarded as a remarkable circumstance that, though the sun supplies Jupiter with only one twenty-seventh part of the heat which we receive, there should yet be raised from the oceans of Jupiter such masses of clouds as to form veritable zones; and that, moreover, *above* these clouds there should be so large a quantity of invisible aqueous vapor that the spectroscopist can recognize the bands of this vapor in the planet's spectrum.

Even more perplexing is the circumstance that the cloud-masses should form themselves into zones. We cannot get rid of this difficulty by a mere reference to the planet's rapid rotation, unless we are prepared to show how this rotation is to act in forcing the cloud-masses to become true belts. The whole substance of Jupiter and his whole atmosphere must take part in his rotation, and to suppose that aqueous vapor raised from his oceans would be left behind in the upper air, like the steam from a railway-engine, is to make a mistake resembling that which caused Tycho Brahé to deny the rotation of the earth, because bodies projected into the air are not left behind by the rotating earth. Nor is it conceivable that belts which vary remarkably, from time to time, in position and extent, should be formed by sun-raised clouds in the Jovian atmosphere, if the planet's surface is divided into permanent lands and seas.

But we are thus led to consider a circumstance which, as it appears to us, disposes finally of the idea that in the cloud-rings of Jupiter we have to deal with phenomena resembling those presented by our own earth.

We are too apt, in studying the celestial objects, to forget that where all seems at nearly perfect rest, there may be processes of the utmost activity—nay, rather, of the utmost violence—taking place as it were under our very eyes, and yet not perceptible save to the eye of reason. Looking at Jupiter, under his ordinary aspect, even in the finest telescope, one would feel certain that a general calm prevailed over his mighty globe. The steadfast equatorial ring, and the straight and sharply-defined bands over either hemisphere, suggest certainly no idea of violent action. And when some feature in a belt is seen to change slowly in figure—or, rather, when at the end of a certain time it is found to have so changed, for no eye can follow such changes as they proceed—we are not prepared to recognize in the process the evidence of disturbances compared with which the fiercest hurricanes that have ever raged on earth are as mere summer zephyrs.

Indeed, the planet Jupiter has been selected even by astronomers of repute as an abode of pleasantness, a sort of paradise among the planet-worlds. There exists, we are told, in that distant world, a perennial spring—"a striking display of the beneficence of the Creator," says Admiral Smyth; "for the Jovian year contains twelve mundane years; and, if there were a proportionate length of winter, that cold season would be three of the earthly years in length and tend to the destruction of vegetable life."

Even those who have denied that Jupiter can be the abode of life, and have formed altogether unfavorable ideas of his condition, have pictured him nevertheless as the scene of continual calm, though the calm is, according to their view, the calm of gloom and desolation. They recognize in Jupiter an eternal winter rather than a perpetual spring. Whewell, for example, in that once famous work the "Plurality of Worlds," maintained that, if living creatures exist at all in Jupiter, they must be wretched gelatinous monsters, languidly floating about in icy seas. According to him, Jupiter is but a great globe of ice and water, with perhaps a cindery nucleus—a glacial planet, with no more vitality in it than an iceberg.

But when we begin to examine the records of observers, and to consider them with due reference to the vast proportions of the planet, we recognize the fact that, whatever may be Jupiter's unfitness to be the abode of life, it is not of an excess of stillness that his inhabitants (if he have any) can justly make complaint. Setting aside the enormous activity of which the mere existence of the belts affords evidence, and even regarding such phenomena as the formation or a disappearance of a new belt in two or three hours as merely indicative of heavy rainfalls or of the condensation of large masses of invisible aqueous vapor into clouds—there have been signs, on more occasions than one, of Jovian hurricanes blowing persistently for several weeks together at a rate compared with which the velocity of our fiercest tornadoes seems utterly insignificant. During the year 1860, a rift in one of the Jovian cloud-belts behaved in such a way as to demonstrate the startling fact that a hurricane was raging over an extent of Jovian territory equalling the whole surface of our earth, at a rate of fully 150 miles per hour. It is not too much to say that a hurricane of like velocity on our earth would destroy every building in the territory over which it raged, would uproot the mightiest forest-trees, and would cause in fact universal desolation. At sea no ship that man ever made could withstand the fury of such a storm for a single minute. And yet this tremendous Jovian hurricane continued to rage with unabated fury for at least six weeks, or for fully one hundred Jovian days.

But during the last two or three years a change of so remarkable a nature has passed over Jupiter as to imply the existence of forces even more energetic than those at work in producing atmospheric changes.

In the autumn of 1870, Mr. Browning (the eminent optician and observer) called the attention of astronomers to the fact that the great equatorial zone, usually, as we have said, of a creamy-white color, had assumed a decidedly orange-tint. At the same time it had become much less uniform in outline, and sundry peculiarities in its appearance could be recognized, which have been severally compared to port-holes, pipe-bowls, and stems, oval mouldings, and other objects of an uncelestial nature. Without entering into descriptions which could only be rendered intelligible by means of a series of elaborate illustrations, let it suffice to say that the bright edges of the belts bordering on this ruddy equatorial zone seemed to be frayed and torn like the edges of storm-clouds, and that the knots and projections thus formed often extended so far upon the great orange zone from both sides as almost to break it up into separate parts.

Now, without inquiring into the particular form of action to which these remarkable changes were due, we can see at once that they implied processes of extreme energy. For, every one of the projections and knots, the seeming frayed edges of narrow cloud-streaks, had, in reality, an extent exceeding the largest of our terrestrial countries. Yet their aspect, and indeed the whole aspect of the ruddy belt, whose extent far exceeded the whole surface of our earth, changed obviously from night to night.

Strangely enough, these interesting observations, though they were presently confirmed by several well-known students of the heavens, did not attract that full attention, from the senior astronomers of the day, which they appeared to merit. Several, indeed, of our leading astronomers were disposed to deny that any thing unusual was in progress, though none asserted definitely that they based this opinion on a careful reëxamination of the planet's face. But quite recently one of the most eminent of our modern observers—Mr. Lassell, lately president of the Royal Astronomical Society—(having been led to observe the planet by the fact that certain phenomena of interest in connection with the satellite-system are now in progress), found his attention attracted by the marvellous beauty of the colors presented by Jupiter's belts. After describing the appearances he had intended to observe in the first instance, he proceeds: "But this was not the phenomenon which struck me most in this rare and exquisite view of Jupiter. I must acknowledge that I have hitherto been inclined to think that there might be some exaggeration in the colored views I have lately seen of the planet; but this property of the disk, in the view I am describing, was so unmistakable that my skepticism is at last beginning to yield." Nor will this statement be thought to express more than the truth, when we add that, in the picture accompanying his paper, Mr. Lassell presented the equatorial zone as brown-orange, and three neighboring dark zones as purple; one of the intermediate light belts being pictured as of a light olive-green.

Let us compare these observations made in our brumous latitudes with those effected by Father Secchi with the fine equatorial of the Roman Observatory. "During the fine evenings of this month," he wrote last February, "Jupiter has presented a wonderful aspect. The equatorial band, of a very pronounced rose-color, was strewn with a large number of yellowish clouds. Above and below this band, there were many very fine zones, with others strongly marked and narrow, which resembled stretched threads. The blue and yellow colors formed a remarkable contrast with the red zone, a contrast doubtless increased by a little illusion. The surface of the planet is actually so different from that which I have formerly seen, that there is room for the study of the planet's meteorology."

It appears to us that, when these remarkable changes are considered in combination with the circumstance that on *a priori* grounds we should expect the sun to have very little influence on the condition of the planet's atmosphere, the idea cannot but be suggested that the chief source of all this energy resides in the planet itself. The idea may seem startling at a first view, but, when once entertained, many arguments will be found to present themselves in its favor.

For instance, it does not seem to have been noticed, heretofore, as a very remarkable circumstance, if the Jovian belts are sun-raised, that they pass round to the nocturnal half of Jupiter and reappear again, with the same general features as before, and this often for weeks at a stretch. Even that remarkable feature whose changes led to the conclusion that mighty hurricanes were in progress, yet changed continuously and regularly during the Jovian nights as well as during the Jovian days, for one hundred such days in succession. This is perfectly intelligible if the seat of disturbance is in the planet itself, but it is perfectly inexplicable (as it seems to us) if the sun occasions all these meteorological changes in Jupiter, as he occasions all the changes which take place in our earth's atmosphere. The alternation of day and night, which is one of the most potent of all the circumstances affecting the earth's meteorological condition, appears to have no effect whatever on the condition of Jupiter's atmosphere!

Now, as respects the alternation of summer and winter, we can form no satisfactory opinion in Jupiter's case, because he has no seasons worth mentioning. For instance, in latitudes on Jupiter corresponding to our own, the difference between extreme winter and extreme summer corresponds to the difference between the warmth on March 12th and March 28th, or between the warmth on September 15th and on September 30th. Yet we are not without evidence as to seasonal meteorological effects in the case of the sun's outer family of planets. Saturn, a belted planet like Jupiter, and in all other respects resembling him, so far as a telescopic study can be trusted, has seasons even more markedly contrasted than those on our own earth. We see now one pole now another bowed toward us, and his equatorial zone is curved now downward now upward, so as to form two half ovals (at these opposite seasons), which, taken together, would make an ellipse about half as broad as it is long. As no less than fourteen years and a half separate the Saturnian summer and winter, we might fairly expect that the sun's action would have time to exert itself. In particular, we might fairly expect the great equatorial zone to be displaced; for our terrestrial zone of calms or "doldrums" travels north and south of the equator as the sun shifts northward and southward of the celestial equator, accomplishing in this way a range of no less than three thousand miles. But the Saturnian equatorial zone is not displaced at all during the long Saturnian year. It remains always persistently equatorial! Nothing could be more easy than the detection of its change of place if it followed the sun; yet no observer has ever suspected the slightest degree of systematic change corresponding with the changes of the Saturnian seasons. Or, rather, it is absolutely certain that no such change takes place.

It appears, then, that night and day, and summer and winter, are alike without influence on the Jovian and Saturnian cloud-zones. Can it reasonably be questioned that, this being the case, we must look for the origin of the cloud-zones in these planets themselves, and not in the solar orb, whose action must needs be largely influenced by the alternation of night and day and of the seasons?

But further, we find that a circumstance which had seemed perplexing, when we compared the Jovian belts with terrestrial trade-wind zones, finds an explanation at once when we regard the belts as due to some form of action exerted by the planet itself. For, let us suppose that streams of vapor are poured upward to vast heights and with great velocity from the true surface of the planet. Then such streams, starting from the surface with the rational movement there prevailing, would be carried to regions where (owing to increase of distance from the centre) the movement due to the planet's rotation would be greater. They would thus be caught by the more swiftly-moving upper air and carried forward, the *modus operandi* being the reverse of that observed when an engine leaves a trail of condensed steam behind it; or, rather, it may be compared to what would take place if a steam-engine were moving in the same direction as the wind, but less swiftly, so that steam-clouds would be carried in front instead of behind.

Now, heat is the only form of force which could account for the formation of the enormous masses of cloud suspended in the atmosphere of Jupiter. And it seems difficult to conceive that the clouds could be maintained at a great height above the real surface of the planet, unless that surface were intensely hot—as hot perhaps as red-hot iron. If we supposed this to be the case, we should find at once an explanation of the ruddy aspect of the dark belts. Nor would the change of the great equatorial belt from white to red imply more than that, owing to some unknown cause, clouds had not formed during the last two years over the planet's equatorial zone, or, having formed, had been dispersed in some way. We need not even imagine a complete dispersion, since the best telescopes, and notably Mr. Buckingham's fine twenty-one-inch refractor, have shown always a multitude of minute cloud-like objects over the ruddy equatorial zone.

But the idea of a red-hot planet, or of a planet partially red-hot, will appear at first view too *bizarre* to be entertained even for a moment. We have been so accustomed to regard Jupiter and Saturn as other worlds, that the mind is disposed to reject the conception that they can be so intensely heated as to be utterly unfit to be the abode of living creatures.

This unwillingness to accept startling ideas is not to be altogether reprehended, since it prevents the mind from forming rash and baseless speculations. Yet we must not suffer this mental habitude, excellent though it may be in its proper place, to interfere with the admission of conclusions which seem based on trustworthy evidence. Let us, then, inquire whether the startling hypothesis to which we have been led by the study or observed facts may not be found to be in agreement with other facts not yet considered.

It will be obvious that, if the real globe of Jupiter is thus intensely heated, a portion of the planet's light must be inherent. Therefore we might expect that the planet would shine somewhat more brightly than a globe of equal size and similarly placed, shining merely by reflecting the sun's light. Now, two series of good observations have been made upon the luminosity of Jupiter. One was made by the late Prof. Bond, of America, the other by Dr. Zöllner, of Germany. According to the former, Jupiter shines more brightly than he would if he reflected the whole of the light falling upon him! According to the latter, and more trustworthy series, Jupiter does not indeed shine quite so brightly as Prof. Bond supposed; but the planet yet shines *three times* as brightly as a globe of equal size would shine, if similarly placed, but constituted like Mars, and *four times* as brightly as such a globe would shine if constituted like our moon. Jupiter shines, in fact, very nearly as brightly as though he were constituted like one of our terrestrial clouds!

This result is highly significant. If Jupiter showed no belts and shone with a pure white color, we could explain it at once by simply regarding Jupiter as wholly cloud-covered or snow-covered (for snow and cloud shine with nearly equal lustre when similarly illuminated). But the great dark belts which occupy so large a proportion of the planet's disk altogether negative this supposition. We seem compelled to believe that some considerable portion of the planet's lustre is inherent.

Let us, however, proceed carefully here. We have to inquire first how far Zöllner's results can be trusted; and, secondly, whether they are corroborated by any independent evidence. Now, Zöllner carefully estimated the weight of his observations—we may say he jealously estimated their weight, for it must be remembered that he was in no way interested in securing a greater or less result, while he was greatly interested in so stating the value of his results that those who might succeed him in the inquiry should not detect any serious error in his estimate. But his opinion of the probable degree of error in his observations was such as scarcely to affect to an appreciable extent the statements we have made above. Taking Zöllner's lowest estimate of Jupiter's brightness, that statement remains appreciably correct.

And next as to corroborative evidence.

It happens that we have a very delicate means of measuring the degree of Jupiter's luminosity, as compared with that of other orbs similarly placed. For his satellites pass across his face, and nothing can be easier than to observe whether they appear darker or brighter than his surface.

It was an observation such as this which Mr. Lassell had made on the night when he noticed the ruddiness of Jupiter's great medial belt. By a singular chance Father Secchi made a similar observation during *his* researches, and the reader will see, when we have quoted the narratives of both these observers, that the comparative darkness of all four satellites will have been established. "The fourth satellite," says Lassell, "has begun again for a season to cross the planet's disk, and I have looked out for opportunities of observing its passages, and was favored on the night of the 30th December last by witnessing a part of its passage under circumstances more than usually propitious. On its first entrance it was scarcely to be distinguished from the edge, not appearing at all as the others do, as a round bright spot. As it advanced, it grew gradually manifestly darker than the surface of the planet, and, by the time it had advanced a fourth of the way across, it had become a very dark if not a *black* spot—so dark, indeed, that, if I had looked at Jupiter without knowing any thing of the positions of his satellites, I should have said that a *shadow* (of a satellite) was passing. I remember having seen the like phenomenon many years ago; but my impression is that I had never seen the disk of the satellite so near to absolute blackness before. Of course, it is only by contrast that it can possibly so appear; and we have in this fact a striking proof of the exceeding brilliancy of the surface of the planet. In the same way, the solar spots, if not surrounded by the marvellous splendor of the sun's surface, would doubtless appear as brilliant objects."

Next let us hear Secchi's account. "On the evening of February 3d," he says, "I observed the transit of the third satellite and that of its shadow. The satellite seemed almost black when it was upon the middle of the planet's disk, and notably smaller than its shadow, which was visible at the same time; one would have estimated it at only one-half. In approaching the edge the satellite disappeared, and reappeared soon after, close by the edge, but as a bright point. This fact is not a new one for the other satellites, but for the third it is unique. This result shows also the great difference of luminosity at the centre and near the edge of the planet, a difference already confirmed by photography."

It is hardly necessary to point out how strikingly these facts illustrate and confirm Dr. Zöllner's observations. But they also supply fresh evidence of a very interesting nature.

Although a part of the difference dwelt on in Secchi's closing words may be ascribed to the oblique incidence of the light near the planet's edge, yet it does not appear to us that the whole difference can be thus explained. A difference so great that a satellite appears as a bright point close by the planet's edge, and almost black near the middle of the disk, suggests that the light near the edge is not reënforced by the inherent luminosity of our theory, that luminosity adding only to the brightness of the central parts of the disk. We would not insist too strongly on this inference, because the darkening due to oblique incidence is, under certain circumstances, very obvious to direct observation. But it seems to us that a portion of the difference should be referred to the inherent luminosity of the central parts of the disk. This being admitted, it would follow that the real solid globe of the planet is much smaller than the globe measured by astronomers; and that, therefore, instead of that amazingly small density which is so perplexing a feature of the planet's physical condition, Jupiter's globe may have a density equalling or exceeding that of the earth.

And, after all, let us remember that the theory that Jupiter is an intensely heated globe—a theory to which we have been led by the consideration of many observed facts, and which in its turn suggests very satisfactory explanations of other observed facts—would merely show that, as Jupiter and Saturn hold an intermediate position between the sun and the minor planets in respect to size, so those giant orbs hold a corresponding position in respect of inherent heat. Roughly speaking, the earth is 8,000 miles, the sun 840,000 miles, in diameter, and Jupiter, with his diameter of 82,000 miles, comes midway between these orbs. Now, the sun is a white heat, and the earth gives out only what is called obscure heat; and, if Jupiter's globe is at a red heat, he again comes midway between the sun and the earth.

We should be led by the theory here maintained to regard the major planets which travel outside the zone of asteroids as in a sense secondary suns. So viewed, they could not be regarded as orbs fit for the support of living creatures. Yet, as each of them is the centre of a scheme of dependent worlds, of dimensions large enough to supply room for many millions of living creatures, we should not merely find a *raison d'être* for the outer planets, but we should be far better able to explain their purpose in the scheme of creation than on any theory hitherto put forward respecting them. Jupiter as an abode of life is a source of wonder and perplexity, and his satellites seem scarcely to serve any useful purpose. He appears as a bleak and desolate dwelling-place, and they together supply him with scarcely a twentieth part of the light which we receive from our moon at full. But, regarding Jupiter as a miniature sun, not indeed possessing any large degree of inherent lustre, but emitting a considerable quantity of heat, we recognize in him the fitting ruler of a scheme of subordinate orbs, whose inhabitants would require the heat which he affords to eke out the small supply which they receive directly from the sun. The Saturnian system, again, is no longer mysterious when thus viewed. The strange problem presented by the rings, which naturally conceal the sun from immense regions of the planet for years together in the very heart of the winter of those regions, is satisfactorily solved when the Saturnian satellites are regarded as the abodes of life, and Saturn himself as the source of a considerable proportion of their heat-supply. We do not say that, in thus exhibiting the Jovian and Saturnian systems in a manner which accords with our ideas respecting the laws of life in the universe, we have given irrefragable testimony in favor of our theory. The theory must stand or fall according to the evidence in its favor or against it. But, so long as men believe that there is design in the scheme of the universe, they will be readier to accept conclusions which exhibit at once the major planets and their satellites as occupying an intelligible position in that scheme, than views which leave the satellites unaccounted for, and present the giant planets themselves as very questionable abodes for any known orders of living creatures.—*Cornhill Magazine.*

THE MIGRATIONS OF MEN.

By PROF. A. DE QUATREFAGES.

TRANSLATED BY ELIZA A. YOUMANS.

IS it, then, in our country, in France, in the vicinity of Abbeville, or of Aurignac, that man first appeared? Now, he is found everywhere: did he arise everywhere? or was his original abode at some particular point of the globe, and did he afterward disperse in all directions ? If this be so, where is the privileged spot which gave him birth? Such are the questions that arise after that of the antiquity of man.

There has been much discussion on these questions. It has been said, and some still say, that men have originated wherever we find them. But a more careful study, a more profound knowledge of the laws that regulate organic and living beings, leads to the opposite conclusion.

Observe that here we can no longer appeal to the sciences which hitherto have served as our guide. Anatomy and physiology teach us nothing concerning the place of man's origin, his first dispersion, or his original home. It is all the same with regard to physiology, whether man appeared at a single point, or whether he appeared at several points at the same time. To study these questions we must interrogate another order of ideas and facts, but without changing the method on that account. We must always recur to other organized and living beings. It is to botanical and zoological geography that we now appeal.

Plants and animals are not distributed by chance upon the earth. Their distribution is subject to precise laws; and, because living and organic beings in general obey the same laws, man ought to follow the laws of geography as well as animals and plants.

Now, these laws of botanical and zoological geography teach us that in certain parts the flora and fauna are characterized by certain species; that the globe is partitioned off into a certain number of provinces, that have their particular vegetables and animals. These are the kind of provinces that have been called *centres of creation.*

It is natural enough to ask if each centre of creation has not had its own particular man, as it has had its peculiar vegetables and its peculiar animals. Led astray by certain coincidences, more apparent than real, some naturalists have replied in the affirmative. But, whoever will examine the question closely, will find that this is an error; for this mode of reasoning makes man a single exception among all organic and living beings. Now, you know we do not admit the possibility of this. Man ought to obey the laws of geography as he obeys the laws of physiology.

I cannot enter into all the details required for the complete demonstration of this statement. I limit myself to two facts that I hope will suffice to convince you.

The first is: not a single species of vegetable, not a single species of animal, is found at the same time all over the globe.

The most wide-spread species occupied at first only a small part of the globe, and man must have carried with him not only certain vegetables but also certain animals, to have them as widely diffused as we find them in our day. Notwithstanding this intelligent and voluntary intervention, you well know that there are certain parts of the globe occupied by man in which neither the vegetables that have accompanied us almost everywhere, nor the animals which we habitually transport, can survive. Man, on the contrary, is cosmopolitan in every sense of the word; that is to say, we find him everywhere, under the ice of the poles, as under the equator.

Hence, if he had originated wherever we find him, he would constitute a single exception among all organic and living beings, whether vegetable or animal.

This reason, by itself, ought to make us accept at least this much: that man has, at all events, peopled a part of the globe by emigration.

But we may go much further; and always, by virtue of the law which I have just stated, we may say that he had his origin in one spot, and that a narrow one.

In fact, when we study animals, we find that the extent occupied by a species, what we call its habitat, is as much less extended as the species is more perfected, more elevated, in the zoological series.

Not only is this true of species, but of types themselves.

Thus, below man, the animal form which most reminds us of the human form is, you know, that of the monkey. Are monkeys among the number of the most widely-distributed animals? No. The monkey-type is found neither in very cold countries nor in the greater part of the temperate regions, but only in the warmest parts of the globe. Besides, a great part of Oceanica contains not a single monkey.

If, now, we no longer consider the type, the entire group of monkeys, but only the species which approaches nearest to us, we see it occupying an area more and more limited. America has not a single species of monkey in common with Africa and Asia. And, when we come to the most perfect monkeys—to those which, by reason of their great resemblance to man, have been called anthropoid, that is, with a human form—we see the area of their habitat is restricted still more and becomes extremely narrow. So the orang-outang, one of those species of monkeys which some have wished to make our ancestor, is found only in the isle of Borneo, or at most, perhaps, in the isle of Sumatra; the gorilla, still another of the species which comes nearest man in his general proportions, occupies only a small part of the western regions of Africa.

Now, man is everywhere, and still he is incontestably, even from the point of view of his body, very superior to the monkeys. He alone has true hands, those marvellous instruments which you know so well how to use; he alone possesses a brain of which the size of the skull attests the development. Without speaking of other characters, man is evidently superior to all species of monkeys by his hand and his brain.

Well, then, the monkey, which, although so distant from man, still comes nearest to him, occupies but a restricted habitat; while man, the superior being *par excellence*, has originated, you say, simultaneously everywhere! Evidently, gentlemen, to accept this interpretation of facts, will be to make him a single exception among all organized beings; and so, I repeat, we can never accept this conclusion.

So you see, we are led to admit, not only that man originated in one single place upon the globe, but further, that this was a limited region—of very small extent. It was probably not greater than the habitat now allowed either to the gorillas or the orangs.

Can we go still further? Can we determine the particular spot of the globe where arose this privileged species which was to go forth and conquer the whole earth? We cannot answer this question with the same confidence as the others. But we may answer it with great probability. According to all appearances, the point where man originated, and whence he emigrated to all parts of the globe, was situated somewhere in the centre of Asia.

The reasons which lead us to this conclusion are of many kinds. I can only indicate the two following:

Around the elevated central region that you see pictured upon the chart in the heart of Asia, we find the three fundamental types of humanity: the black man, the yellow man, and the white man. Black men are at the present time widely enough dispersed. We see them still, however, in the peninsula of Malacca and in the isles of Andaman. Again, we find traces of these blacks in the east of Asia, at the isle of Formosa, at the south of Japan, and in the Philippines: the Melanesia belong to them. The yellow race occupies almost all the southeast part and even the centre of Asia; and finally we know that from this elevated central region came the great white race which to-day rules everywhere—the Aryan race, that to which we belong. The groups, more or less pure, are besides related to each other by a multitude of intermediates which may be regarded as transitional.

It is not only by the features, by fundamental physical traits, that the men found around this immense table-land are interrelated, and seem to blend into one another. We see, furthermore, on the sides of this vast table-land, the three essential types of language—of the most striking intellectual manifestation of man.

We shall come to this question by-and-by, but to-day I may say to you that we distinguish three fundamental forms of human language:

monosyllabic languages, in which each word has but one syllable; agglutinated languages, in which the words are welded together; and, finally, flexible languages, which resemble the languages now generally spoken in Europe.

Now, we find around this central plateau of Asia the monosyllabic language, *par excellence*, all over the Chinese Empire; on the north an assemblage of peoples speaking agglutinative languages, and extending even to Europe. Then, again, we have the portion occupied by the Aryan race, speaking the flexible languages. So the three linguistic types are represented around this table-land of Asia, the same as the three fundamental physical types. It seems that, almost from his cradle, man has presented all the essential modifications that he could undergo.

I pass to another question. Man, starting from a single and limited spot, has spread all over the globe. Consequently, he has peopled the globe by way of emigration and colonization. Such is the conclusion drawn from actual facts interpreted by science alone. But, is it possible to people the earth by human migration? Some say no; and make this assertion an objection to the ideas that I have just indicated.

I own that, for my part, this objection has always surprised me.

Migrations—colonizations! why, they occur everywhere in history, and particularly in our own history.

Go back as far as we may, we see populations in movement from one end of continents to the other; so that, to say *a priori* that man has always lived where we find him, is to contradict all historical documents.

However, some have insisted that certain migrations were beyond human power and intelligence. I will give you two examples to show that migrations are always possible, even when the conditions in the midst of which they take place seem made expressly to arrest them.

We must distinguish, in migrations, those over land from those across seas.

As to migrations by land, it is very evident that, when men have to war only against brute Nature, nothing can prevent their passage, especially when they can choose their moment. But I add that men will emigrate, even when they have to combat all difficulties united, not only the rigors of physical Nature, but also the action of man, who alone absolutely arrests man.

For example, I will cite a fact borrowed from the history of a people of whom I here show you some drawings:

Toward 1616, according to Chinese dates, a horde of Calmucks, for some reason which we do not know, left the country bordering upon China, crossed the whole of Asia, and established themselves on the banks of the Volga. There they accepted the sovereignty of Russia, and for more than a century rendered good service to the empire. But there came a time when the Calmucks found that the Russian yoke was growing more and more oppressive. To throw it off, they decided to emigrate, and return to the country of their ancestors. The tribe had settled on either bank of the Volga, and, in order to come together at a determined place, it had been arranged to start in the dead of winter, at a time when the ice would be strong enough to allow the people on the right bank to gain the left bank of the river. On a given day, all the people of the left bank came together; but some unknown cause hindered the people of the right bank from crossing. The number of emigrants was, however, very considerable, for, including women and children, there were 250,000. The rear-guard was composed of a select body of horsemen, which counted 80,000 men. You see, here was an emigration of an entire people.

From the beginning of the journey, the leaders understood that they must hasten; for, at the first news of their departure, the Russians gave orders to pursue the fugitives. A regular army was soon organized and advancing upon them, preceded by a host of Cossacks. These sworn enemies of the Calmucks massacred all those that strayed away any distance from the main body. Although it was the 5th of January, 1771, when they started, this entire people traversed the regions here indicated, and arrived on the following September on the frontiers of China.

In this long journey of more than 700 leagues, this wandering horde was constantly pursued by the Russian army, obliged to advance always by forced marches, to open a passage through hostile countries, harassed not only by the Cossacks but also by the Kirgheez, and the Bashkeers, the most savage and warlike inhabitants of these countries, who gave them not a single moment's peace.

I forgot to say that the winter, always very severe in these regions, was exceptionally so at this time; that in the first eight days all the beasts of burden perished, and that they had to burn their tents to obtain a moment's warmth. The women, the children, the aged, and men in their vigor, perished by thousands from the cold. This journey was, in reality, for these people, what the retreat from Russia was for the French army; but with this difference, that the Calmucks emigrated in families, with women and children, so that the disaster would be much more terrible. Winter was followed by summer; and, much as they had suffered from cold, they suffered equally from heat, and, above all, from want of water. There was even a time when the entire body of Calmucks, at the sight of water, disbanded to quench the thirst that devoured them. The rear-guard itself yielded to the temptation. The Bashkeers and the Kirgheez, taking advantage of this disorder, fell upon the multitude and put them to great slaughter. Happily, Kien-Long was engaged in the chase in these parts, and, as is usual with the Emperors of China, he was accompanied by a real army, in which were several batteries of artillery. He fired some pieces of cannon on the Kirgheez and the Bashkeers. The Calmucks recovered their coolness, defended themselves, and all that remained of these people were saved. The emperor immediately gave them some food and clothing; then he gave them the country which is occupied by their descendants at the present time.

I will add that Kien-Long caused a column to be erected on the spot where the encounter had taken place. On this column we read an inscription, in very simple words, recording how Kien-Long saved an entire nation. The inscription ends with these words: "Let this place ever be regarded as holy." Gentlemen, I cannot be deceived in saying that you will join in this prayer of one of the greatest sovereigns of China. The place where a nation has been saved merits consecration much more than that where the most brilliant victory has been gained at the price of thousands of human lives.

The hour passes, and I cannot enlarge upon this interesting question of migration as much as I intended. I will content myself with citing one example of migration by sea. It is still more striking, as it bears upon a race constantly referred to when it is wished to prove that men were born where we find them. At the present time, the part of the globe of which I am about to speak is one of those where the peopling by migration is most completely demonstrated. I mean Polynesia.

Here is Polynesia. You see that it occupies a good part of the great Pacific Ocean, and that it is included in a triangle whose sides, from the Sandwich Islands to New Zealand and to the isle of Pâques, measure, in round numbers, 1,800 leagues. The islands dispersed in this immense space are scarcely as much as a grain of sand in the Place de la Concorde. Several among them are smaller than Paris. The isle of Pâques in particular, which forms one of the extremities of the triangle, has precisely the extent of the city-wall of ancient Paris before the annexation of the suburbs—that is to say, 25 kilometres (15½ miles) in circumference.

You understand what in this vast sea an isle of these dimensions amounts to; and there are others much smaller, which are likewise peopled. The argument drawn from this situation would seem, then, to have great force. How do you suppose, says one, that savages, having no improved means of navigation, have been able to cross such spaces? Why were they not lost in this vast ocean before finding these small isles?

Unfortunately, I cannot go into the detail of facts to show you how inexact is this *a priori* reasoning. I will only say that at the present time we know not only that the people of Polynesia came from some other place, but that they came from the Indian Archipelago. We know, besides, what has been the general course of their migrations, and can trace them on the map. Further, we have been able to determine the epoch when they took place, relying on precise documents, as positive as the charts on which we rely in writing the history of our middle ages.

These people came from Asia, from a point of the Indian Archipelago that we can determine approximately. They reached the Marquesas Isles in the beginning of our era, or in the years immediately preceding. We know with still greater certainty that the emigration to New Zealand, that is to say, to the most distant portion of Polynesia, took place in the beginning of the fifteenth century, and that the emigration from New Zealand to people the Isles of Chatham occurred scarcely a century ago.

Here we meet with a significant fact. When these emigrants established themselves in the islands of which we are speaking, they found them deserted. This circumstance singularly facilitated their new settlement. If the Calmucks, of whom I just sketched the history, suffered so much, it is because they found men on their route. In our day, if it is still difficult to traverse Africa—if the journey from Timbuctoo has cost the lives of so many courageous travellers—it is because the Tuaregs close the passage to us.

The more we study, the better we know that all over the surface of the globe man surmounts every difficulty, so long as he wars only against Nature. If he is arrested, it is when he encounters man. In a word, man alone can arrest man.

I wish to say a few words also on the last of the questions suggested by this subject.

Man, we have seen, took his departure from a particular place on the globe, and now he is everywhere. Consequently, in his long and multiplied journeyings, he has encountered climates the most extreme, and conditions of existence the most opposite. He has adapted himself to all. Does it follow that a new-comer, that a European for example, can establish himself anywhere on the globe and immediately prosper there? You know he cannot. He must become acclimated; and you can easily understand that it ought to be so. The human body, which has developed under certain conditions of existence, is in harmony with them. If they change, and above all if they change suddenly, it is evident that the entire organism receives a shock; and this shock brings with it suffering, that you know often ends in death.

Experience has shown that these sufferings have been more grave and frequent when the course of emigration has been from cold toward warm countries—whence a certain number of physicians and anthropologists have drawn the conclusion that there are some countries on the globe that the European cannot inhabit—in which he can never prosper and multiply Some have even gone further. They have maintained that men could only propagate where they were born; so that, in reality, the Frenchman can only live in France, the Englishman in England, the Dutch in Holland, etc.

This exaggeration needs no refutation. It is already refuted by the existence of our colonies. We know very well that there are some parts of the globe where the European is acclimated almost immediately; not that he can escape all sacrifices, but they are relatively few. I refer you to the case of Acadia, that country in Canada peopled by sixty French families, and which, in a very short time, counted its inhabitants by thousands. I may cite you also to what is passing every day at the Cape, in Australia, at Buenos Ayres.

You see, then, in both worlds, and under the most diverse climates, Europeans prosper, multiply, and work, as they do in Europe. Still there are places where the question is much more diffcult of solution, and which have been considered fatal to Europeans. I will name in particular, on the western coast of Africa, our colony of Senegal, and above all that of Gaboon; I will point out, in America, the Antilles generally, and consequently Guadeloupe and Martinique; then French Guiana. Algeria itself has been a subject of lively debate from this point of view. It will seem natural to you that I should dwell a little more upon this last place, because of its special interest for all of us.

From the day of our conquest the question has been, whether the French could be acclimated on the soil of Algeria; and, curiously enough, friends and enemies, Englishmen and Frenchmen, military commanders and physicians, were almost unanimously agreed that it could not be done. They relied on the tables of mortality, which showed an excess of deaths over births. It is easy to see that a country, where the number of those who die gains on that of those who are born, is fated to become depopulated, unless new immigrants repair the annual losses. This is what was said of Algeria, and it is one of the points that I have had to discuss in my lectures.

Now, in spite of documents so often quoted, I do not hesitate to say that Frenchmen have been acclimated in Algeria, and have lived there very well. To arrive at this conclusion I have not denied the figures—the facts cited by those who reached the opposite one; on the contrary, I have accepted them. But I have interpreted them, resting on this principle, which we never abandon, namely, that, as regards his body, man is an animal and nothing else. Consequently, if the laws that govern animality bear heavily on him in certain circumstances, he profits, in return, by advantages that these same laws bring to animals.

Now, before studying the acclimation of man, I began by studying the acclimation of plants and animals. This study taught me that, from the moment when an organized species changes its environment, be it plant, animal, or man, it must be resigned to make two kinds of sacrifices: sacrifices bearing upon the individual, and sacrifices bearing upon the race. In Algeria, the former were shown by the figures of mortality of the army, which were much more considerable than in France. The latter were made apparent by the figures of mortality of children, which, in Algeria, were double those of France.

But I was aware that, when we Europeans tried to transplant to America certain species of domestic animals, the figures of mortality at first were much more considerable than those of the mortality of our army; that the figures of the sacrifices bearing on the race were much higher than those of the mortality of children in Algiers. However, to-day, those animals are acclimated in America, and prosper so well that certain species have run wild, and are, so to speak, become indigenous.

Relying upon these facts, I said, almost from the first of my lecturing, The time will come when Frenchmen will be acclimated in Algeria.

The event has justified me sooner than I hoped. Public documents this year, containing the quinquennial census, show, relatively to the preceding period, an increase of more than 25,000 souls. But, what is more important, they establish that this increase is almost entirely due to the excess of births over deaths.

So that the sacrifices of the French in peopling Algeria already begin to bear fruit; and certainly the time will come when that country, conquered by our armies, will be, for the descendants of our first colonists, as salubrious as France is for ourselves. Then Algeria will truly be the France of the South.

But the sacrifices which accompany colonization are none the less sad, and it is often asked if there are no means of diminishing them. Unhappily, this is always difficult, often impossible.

However, here are two facts that I ask you to reflect upon:

Some of our colonies have the reputation of being particularly unhealthy, and it is said that in them manual labor is impossible for Europeans. The worst of these are on the western coast of Africa. Now, listen to the statement of Captain Bolot, commanding a company employed in the construction of a pier at Great Bassam, made to Captain Vallon, from whom I drew the fact: "A single Sunday put more men in the infirmary than three days of work under the hot sun." This is because the Sunday was given, not to work, but to debauchery.

Captain Vallon profited by the experience thus acquired. In his cruises to Gaboon he maintained on board his ship severe discipline and regular work. When not at sea, he made the sailors of the Dialmate work regularly in the full sun, but he forbade all excess, and in this way he preserved his own health and that of his crew.

I will give you another and much more important example, as it constitutes a true comparative experience.

It is another of the colonies I referred to as devouring Europeans. I mean the Isle of Bourbon, at the east of Madagascar, almost under the tropics—on one of the warmest points of the globe.

The tables of mortality of this island show a frightful excess of deaths over births. Judged alone by these tables, we must admit that the inferences drawn are perfectly justified. But these tables are true only when we take the population *en masse*. Now, the people composing it form naturally two parties. One includes the great proprietors, the great planters, the leading merchants, and all those who belong to them, who, so to speak, lead the life of colonists. It is to such, and to such alone, that the desolating figures referred to apply.

The other part of the population is composed of people who till the ground with their hands, and who are disdainfully called by the name of poor whites. These are the descendants of the first colonists, who were all too poor to buy slaves, too proud to enter into the service of others, and who accepted for themselves and their posterity the life of small farmers. This last population keeps very much by itself; it has multiplied, and not only become prosperous, but its physical type has improved so much that travellers all speak of the personal beauty, both of the men and the women, of this race.

So, in this same Island of Bourbon, the rich planter and the working-men in cities, perish from the life of excess and debauchery, for which they are too much inclined in the colonies. The poor whites, who devote themselves to the cultivation of the earth, which is said to be impossible for the European under the tropics, have continued to develop, and have gained in all respects, because they have joined to moderate labor a sober life and pure manners.

Gentlemen, there is in this fact a practical lesson. Perhaps some among you will leave France; perhaps you will go to the colonies or to Algeria to seek your fortune! Let me impress upon you the history of the poor whites of the Isle of Bourbon—they have found that, to maintain health of the body, one of the best means, undoubtedly, is to preserve the health of the soul.

ON THE DIGESTIBILITY OF VEGETABLE AND ANIMAL FOODS.

By PROFESSOR VOIT,

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(Abstract by M. André Sanson)

AT the session of the Munich Academy of Science, December 4, 1869, Voit detailed the chief results of investigations made in his laboratory by Drs. Bischoff, Förster, Hoffmann, and Meyer, students of medicine, as to the differences which exist between animal and vegetable substances in point of digestibility, both in the carnivora and human beings; and also as to the importance of nutritive salts and condiments. These results have such a bearing upon alimentary hygiene that we have thought it desirable to give an extended analysis of this essay of the learned Bavarian physiologist. As the subject is important, we give a *verbatim* statement of the results.

Vegetable food, it is well known, contains, as its essential nutritive elements, albuminates, or nitrogenous materials, fatty matter, and hydrates of carbon, with water and nutritive salts. Such food, therefore, has the same elements as animal food; but in point of digestibility the two differ widely. Thus, while the carnivorous animal, when fed with sufficient flesh-meat, passes but little excrementitious matter, while it traverses the entire intestinal tract within eighteen hours after a meal; the herbivorous animal, on the contrary, when fed abundantly with vegetable substances, often retains the food in the intestine a whole week; and a considerable portion of this food remains unused. The proportion which the solid excretions bear to the weight of the animal is, for a dog fed on meat, as 3 to 10,000; for man with mixed food, 5 to 10,000; and for the ox, as 60 to 10,000.

We must observe that this difference is not due solely to the varying digestibility of the substances compared. These substances, as found in the excreta of herbivorous animals, are not such as resist the action of the digestive fluids. Henneberg and Stohmann have shown that the proportion of such substances digested depends upon their respective proportions in the sum of the food consumed. This is one of the most important recent contributions to the physiology of digestion. What renders vegetable food harder to digest is the fact that the albuminoid substances, fatty matters, starch, etc., are there incased in a coating of cellulose, to break up which requires some time. On this account, the intestine of the herbivora is longer and more complicated than that of the carnivora. The latter digest but a small proportion of cellulose. The same holds good for man, except when he consumes young cellulose but little consolidated, as tender pulse, roots, or fruits. The cellulose of hay and grass is of such quality that the human digestive apparatus cannot extract any of their nutritive elements. In order that we may utilize them, they must first be transformed by herbivora into their own substance.

Albuminates, whether derived from the animal or from the vegetable kingdom, leave but little alimentary residue. If fat be added to the albuminates, this residue is increased in proportion to the amount of fatty matter, especially when the latter is in excess. The addition of sugar, no matter in what quantity, has not the same result, provided it does not cause a diarrhœa. Of sugar, but faint traces are to be found in the residuum. With starch it is quite different, even when it is made pulp by boiling.

Adolph Meyer has made some interesting experiments in this matter. A dog was given 1,000 parts of bread per day (536 dry matter) and with such food his excreta amounted to 70 parts of dry substance. The equivalent of the albumen in the bread was then given, in the shape of flesh-meat, its starch being replaced by the respiratory equivalent in the shape of fat (2, 4 : 1); consequently the sum must have been 377 meat, 184 fat. The dry excrement was then only 20, with five of fat. More albumen was, therefore, digested in the latter case than in the former, for in the excretory residue from the bread there was found of nitrogen 2.45, while in that from meat and fat it was only 0.97. To show that it is really the starch which yields excessive residue, and not some other constitutent part of the bread, Mr. Meyer gave the albumen of 1,000 parts of bread under the form of pure flesh-meat, and also starch in the form of fecula reduced to a pulp. The sum was 377 parts of meat and 522 of starch. This ration yielded 68 parts of excrementitious matter per day, as when the equivalent food was given in the shape of bread. Still these excreta contained less nitrogen than that from bread. According to the investigations made by Dr. Bischoff, more nitrogen was assimilated out of 302 parts of meat and 354 of starch, than out of 800 of bread, although in each case the quantity of albumen was equal. It is hence seen that it is the starch which gives the greater part of the rejected residue. It follows that carnivora and man living on vegetable food ought to evacuate the bowels twice a day; whereas, on an exclusive meat-diet, they might retain the intestinal contents for at least four days.

Bischoff thinks that, as the starch must first be transformed into sugar before it can be absorbed, there is not sufficient time for this change to be thoroughly brought about, before the starch is carried along by the general action of the intestine. At first, excrementary matter has a very strong acid reaction, which, as Bischoff supposes, is owing to the presence of a great quantity of organic acids, especially butyric acid. Pettenkofer and Voit have found in the gases exhaled by animals consuming starchy food, chiefly hydrogen and carburetted hydrogen. These same gases are also found, in the intestine of the herbivora. The expulsion of the starch is probably due to the generation of these gases, which excites the peristaltic movement of the intestine. If the chyme were permitted to remain longer in the intestine, the starch would be completely transformed into sugar and entirely absorbed. The obstinate diarrhœas of infants are doubtless often occasioned by this same phenomenon.

Voit shows that there are many other agencies which may exert similar influence upon intestinal movement. His assistant, Dr. Hoffmann, has observed that when cellulose is added to human food, for instance to flesh-meat, such meat then gives a largely-increased proportion of excrementitious matter. Purgatives, or sudden refrigeration of the abdominal region, may have the same effect. Bread containing all the constitutents of wheat causes, according to Meyer's experiments, prompt evacuation, by reason of the indigestible cellulose it contains. It yields a widely disproportionate quantity of excreta, as has been demonstrated by Panuni in the case of dogs fed on bread, when, though evacuation increased, the amount of urea was diminished. White wheaten bread gives least excreta. The proportion of water contained in this matter affords the means of judging how long it had remained in the intestine, and how far the process of extracting the nutritive properties had gone. The substance evacuated in small quantity after a meal of flesh-meat contains hardly any remains of meat and 50 per cent. of solid matter, while the excreta from bread-food, evacuated in greater quantity, with much of the bread not transformed, has only 23 per cent. solid matter.

It might be supposed that the yeast in the bread is the cause of this; but Meyer has shown that a ration of starch-pudding and unleavened bread gives residuum in equal proportion with leavened bread. He has also shown that bread, into the composition of which enter nutritive salts, according to the Horsford process, gives a residuum equal to that of common bread. The result, therefore, is not due to the absence of these salts from bread. Dr. Bischoff has shown, in the course of some experiments he made at the instance of Liebig, that the addition of extract of meat, with or without salt, to the bread given to a dog, does not affect the intestinal absorption, nor does it lessen the amount of excrementitious matter. The objection might perhaps be urged that, as the dog is purely carnivorous, experiments made on him will not warrant a universal conclusion. Therefore, Dr. Hoffmann made the same experiment with a man. The man was fed on potatoes, pulse, and bread, and there were then 116 parts of dry excreta; when extract of meat was added, there were still 109.

According to Haubner, the addition of a little peas to potatoes notably diminishes or even entirely dissipates the starch, which else is found in great quantity in the excreta of sheep. This result he attributes to the influence of the albumen in the peas. Dr. Bischoff gave a dog 800 parts of bread and 100 of meat. The amount of residuum was not lessened, nor the assimilation of the bread increased. Dr. Meyer found a dog, on 1,000 parts of bread, to give 70 of excreta; on 1,000 of bread and 100 of meat, 66 parts; and on 1,000 of bread and 300 of meat, 75 of solid residue. There is, then, no means of promoting the digestion of bread or potatoes, or other vegetable food, in the intestine whether of man or of dog, nor of preventing the loss of the starch.

From the persevering observations of Dr. Hoffmann, it follows that this imperfect digestion and this voluminous excretion are unavoidable—a fact which, on a vegetable diet, necessitates larger consumption, even though each of the elements were in itself capable of absorption. If a man consumes in a day 1,000 parts potatoes, 207 lentils, 40 bread and beer, he takes in 14.7 of nitrogen. Of the latter he gives out 7 by the kidneys, and 6.9 in 116 of dry excreta. The latter contain 24 per cent. of the dry food, and 47 per cent. of the nitrogen. But, when he takes in animal food, the same amount of azote and of starch in its respiratory equivalent of fat, i. e., 390 parts meat and 126 fat, he eliminates daily only 28.3 parts solid matter, with 2.6 of nitrogen; while on the contrary, the liquid excretion holds 14.2 of nitrogen. Consequently, though the amount of albumen in the two cases was the same, still twice as much of it was absorbed by the intestine from the ration of meat as from that of vegetables. The 800 parts of meat yielded only 27 of dry residuum.

This difference in absorption makes the essential difference between vegetable and animal food. Consequently, we are not justified in saying that 2.4 of starch is the equivalent of one part fat. Further, 1 part fat and 2.4 albumen, both absorbed by the same organism, have not the same action on the transformation of albumen or the admission of oxygen. Great caution must therefore be observed, in treating of such equivalencies, even where the elements of nutrition are analogous, but come from diverse sources. Their mutually different behavior in digestion has not been always taken into account.

Dr. Hoffmann has studied this subject for the human economy, as regards various alimentary substances or nutritive elements. Bread, potatoes, rice, maize, etc., taken in any quantity whatsoever, can scarcely support the life of man or of carnivorous animals, communicating to them no bodily strength. Too large a proportion of their nutritive elements is eliminated in the excretion. Still, with the addition of a small quantity of albumen, whether animal or vegetable, they may suffice. They are poor in albuminates, but rich in starch. Even herbivorous animals often take in an excess of food, so as to get the requisite amount of albumen.

The same occurs with man, and therefore he will waste non-azotized material. The quality of the food he takes may be told from the excreta. It is Liebig who said that you might make out the boundary-lines of those countries where the coarse brown bread of Westphalia is used, from certain indications found along the hedge-rows. An Irish laborer, according to Buckle, consumes daily 9½ lbs. of potatoes, a weight too great for all the intestines to carry. These potatoes would contain of water 3,200 parts, dry albumen 70, and of non-nitrogenous substances 725. The latter quantity is far in excess of what is necessary to nourish a strong man; but there is a deficiency of albumen, to say nothing of the amount lost in the excreta. As a consequence, the body is capable of but little work, notwithstanding the great quantity of potatoes taken in, and it is but ill provided with the means of resisting disease, owing to the excess of water in the organs. The same is to be said of rice, which is poor in nitrogen. According to Salvator Thomassi, the farmers of the rice-fields in Italy, who enjoy liberal fare, reach an advanced age, while the day-laborers who live on rice succumb prematurely to diseases caused by exhaustion. In Western India, where rice is the chief food of the natives, they always add some element of food which is richer in azote. Those Italian laborers who come into Germany to work upon the railways always eat cheese with their staple food, maize. Other populations derive all their nutriment from 800 parts of bread and 100 of meat, besides potatoes and herrings. All these facts are in full accord with the experiment made on the dog, which lost weight on 800 parts of bread, or on the same with extract of meat, and finally died in convulsions.

On this subject we have the valuable researches of William Stark, dating from 1789. He tried experiments upon himself as to the relative value of different kinds of food. For 42 consecutive days he lived on 556 to 849 parts of bread and 900 to 1,800 water per day. Meanwhile he lost 17 lbs. weight. Then he took 736 to 962 of bread, 113 to 226 sugar and 900 to 1,300 water, and in 28 days lost 3 lbs. But he gained with 849 bread, 1,800 milk and 1,300 water. Hence it will be seen that prison-fare of bread-and-water is justly to be regarded as a punishment. In fact, the sentence condemning a man to live four weeks on such fare is in Danish law equivalent to sentence of death, and in Denmark no case has ever occurred of a culprit surviving his punishment.

Of course, Prof. Voit is far from condemning the use of vegetable substances for food; but he insists upon it that they must be combined with proper nutritive elements in assimilable form, in order to keep the body vigorous. These vegetable substances are deficient in albumen, and nothing can supply it better than flesh-meat. It is also advisable to substitute, for a part of the mass of starchy material, animal or vegetable fat. It is not denied but that one may sustain life on purely vegetable fare. The only conclusion the author insists upon in this first portion of his essay is, that the alimentation of man is always best secured, as regards azotic and fatty food, when the latter is got from animal matter, and oftentimes the elements in question cannot be derived from any other source. Chemistry alone will not account for this disparity. The principles of which we speak do not differ from one another chemically in their origin. It is only physiological experimentation, with the living being as the reactive agent, that can show these differing properties, as we have seen. This is a point of great importance. The question of nutritive salts, which we are next to consider, is no less important.—*Revue Scientifique.*

MR. MARTINEAU ON EVOLUTION.

By HERBERT SPENCER.

THE propriety of dealing with the leading criticisms that have been made on the general doctrine set forth in "First Principles"—more especially criticisms on the metaphysical aspects of that doctrine—has been from time to time pressed upon me. Having recently been led to undertake a subject outside of, though ancillary to, the work with which I am chiefly occupied, a contemplated reply to these criticisms has beer put aside for a while. The article by Mr. Martineau, in the April number of the *Contemporary Review*, on "The Place of Mind in Nature, and Intuition in Man," while it reminded me of this postponed essay, because containing further criticisms to be met, did not lead to any change of intention. I learn, however, that Mr. Martineau's arguments, which, though not avowedly directed against propositions asserted or implied in "First Principles," tell against them by implication, are supposed by some to be conclusive, and that, in the absence of replies, it will be assumed that no replies can be made. It seems desirable, therefore, to notice these arguments at once—especially as the essential ones may, I think, be effectually dealt with in comparatively small space.

The first definite objection which Mr. Martineau raises is, that the hypothesis of general evolution is powerless to account even for the simpler orders of facts in the absence of numerous different substances. He argues that, were matter all of one kind, no such phenomena as chemical changes would be possible, and that, "in order to start the world on its chemical career, you must enlarge its capital, and present it with an outfit of *heterogeneous* constituents. Try, therefore, the effect of such a gift; fling into the preëxisting caldron the whole list of recognized elementary substances, and give leave to their affinities to work." The intended implication obviously is, that there must exist the separately-created elements before evolution can begin. Here, however, Mr. Martineau makes an assumption which few, if any, chemists will commit themselves to, and which many will distinctly deny. There are no "recognized elementary substances," if the expression means substances known to be elementary. What chemists, for convenience' sake, call elementary substances, are merely substances which they have thus far failed to decompose; but, bearing in mind past experiences, they do not dare to say that they are absolutely undecomposable. Water was taken to be an element for more than 2,000 years, and then was proved to be a compound; and, until Davy brought a galvanic current to bear upon them, the alkalies and the earths were supposed to be elements. So little true is it that the "recognized elementary substances" are supposed to be absolutely elementary, that there has been much speculation among chemists respecting the process of compounding and recompounding by which they have been formed out of some ultimate substance—some chemists having supposed the atom hydrogen to be the unit of composition, but others having contended that the atomic weights of so-called elements are not thus interpretable. If I remember rightly, Sir John Herschel was one, among others, who, some five-and-twenty years ago, threw out suggestions respecting the composition of them. What was at that time a suspicion has now become practically a certainty. Spectrum analysis yields results wholly irreconcilable with the assumption that the conventionally-named simple substances are really simple. Each yields a spectrum having lines varying in number from two to eighty—lines every one of which implies the intercepting of ethereal undulations of a certain order by something oscillating in unison or in harmony with them. Were iron absolutely elementary, it is not conceivable that its atom could intercept ethereal undulations of eighty different orders: though it does not follow that its molecule contains as many separate atoms as there are lines in its spectrum, it must clearly be a complex molecule. The evidence thus gained points to the conclusion that, out of some primordial unit, the so-called elements arise by compounding and recompounding; just as by the compounding and recompounding of elements there arise oxides, and acids, and salts. And this hypothesis is entirely in harmony with the phenomena of allotropy. Various so-called elementary substances have several forms under which they present quite different properties. The semitransparent, colorless, extremely active substance commonly called phosphorus may be so changed as to become opaque, dark red, and inert. Like changes are known to occur in some gaseous, non-metallic elements, as oxygen; and also in metallic elements, as antimony. These total changes of properties, brought about without any changes to be called chemical, are interpretable only as due to molecular arrangements; and, by showing that difference of property is produced by difference of arrangement, they support the inference otherwise to be drawn, that the properties of different elements result from differences of arrangement produced by the compounding and recompounding of ultimate homogeneous units. Thus Mr. Martineau's objection, which at best would imply a turning of our ignorance of the nature of elements into positive knowledge that they are simple, is, in fact, to be met by two sets of evidences, which distinctly imply that they are compound.

Mr. Martineau next alleges that a fatal difficulty is put in the way of the General Doctrine of Evolution by the existence of a chasm between the living and the not-living. He says: "But with all your enlargement of data, turn them as you will, at the end of every passage which they explore, the *door of life* is closed against them still." Here again our ignorance is employed to play the part of knowledge: the fact that we do not know distinctly how an alleged transition has taken place is transformed into the fact that no transition has taken place. We have over again the mode of argument which until lately was thought conclusive—because the genesis of each species of creature had not been explained, therefore each species must be specially created. Merely noting this, however, I go on to remark that scientific discovery is day by day narrowing the chasm, or, to use Mr. Martineau's metaphor, "opening the door." Not many years since, it was held as certain that the chemical compounds distinguished as organic could not be formed artificially. Now, more than a thousand organic compounds have been formed artificially. Chemists have discovered the art of building them up, from the simpler to the more complex, and do not doubt that they will eventually produce the most complex. Moreover, the phenomena attending isomeric change give a clew to those movements which are the only indications we have of life in its lowest forms. In various colloidal substances, including the albuminoid, isomeric change is accompanied by contraction or expansion, and consequent motion; and, in such primordial types as the *Protogenes* of Haeckel, which do not differ in appearance from minute portions of albumen, the observed motions are comprehensible as accompanying isomeric changes caused by variations in surrounding physical actions. The probability of this interpretation will be seen on remembering the evidence we have that, in the higher organisms, the functions are essentially effected by isomeric changes from one to another of the multitudinous forms which protein assumes. Thus the reply to this objection is, first, that there is going on from both sides a rapid narrowing of the chasm supposed to be impassable; and, second, that, even were the chasm not in course of being filled up, we should no more be justified in therefore assuming a supernatural commencement of life than Kepler was justified in assuming that there were guiding-spirits to keep the planets in their orbits, because he did not see how else they were to be kept in their orbits.

The third definite objection made by Mr. Martineau is of kindred nature. The Hypothesis of Evolution is, he thinks, met by the insurmountable difficulty that plant-life and animal life are absolutely distinct. He says:

"You cannot take a single step toward the deduction of sensation and thought: neither at the upper limit do the highest plants (the exogens) transcend themselves and overbalance into animal existence; nor at the lower, grope as you may among the sea-weeds and sponges, can you persuade the sporules of the one to develop into the other."

This is an extremely unfortunate objection to raise. For, though there are no transitions from vegetal to animal at the places Mr. Martineau names, where, indeed, no biologist would dream of looking for them, yet the connection between the two great kingdoms of living things is so complete that separation is now regarded as impossible. For a long time naturalists endeavored to frame definitions such as would, the one include all plants and exclude all animals, and the other include all animals and exclude all plants. But they have been so repeatedly foiled in the attempt that they have given it up. There is no chemical distinction that holds; there is no structural distinction that holds; there is no functional distinction that holds; there is no distinction as to mode of existence that holds. Large groups of the simpler animals contain chlorophyll, and decompose carbonic acid under the influence of light as plants do. Large groups of the simpler plants, as you may observe from the diatoms from any stagnant pool, are as actively locomotive as the minute creatures classed as animals seen along with them; and among these lowest types of living things it is common for the life to be now predominantly animal and presently to become predominantly vegetal. The very name *zoospores*, given to germs of *algæ*, which for a while swim about actively by means of cilia, and presently settling down grow into plant-forms, is given because of this conspicuous community of nature. So complete is this community of nature that for some time past many naturalists have wished to establish for these lowest types a sub-kingdom intermediate between the animal and the vegetal: the reason against this course being, however, that the difficulty crops up afresh at any assumed places where this intermediate sub-kingdom may be supposed to join the other two. Thus the assumption on which Mr. Martineau proceeds is diametrically opposed to the conviction of naturalists in general.

Though I do not perceive that it is specifically stated, there appears to be tacitly implied a fourth difficulty of an allied kind—the difficulty that there is no possibility of transition from life of the simplest kind to mind. Mr. Martineau says, indeed, that there can be "with only vital resources, as in the vegetal world, no beginning of mind;" apparently leaving it to be inferred that in the animal world the resources are such as to make the "beginning of mind" comprehensible. Whether any consciousness of an incongruity between the conception of "germs of mind as well as the inferior elements," and his hypothesis of universal mind as the cause of evolution, prevented Mr. Martineau from pressing this objection, I do not know. But, had he asserted a chasm between mind and bodily life, for which there is certainly quite as much reason as for asserting a chasm between animal life and vegetal life, the difficulties in his way would have been no less insuperable. For those lowest forms of irritability in the animal kingdom, which, I suppose, Mr. Martineau refers to as the "beginning of mind," are not distinguishable from the irritability which plants display: they in no greater degree imply consciousness. If the sudden folding of a sensitive-plant's leaf when touched, or the spreading out of the stamens in a cistus-flower when you brush them, is to be considered as a vital action of a purely physical kind, then so too must be considered the equally slow retraction of a polype's tentacles. And yet, from this simple motion of an animal having no nervous system, we may pass by insensible stages through ever-complicating forms of actions, with their accompanying signs of feeling and intelligence, until we reach the highest. Even apart from the evidence derived from the ascending grades of animals up from *zoophytes*, as they are significantly named, it needs only to observe the evolution of a single animal to see how baseless is the assumption that there exists any break or chasm between the life that shows no mind and the life that shows mind. The yolk of an egg which the cook has just broken not only yields no sign of mind, but yields no sign of life. It does not respond to a stimulus as much even as many plants do. Had the egg, instead of being broken by the cook, been left under the hen for a certain time, the yolk would have passed by infinitesimal gradations through a series of forms ending in the chick, and by similarly infinitesimal gradations would have arisen those functions which end in the chick breaking its shell; and which, when it gets out, show themselves in running about, distinguishing and picking up food, and squeaking if hurt. When did the feeling begin, and how did there come into existence that power of perception which the chick's actions show? Should it be objected that the chick's actions are mainly automatic, I will not dwell on the fact that, though they are largely so, the chick manifestly has feeling and therefore consciousness, but I will accept the objection, and propose that instead we take the human being. The course of development before birth is just of the same general kind; and similarly, at a certain stage, begins to be accompanied by reflex movements. At birth there is displayed an amount of mind certainly not greater than that of the chick—there is no power of running from danger, no power of distinguishing and picking up food. If we say the chick is unintelligent, we must certainly say the infant is unintelligent. And yet from the unintelligence of the infant to the intelligence of the adult, there is an advance by steps so small that on no day is the amount of mind shown appreciably different from that shown on preceding and succeeding days. Thus the tacit assumption, that there exists a break, is not simply gratuitous, but one that is negatived by the most obvious facts.

And now, having dealt with the essential objections raised by Mr. Martineau to the Hypothesis of Evolution as it is presented under that purely scientific form which generalizes the process of things, firstly as observed, and secondly as inferred from certain ultimate principles, let me go on to examine that form of the Hypothesis which he propounds—Evolution as determined by Mind and Will—Evolution as prearranged by a Divine Actor. For Mr. Martineau apparently abandons the primitive theory of creation by "fiat of Almighty Will" and also the theory of creation by manufacture—by "a contriving and adapting power," and seems to believe in Evolution; requiring only that "an originating mind" shall be taken as its antecedent. Let us ask, first, in what relation Mr. Martineau conceives the "originating mind" to stand to the evolving universe. From some passages it is inferable that he considers the "presence of mind" to be everywhere needful. He says:

"It is impossible to work the theory of Evolution upward from the bottom. If all force is to be conceived as one, its type must be looked for in the highest and all-comprehending term; and Mind must be conceived as there, and as divesting itself of some specialty at each step of its descent to a lower stratum of law, till represented at the base under the guise of simple Dynamics."

This seems to be an unmistakable assertion that, whenever evolution is going on, mind is then and there behind it. At the close of the argument, however, a quite different conception is implied. Mr. Martineau says:

> "If the Divine Idea will not retire at the bidding of our speculative science, but retain its place, it is natural to ask, What is its relation to the series of so-called Forces in the world? But the question is too large and deep to be answered here. Let it suffice to say, that there need not be any overruling of these forces by the Will of God, so that the supernatural should disturb the natural; or any supplementing of them, so that He should fill up their deficiencies. Rather is His thought related to them as, in Man, the mental force is related to all below it."

It would take too much space to deal fully with the various questions which this passage raises. There is the question, Whence come these "Forces," spoken of as separate from the "Will of God"—did they preëxist? Then what becomes of the divine power? Do they exist by the divine Will? Then what kind of nature is that by which they act on the divine Will? Again, there is the question, how do these deputy-forces coöperate in each particular phenomenon, if the presiding Will is not there present to control them? Either an organ which develops into fitness for its function, develops by the coöperation of these forces only under the direction of Mind there present, or they do it in the absence of Mind? If they do it in the absence of Mind, the hypothesis is given up; and if the "originating mind" is required to be then and there present, it must be regarded as universally present. Once more there is the question, If "His thought" is related to them [these forces] as, in Man, the mental force is related to all below it, how can "His thought" be regarded as the cause of evolution? In man the mental force is related to the forces below it neither as a creator of them, nor as a regulator of them, save in a very limited way: the greater part of the forces present in man, both structural and functional, defy the mental force absolutely. Not dwelling on these questions, however, it will suffice to point out the entire incongruity of this conception with the previous conception which I have quoted. Assuming that, when the choice is pressed on him, Mr. Martineau will choose the first, which alone has any thing like defensibility, let us go on to ask how far Evolution is made comprehensible by postulating Mind, universally immanent, as its cause.

In metaphysical controversy, many of the propositions propounded and accepted as quite believable are absolutely inconceivable. There is a perpetual confusing of actual ideas with what are nothing but pseud-ideas. No distinction is made between propositions that contain real thoughts, and propositions that are only the forms of thoughts. A thinkable proposition is one of which the two terms can be brought together in consciousness under the relation said to exist between them. But very often, when the subject of a proposition has been thought of as something known, and when the predicate has been thought of as something known, and when the relation alleged between them has been thought of as a known relation, it is supposed that the proposition itself has been thought. The thinking separately of the elements of a proposition is mistaken for the thinking of them in the combination which the proposition affirms. And hence it continually happens that propositions which cannot in truth be rendered into thought at all are supposed to be not only thought but believed. The proposition that Evolution is caused by Mind is one of this nature. The two terms are separately intelligible; but they can be regarded in the relation of effect and cause only so long as no attempt is made to put them together in the relation.

The only thing which any one knows as mind is the series of his own states of consciousness. The mind so known to each person, and inferred by each to be present in others, has the essential characters, that its components are limited by one another, and that it is itself localized both in time and space. If I am asked to frame a notion of mind, divested of all those structural traits under which alone I am conscious of mind in myself, I cannot do it. I know nothing of thought save as carried on in terms originally derived from the effects wrought by objects on me. A mental act is an unintelligible phrase if I am not to regard it as an act in which states of consciousness are severally assimilated to other states in the series that has gone by, and in which the relations between them are severally assimilated to past relations in this series. I cannot give any meaning to the word Will, unless I am to think of it in terms of contemplated ends, of which some one is preferred.

If, then, I have to conceive Evolution as caused by an "originating Mind," I must conceive this mind as having attributes akin to those of the only mind I know, and without which I cannot conceive mind at all. I will not dwell on the many incongruities hence resulting, by asking how the "originating Mind" is to be thought of as having states produced by things objective to it; as discriminating among these states, and classing them as like and unlike; and as preferring one objective result to another. I will simply ask, What happens if we ascribe to the "originating Mind" the character absolutely essential to the conception of mind, that it consists of a series of states of consciousness? Put a series of states of consciousness as cause, and the evolving universe as effect, and then endeavor to see the last as flowing from the first. It is possible to imagine in some dim kind of way a series of states of consciousness serving as antecedent to any one of the movements I see going on; for my own states of consciousness are often indirectly the antecedents to such movements. But how if I attempt to think of such a series as antecedent to all actions throughout the universe—to the motions of the multitudinous stars through space to the revolutions of all their planets round them, to the gyrations of all these planets on their axes, to the infinitely-multiplied physical processes going on in each of these suns and planets? I cannot even think of a series of states of consciousness as causing the relatively small group of actions going on over the earth's surface; I cannot even think of it as antecedent to all the various winds and the dissolving clouds they bear, to the currents of all the rivers, and the guiding actions of all the glaciers; still less can I think of it as antecedent to the infinity of processes simultaneously going on in all the plants that cover the globe, from tropical palms down to polar lichens, and in all the animals that roam among them, and the insects that buzz about them. Even to a single small set of these multitudinous terrestrial changes, I cannot conceive as antecedent a series of states of consciousness—cannot, for instance, think of it as causing the hundred thousand breakers that are at this instant curling over the shores of England. How, then, is it possible for me to conceive an "originating Mind," which I must represent to myself as a series of states of consciousness, being antecedent to the infinity of changes simultaneously going on in worlds too numerous to count, dispersed throughout a space that baffles imagination? If, to account for this infinitude of physical changes everywhere going on, "Mind must be conceived as there under the guise of simple Dynamics," then the reply is that, to be conceived as there, Mind must be divested of all attributes by which it is distinguished; and that when thus divested of its distinguishing attributes, the conception disappears—the word Mind stands for a blank. If Mr. Martineau takes refuge in the entirely different and, as it seems to me, incongruous hypothesis of something like a plurality of minds—if he accepts, as he seems to do, the doctrine that you cannot explain Evolution "unless among your primordial elements you scatter already the *germs* of Mind as well as the inferior elements"—if the insuperable difficulties I have just pointed out are to be met by assuming a local series of states of consciousness for each phenomenon, then we are obviously carried back to something like the old fetichistic notion, with the difference only, that the assumed spiritual agencies are indefinitely multiplied. Clearly, therefore, the proposition that an "originating Mind" is the cause of Evolution is a proposition that can be entertained so long only as no attempt is made to unite in thought its two terms in the alleged relation. But when the attempt to unite them is made, the proposition turns out to be not simply unprovable, but unthinkable.

Here let me guard myself against a misinterpretation very likely to be put upon the foregoing arguments—especially by those who have read the Essay to which they reply. The statements of that Essay carry the implication that all who adhere to the hypothesis it combats imagine they have solved the mystery of things when they have explained the processes of Evolution as naturally caused. Mr. Martineau tacitly represents them as believing that, when every thing has been interpreted in terms of Matter and Motion, nothing remains to be explained. This, however, is by no means the fact. The Doctrine of Evolution, under its purely scientific form, does not involve Materialism, though its opponents persistently represent it as doing so. Indeed, among adherents of it who are friends of mine, there are those who speak of the Materialism of Buchner and his school, with a contempt certainly not less than that felt by Mr. Martineau. To show how entirely anti-materialistic my own view is, I may, perhaps, without impropriety, quote passages which I have written elsewhere:

"Hence, though of the two it seems easier to translate so-called Matter into so-called Spirit, than to translate so-called Spirit into so-called Matter (which latter is, indeed, wholly impossible), yet no translation can carry us beyond our symbols."[1]

And again:

"See, then, our predicament. We can think of Matter only in terms of Mind. We can think of Mind only in terms of Matter. When we have pushed our explorations of the first to the uttermost limit, we are referred to the second for a final answer; and, when we have got the final answer of the second, we are referred back to the first for an interpretation of it. We find the value of *x* in terms of *y*; then we find the value of *y* in terms of *x*; and so on we may continue forever, without coming nearer to a solution. The antithesis of subject and object, never to be transcended while consciousness lasts, renders impossible all knowledge of that Ultimate Reality in which subject and object are united."[2]

It is thus, I think, manifest that the difference between Mr. Martineau's view and the view he opposes is by no means so wide as he makes it appear; and further, it seems to me that such difference as exists is, in truth, rather the reverse of that which his exposition implies. Briefly expressed, the difference is this, that, when he thinks there is no mystery, the doctrine he combats recognizes a mystery. Speaking for myself only, I may say that, agreeing entirely with Mr. Martineau in repudiating the materialistic interpretation as utterly futile, I differ from him simply in this, that while he says he has found another interpretation, I confess that I cannot find any interpretation; while he holds that he can understand the Power which is manifested in things, I feel obliged to admit, after many failures, that I cannot understand it. This contrast does not appear of the kind which his Essay tacitly implies. I fail to perceive humility in the belief that human thought is capable of comprehending that which is behind appearances; and I do not see how piety is especially exemplified in the assertion that the Universe contains no mode of existence higher in Nature than that which is present to us in consciousness. On the contrary, I think it quite a defensible proposition that humility is better shown by a confession of incompetence to grasp in thought the Cause

[1] "Principles of Psychology," second edition, vol. i., § 63. [2] Ibid., § 272.

of all things; and that the religious sentiment may find a higher sphere in the belief that the Ultimate Power is no more representable in terms of human consciousness than human consciousness is representable in terms of a plant's functions.

Other parts of Mr. Martineau's argument I pass over as being met by implication in the above replies. I will now add only that, should any further explanation be required, I must postpone it until I am free from present special engagements.

MUSICAL MICE.

By Rev. SAMUEL LOCKWOOD, Ph. D.

THE study of geographical range is of extreme interest as affecting the life, forms, and functions of animals. In this way has come about that convenient division of the Monkey order into two great sections—the Simiadæ, or Old-World monkeys—and the Cebidæ, or New-World monkeys. And this distinction is based on differences easy to be understood. The monkeys of the Old World have their nostrils so nearly terminal, and so near to each other, and their teeth in sort and number so much like those of man, as to give them traits more human-like than those of the New World. They have also cheek-pouches, but none of them have prehensile tails. The New-World monkeys have their nostrils wide, lateral, and sprawling; they have more teeth than man has; they have no cheek-pouches; and with many the tail is prehensile. But does this law of geographical distribution, whatever it may be, affect "mice, and such small deer?" It does. A very large order is that known as the Rodents, or Gnawers, well represented by the squirrels and rabbits. These animals are all characterized by two chisel-shaped teeth in the front of each jaw. The order contains several well-marked families, and some six hundred species. Of these families, one is known as the *Muridæ*, which embraces the rats and the mice, and their allies. Now, it is interesting to know that the Muridæ, namely, the true rats and mice, as well as the monkeys, naturally divide into two geographical groups: the one called the *Mures*, or Old-World rats; and the other known as the *Sigmadontes*, or New-World rats. Each of these divisions includes the true rats and mice, indigenous to the New and the Old World, respectively. And these distinctions are founded on a real difference in anatomical structure. Let it suffice to mention the most striking, that of the teeth. The Mures, or Old-World rats and mice, have comparatively "large, broad molars, and those of the upper jaw have three tubercles: the Sigmadontes, or New-World rats and mice, have narrow molars, and those in the upper jaw have two tubercles." The word *sigmadont* means sigma-toothed, from a marking on the enamel, resembling the Greek letter *sigma*, which really would be like our own letter *S*, if the latter were made by uniting two angles, instead of two curves.

The writer has elsewhere expressed his belief that among the Rodents is a good deal of latent or undeveloped musical capacity. The squeal of the frightened rabbit is musical; while the whistle of the woodchuck enlivens its burrow with its homely, merry little sound.

That our little cosmopolite, the Old-World mouse, whom Linnæus, on account of its smallness among its fellows, named *Mus musculus*, has achieved some distinction in the musical line, almost everybody knows. Indeed, these musical house-mice are almost ceasing to be uncommon. Even his less graceful, big relative, the rat, has tried his hand at the pipes, and not wholly without success. And, among these little erratics, some have been known that might be called more comical than entertaining—certain eccentrics, known as hiccoughing-mice. But these and the above are all, wherever found, directly or indirectly, of the Old-World race. That any New-World species had done aught of this sort was to naturalists unknown. A late friend of ours had a domestic mouse—"a singer, that is," as the old man said—"not much, but it would whistle a little—chirrup, you know." Now, it happened that, one day, our friend caught two wood-mice, real natives—delicate, white-footed things, that looked too innocent to do any thing else than step mincingly around in their delicate white-satin slippers. So they were put into the cage with the singing-mouse. Whether, like some other folks, they had no appreciation of foreign airs, we have no means of answering; but alas! in spite of their silken ways, they at once set upon and murdered the little musical mouse.

These wood-mice are often called white-footed mice. They belong to a genus of the Sigmadontes, known as the *Hesperomys*, or Vesper-mice, and are indigenous to this our Western Continent. There is a number of species in the genus; but those best known are diminutive things, not so large as the house-mouse, their sides are yellowish-brown, the back considerably darker, the abdomen and feet almost snowy-white. Their home is the woods. With but little sympathy for man, they will occasionally intrude for a time into his dwelling, when, as I believe, the domestic mouse withdraws. My friend Philip J. Ryall, Esq., in the spring of 1871, when at his Florida home, near St. Augustine, was disturbed, at night, by what he supposed to be the chirping of birds in the chimney. The mystery was cleared up in an unexpected way. A very small mouse came up from a crevice in the hearth, and, with singular boldness, took position in the middle of the sitting-room floor. Here it sat up on its hind-feet, and looked around with the utmost confidence, all the time singing in a low, soft, yet really warbling style. This visit became a daily business, until it paid the penalty of its temerity by being captured. About a month after, this prodigy was intrusted to the custody of the writer. Of course, it came introduced as a "singing house-mouse." What was our astonishment at recognizing, in the little stranger, a true Hesperomys, and no house-mouse at all! It was one of the wood-mice, and among the smallest of the species. It is a female, and fully grown, yet not so large as a domestic mouse. Every pains was taken to secure the comfort and well-being of my little guest.

And what an ample reward I reaped! For a considerable time she carolled almost incessantly, except when she slept. Day and night she rollicked in tiny song, her best performances being usually at night. To me it was often a strange delight, when, having wrought into the late hours, and the weary brain had become so needful and yet so repellant of sleep, I lay down, and gave myself up to listening to this wee songster, whose little cage I had set on a chair by my bedside. To be sure, it was a low, very low, sweet voice. But there was, with a singular weirdness, something so sweetly merry, that I would listen on, and on, until I would fall asleep in the lullaby of my wingless and quadrupedal bob-o'-link. The cage had a revolving cylinder or wheel, such as tame squirrels have. In this it would run for many minutes at a time, singing at its utmost strength. This revolving cage, although ample as regards room, was not over three and a half inches long, and two and a half inches wide. Although I have now been entertained by these pretty little melodies for a year, yet I would not dare redescribe them. In the *American Naturalist*, for December, 1871, the music is given with that elaboration which was possible under impressions so novel and delightful. She had two especially notable performances. I called these *rôles*—one the *wheel-song*, because it was usually sung while in the revolving cylinder, and the other the *grand rôle*. A remarkable fact in the latter is the scope of the little creature's musical powers. Her soft, clear voice falls an octave with all the precision possible; then, at its wind-up, it rises again into a very quick trill on C sharp and D.

I must quote from the above a paragraph entire. Let me simply premise that in our household this little creature goes by the pet name "Hespie."

"Though it be at the risk of taxing belief, yet I must in duty record one of Hespie's most remarkable performances. She was gambolling in the large compartment of her cage, in intense animal enjoyment. She had just woke from a long sleep, and had eaten of some favorite food, when she burst into a fulness of song very rich in its variety. While running and jumping, she carolled off, what I have called her *grand rôle;* then, sitting, she went over it again, ringing out the strangest diversity of changes, by an almost whimsical transposition of the bars of the melody; then, without, for even an instant, stopping the music, she leaped into the wheel, sent it revolving at its highest speed, and, while thus running in the wheel, she went through the wheel-song in exquisite style, giving several repetitions of it. After this, without at all arresting the singing, she returned to the large compartment, sat upright, resumed again the *grand rôle*, and put into it some variations of execution which astonished me. One measure, I remember, was so silvery and soft that I said, to a lady who was listening, that a canary able to execute that would be worth a hundred dollars. I occasionally detected what I am utterly unable to explain—a literal dual sound (a rollicking chuckling), very like a boy, whistling as he runs, drawing a stick along the pickets of a fence. So the music went on, as I listened, watch in hand, until actually *nine minutes had elapsed!* Now, the wonderful fact is, that the rest between the *rôles* was never much more than for a second of time; and, during all this singing, the muscles could be seen in vigorous action, through the entire length of the abdomen. This feat would be impossible to a professional singer; and the nearest to it that I have heard was the singing of a wild mocking-bird in a grove."

The point which I think I have demonstrated elsewhere in this matter is, the invalidity of the position taken by some, that the singing faculty of these little creatures is due to a diseased condition. The specimen above dwelt on has been for a whole year at least in perfect health. It now appears, from a late number of the *Naturalist*, that a gentleman in Maryland amused himself in breeding white mice, in the hope of raising a singer. After raising several hundred, he procured one that manifested a little musical ability. It sang in six months about half a dozen times. He says that it is in perfect health, and that its offspring are the largest and the finest, and that it is an amiable, playful little pet. This was a domestic mouse, and at best but a very moderate singer. But Hespie differs in all respects. She is the wild wood-mouse, and an incessant singer, and one of very remarkable parts in musical ability. She has also many interesting differences pertaining to habits and food. Cheese is not relished by her; but insects and grass are choice morsels. Her greatest luxuries are worms, and maggots out of nuts and fruit. She will take an earthworm into her little hands, and, holding it up to her mouth at one end, will cause it to gradually shorten and disappear, as some bipeds from Faderland might dispatch a favorite sausage. Her agility in catching flies is wonderful; she leaps at the object, and rarely misses a catch.

A singular fact is this: she is subject to occasional attacks of nostalgia. They are brought about in this way: For her health, as well as for our comfort, the cage must be regularly cleansed. This is at all times annoying to her. But occasionally the little bed of cotton-wool, in a small box in her large compartment, is taken out, and burnt, and a new one is supplied. This occurs about once a month, and invariably this change of bed is followed by a day or two of homesickness. She is unhappy, seems not to like the situation, tears her bed up, pulls it out, then pulls it in, in part, and goes off somewhere, and lies down, a habit she does not like to indulge in outside of the privacy of her little box. The tiny being is undoubtedly sick, and has not much appetite. After at most two days, she becomes reconciled, and is as merry and rollicking as ever, proving that to animals and men contentment is a continual feast.

She is not without imitation, for she has appeared to listen to, and to aim to imitate, the canary's song. Of course, imitations are seldom to be admired, and perhaps, even in music, mimicry may be set down as in the main base. I have known her to be excited into song by the playing of the piano, especially if the playing was in the natural key. There are many things that might be said, but the proverb on brevity is suggestive; so we will add only one thing more, and we regret that this last say is not in keeping with the Christian moral of speaking the last word kindly. Alas for little Hespie! She repels every gentle approach, even the hands that lovingly minister to her comforts; and, notwithstanding her great accomplishments, she is a capricious and unamiable little vixen.

THE STUDY OF HUMAN NATURE.

By Rev. H. W. BEECHER.

MY impression is, that preachers are quite as well acquainted with human nature as the average of well-informed citizens, but far less than lawyers, or merchants, or teachers, or, especially, politicians. I mean that, taking our American clergy generally, in their practical relations with society, while on the one hand they have shown themselves to be shrewd, discreet, and sagacious—and if their separate functions had lain in the conduct of affairs, socially, there would be but little to be criticised on the whole—yet, as *preachers*, they stand off toward the bottom of the list among students of human nature.

The school of the future (if I am a prophet, and I am, of course, satisfied in my own mind that I am!) is what may be called a *Life School*, with a style of preaching that is to proceed, not so much upon the theory of the sanctity of the Church and its ordinances, or upon a preëxisting system of truth which is in the Church somewhere or somehow, as upon the necessity for all teachers, first, to study the strengths and the weaknesses of human nature minutely; and then to make use of such portions of the truth as are required by the special needs of man, and for the development of the spiritual side of human nature over the animal or lower side—the preparation of man in his higher nature for a nobler existence hereafter. It is a life-school in this respect, that it deals not with the facts of the past, except in so far as they can be made food for the present and factors of the life that now is; but rather studies to understand *men*, and to deal with them face to face and heart to heart—yea, even to mould them as an artist moulds his clay or carves his statue. And, in regard to such a school as that, while there has been a good deal done incidentally, the revised procedure of education yet awaits development and accomplishment; and I think that our profession is in danger, and in great danger, of going under, and of working effectively only among the relatively less informed and intelligent of the community; of being borne with, in a kind of contemptuous charity, or altogether neglected, by the men of culture who have been strongly developed on their moral side—not their moral side as connected with revealed religion, but as connected rather with human knowledge and worldly wisdom. The question, then, comes up, Do men need this intimately practical instruction; and, if so, must there be to meet it this life-school of preachers?

It is said, by some, "Has not Christianity been preached by plain men, who did not understand so very much about human nature, in every age of the world?" It has; and what has eighteen hundred years to show for it? To-day, three-fourths of the globe is heathen, or but semi-civilized. After eighteen hundred years of preaching of the faith under the inspiration of the living Spirit of God, how far has Christianity gone in the amelioration of the condition of the race? I think that one of the most humiliating things that can be contemplated, and one of the things most savory to the skeptical, and which seems the most likely to infuse a skeptical spirit into men, is to look at the pretensions of the men who boast of the progress of their work, and then to look at their performances. I concede that there has been a great deal done, and there has been a great deal of preparation for more; but I say that the torpors, the vast retrocessions, the long lethargic periods, and the wide degeneration of Christianity into a kind of ritualistic mummery and conventional usage, show very plainly that the past history of preaching Christianity is not to be our model. We must find a better mode of administration.

We need to study human nature, in the first place, because it is the Divine nature which we are to interpret to men. Divine attribute corresponds to our idea of human faculty. The terms are analogous. You cannot interpret the Divine nature except through some knowledge of human nature. There are those who believe that God transcends men, not simply in quality and magnitude, but in kind. Without undertaking to confirm or deny this, I say that the only part of the Divine nature that we can understand is that part which corresponds to ourselves, and that all which lies outside of what we can recognize is something that never can be interpreted by us. It is not within our reach. Whatever it may be, therefore, of God that, by searching we can find out, all that we interpret, and all that we can bring, in its moral influence, to bear upon men, is in its study but a higher form of mental philosophy.

Now, let us see what government is. It is the science of managing men. What is moral government? It is moral science, or the theory upon which God manages men. What is the management of men, again, but a thing founded upon human nature? so that, to understand moral government, you are run right back to the same necessity. You must comprehend that on which God's moral government itself stands, which is human nature.

But, again, the fundamental doctrine on which our labors stand is the need of the transformation of man's nature by the Divine Spirit. This is altogether a question of pyschology. The old theological way of stating man's sinfulness, namely, "Total Depravity," was so gross and so undiscriminating, and was so full of endless misapprehensions, that it has largely dropped out of use. Men no longer are accustomed, I think, to use that term as once they did. That all men are sinful, is taught; but "What is meant by 'sinful?'" is the question which immediately comes back. Instantly, the schools begin to discuss it. Is it a state of the fibre of the substance or the soul? Is it any aberration, any excess, any disproportion of natural elements? Wherein does the fault lie? What is it? The moment you discuss this, you are discussing human nature. It is the mind you are discussing. In order to know what is an aberration, you must know what is normal. In order to know what is in excess, you must know what is the true measure. Who can tell whether a man is selfish, unless he knows what is benevolent? Who can tell whether a man has departed from the correct idea unless he has some conception of that idea? The very foundation on which you stand to-day necessitates knowledge of man as its chief basis.

Consider, too, how a minister, teaching the moral government of God, the nature of God, and the condition of man and his necessities, is obliged to approach the human soul. Men are sluggish, or are so occupied and filled with what are to them important interests, that, ordinarily, when a preacher comes into a community, he finds it either slumbering, or averse to his message, or indifferent to it; and, in either case, his business is to stimulate their moral nature. But how shall he know the art of stimulating man's moral nature, who has never studied it? You must arouse men and prepare them to be moulded. How can you do it, if you know nothing about them?

A man who would minister to a diseased body must have an accurate knowledge of the organs, and of the whole structure of the body, in a sanitary condition. We oblige our physicians to know anatomy and physiology. We oblige them to study morbid anatomy, as well as normal conditions. We say that no man is prepared to practise without this knowledge, and the law interferes, or does as far as it can, to compel it. Now, shall a man know how to administer to that which is a thousand times more subtle and important than the body, and which is the exquisite blossom of the highest development and perfection of the human system, namely, the mind in its modern development—shall a man assume to deal with that, and raise and stimulate it, being ignorant of its nature? A man may know the Bible, from Genesis to Revelation; he may know every theological treatise from the day of Augustine to the day of Dr. Taylor; and, if he does not understand human nature, he is not fit to preach.

Suppose a man should undertake to cut off your leg because he had been a tool-maker? He had made lancets, probes, saws, and that sort of thing all his life; but he had never seen a man's leg amputated, and did not know exactly where the arteries or veins lie. Suppose he should think that making surgeons' tools fitted him to be a surgeon—would it? The surgeon must know his tools and how to handle them, but he must know, too, the system on which he is going to use them. And shall a man, charged with the care of the soul, sharpen up his understanding with moral distinctions and learned arguments, and know all about the theories of theology, from Adam down to our day, and yet know nothing of the organism upon which all these instrumentalities are to be used? Shall he know nothing about man himself? The student who goes out to his work with a wide knowledge of theology, and no knowledge of human nature, is not half fitted for his duty. One reason why so many succeed is, that, although they have no formal instruction in human nature, they have learned much in the family and in the school and by other indirect methods, and so have a certain stock—I might say an illegitimate stock—of knowledge, but which was not provided in the system of their studies.

If I might be allowed to criticise the general theological course, or to recommend any thing in relation to it, I should say that one of the prime constituents of the training should be a study of the human soul and body from beginning to end. We must arouse and stimulate men, and seek to bring them into new relations with truth, with ourselves, and with the community.

There is another consideration that we cannot blink, and that is, that we are in danger of having the intelligent part of society go past us. The study of human nature is not going to be left in the hands of the church or the ministry. It is going to be a part of every system of liberal education, and will be pursued on a scientific basis. There is being now applied among scientists a greater amount of real, searching, discriminating thought, tentative and experimental, to the whole structure and functions of man and the method of the development of mental force, than ever has been expended upon it in the whole history of the world put together. More men are studying it, and they are coming to results, and these results are starting, directly or indirectly, a certain kind of public thought and feeling. In religion, the psychological school of mental philosophers are not going to run in the old grooves of Christian doctrine. They are not going to hold the same generic ideas respecting men; and if ministers do not make their theological systems conform to facts as they are—if they do not recognize what men are studying, the time will not be far distant when the pulpit will be like the voice crying in the wilderness. And it will not be, "Prepare the way of the Lord," either. This work is going to be done. The providence of God is rolling forward a spirit of investigation that Christain ministers must meet and join. There is no class of people upon earth who can less afford to let truth run ahead of them than Christian ministers. You cannot wrap yourselves in professional mystery, for the glory of the Lord is such that it is preached with power throughout all the length and breadth of the world, by these investigators of His wondrous creation. You cannot go back and become an apostle of the dead past, drivelling after ceremonies, and letting the world do the thinking and studying. There must be a new spirit infused into the ministry. Some men are so afraid that, in breaking away from the old systems and original forms and usages, Christianity will get the go-by! Christianity is too vital, too really divine in its innermost self, to fear any such results. There is no trouble about Christianity. You take care of yourselves and of men, and learn the truth as God shows it to you all the time, and you need not be afraid of Christianity—that will take care of itself. You might as well be afraid that battles would rend the sky, or that something would stop the rising and setting of the sun. The power of Divine love and mercy is not going to be stopped, and will certainly not be stopped, by the things that are true.

You cannot afford to shut your eyes to the truths of human nature. Every Christian minister is bound to fairly look at these things. Every scientific man who is studying human nature is bound to open his eyes and ears, and to study all its phenomena. I read that Huxley refused to attend a *séance* of spiritualists. He said, contemptuously, that it was a waste of time, and gave expression to other sentiments of disdain. I am not an adherent of the spiritual doctrines; I have never seen my way clear to accept them. But phenomena which are wrapping up millions of men, and vitally affecting their condition, are not to be disdained by scientific men, whose business it is to study phenomenology of all kinds. No scientific man can excuse himself from examining them. He may say that he has no time to do it, and that some other man must investigate them. That would be right. All men cannot do all things. But to speak of any thing of this kind with contempt is not wise. I am not afraid to look at this thing, or any thing. I am not afraid that we are going to have the New Testament taken away from us. We must be more industrious in investigation, more honest in deduction, and more willing to take the truth in its new fulness; and we must be imbued with that simplicity in faith and truth which we inculcate in our people.

With this general statement of the necessity of the study of the human nature and mind in its structure and functions, I will pass on to the next point, which is, the way in which this study is to be prosecuted. How are we going about it?

In the first place, you must study facts; scientifically. I think that such works as Bain's, while criticisable in many directions, nevertheless are works of very great interest, as showing a wise tendency in the investigation of the mind of man—the founding of mental philosophy upon physiology. I do not commend the system in all its particulars, but I speak of its tendency, which is in the right direction. I would say the same, also, of Herbert Spencer's works. There is much in him that I believe will be found sovereign and noble in the final account of truth, when our knowledge of it is rounded up. There was never a field of wheat that ripened which did not have a good deal of straw and husk with it. I doubt not but Herbert Spencer will have much straw and husk that will need to be burned. Nevertheless, the direction he is moving in is a wise one, which is the study of human nature—of the totality of man.

It was believed once that man did not think by the brain. I believe that notion has gone by. Most men now admit that the brain is the organ of the mind. It is held that it cannot be partitioned off into provinces, and that there are no external indications of its various functions. I shall not dispute that question with you. It is now generally conceded that there is an organization which we call the nervous system in the human body, to which belong the functions of emotion, intelligence, and sensation, and that that is connected intimately with the whole circulation of the blood, with the condition of the blood as affected by the liver, and by aëration in the lungs; that the manufacture of the blood is dependent upon the stomach: so a man is what he is, not in one part or another, but all over; one part is intimately connected with the other, from the animal stomach to the throbbing brain; and when a man thinks, he thinks the whole trunk through. Man's power comes from the generating forces that are in him, namely, the digestion of nutritious food into vitalized blood, made fine by oxygenation; an organization by which that blood has free course to flow and be glorified; a neck that will allow the blood to run up and down easily; a brain properly organized and balanced; the whole system so compounded as to have susceptibilities and recuperative force; immense energy to generate resources and facility to give them out—all these elements go to determine what a man's working power is. And shall a man undertake to study human nature, every thing depending upon his knowledge of it, and he not study the prime conditions under which human nature must exist?

I have often seen young ministers sit at the table, and even those of sixty years of age, eating out of all proportion, beyond the necessities of their systems; and I have seen, on the other hand, ministers who ate below the necessities of their systems, under a vague impression that sanctifying grace wrought better on an empty stomach than on a full one. It seems to me that all Divine grace and Divine instruments honor God's laws everywhere; and that the best condition for grace in the mental system is that in which the human body is in a perfect state of health. That is a question which every man can best settle for himself. Some men under-sleep and some over-sleep; some eat too much, and some too little. Some men use stimulants who do not need them, while others avoid them who need them and would be better for their use. There is a vast amount of truth relative to the individual that is not studied by the minister, though it ought to be, as to the incoming and the outflow of force. Some clergymen prepare themselves to preach on Sunday by sitting up very late on Saturday night, and exhausting their vitality, thus compelling themselves to force their overtasked powers to extraordinary exertion to perform their Sabbath duties; which entails upon them the horrors of Blue Monday, the result of a spasmodic and drastic excitement. It is, and it ought to be, a purgatory to them. You must study yourselves as men. Is there no self-knowledge that can be acquired, so that a man shall know how to be merciful to his beast?

You see that whatever relates to the whole organization of the human body and its relations to health and to perfect symmetry must be studied, for all these relations are intimate, and concern both your own working powers and the material among men that you will have to work on.

In studying mental philosophy after this fashion, I would not have you ignore metaphysics. The perceptions of those subtle relations, near and remote, specific and generic, that obtain among spiritual facts of different kinds, I understand to be metaphysics; and that, I suppose, must be studied. I think it sharpens men and renders them familiar with the operations of the human mind, if not carried too far, and gives them a grasp and penetration that they would not get otherwise. It is favorable to moral insight, when developed in connection with the other sides of human nature. While I say that you ought to study mental philosophy with a strong physiological side to it, I do not wish it to be understood that I decry mental philosophy with a strong metaphysical side to it.

There is one question beyond that. While studying mental philosophy for the sake of religious education, and studying both sides of it, you are doing one thing; but when the question comes up *how* to study mental philosophy, I do not know any thing that can compare in facility of usableness with Phrenology. I do not suppose that phrenology is a perfect system of mental philosophy. It hits here and there. It needs revising, as in its present shape it is crude; but, nevertheless, when it becomes necessary to talk to people about themselves, I know of no other nomenclature which so nearly expresses what we need, and which is so facile in its use, as phrenology. Nothing can give you the formulated analysis of mind, as that can. Now let me say, particularly, a few things about this, and personally, too. I suppose I inherited from my father a tendency or intuition to read man. The very aptitude that I recognize in myself for the exercise of this power would indicate a preexisting tendency. In my junior college year I became, during the visit of Spurzheim, enamoured of phrenology. For twenty years, although I have not made it a special study, it has been the foundation on which I have worked. Admit, if you please, it is not exactly the true thing; and admit, if you will, that there is little form or system in it; yet I have worked with it the same as botanists worked with the Linnæan system of botany, the classification of which is very convenient, although an artificial one. There is no natural system that seems to correspond to human nature so nearly as phrenology does.

For example, you assume that a man's brain is the general organ of the spiritual and intellectual functions.

I see a man with a small brow and big in the lower part of his head, like a bull, and I know that that man is not likely to be a saint. All the reasoning in the world would not convince me of the contrary, but I would say of such a man, that he has very intense ideas, and will bellow and push like a bull of Bashan. Now, practically, do you suppose I would commence to treat with such a man by flaunting a rag in his face? My first instinct in regard to him is what a man would have if he found himself in a field with a wild-bull, which would be to put himself on good manners, and use means of conciliation, if possible.

On the other hand, if I see a man whose forehead is very high and large, but who is thin in the back of the head, and with a small neck and trunk, I say to myself, "That is a man, probably, whose friends are always talking about how much there is in him, but who never does any thing. He is a man who has great organs, but nothing to drive them with. He is like a splendid locomotive without a boiler."

Again, you will see a man with a little bullet-head, having accomplished more than that big-headed man, who ought to have been a strong giant and a great genius. The bullet-headed man has outstripped the broad-browed man in every thing he undertook; and people say, "Where is your phrenology?" In reply, I say, "Look at that bullet-headed man, and see what he has to drive his bullet-head with!" His stomach gives evidence that he has natural forces to carry forward his purposes. Then look at the big-headed man. He can't make a spoonful of blood in twenty-four hours, and what he does make is poor and thin. Phrenology classifies the brain-regions well enough, but you must understand its relations to physiology, and the dependence of brain-work upon the quantity and quality of blood that the man's body makes.

You may ask, "What is the use of knowing these things?" All the use in the world. If a person comes to me, with dark, coarse hair, I know he is tough and enduring, and I know, if it is necessary, that I can hit him a rap to arouse him; but, if I see a person who has fine, silky hair, and a light complexion, I know that he is of an excitable temperament, and must be dealt with soothingly. Again, if I see one with a large blue, watery eye, and its accompanying complexion, I say to myself that all Mount Sinai could not wake that man up. I have seen men of that stamp, whom you could no more stimulate to action, than you could a lump of dough by blowing a resurrection-trump over it.

Men are like open books, if looked at properly. Suppose I attempt to analyze a man's deeds; I can do it with comparative facility, because I have in my eye the general outline of the man's disposition and mental tendencies. A deed is like a letter stamped from a die. The motive that directs the deed is like the matrix that moulds the stamp. You may know the mould from the impression made by the stamp. You must know what men are in order to reach them, and that is a part of the science of preaching. If there is any profession in the world that can afford to be without this practical knowledge of human nature, it certainly is *not* the profession of a preacher.—*Abridged from the Christian Union.*

ASTRO-METEOROLOGY.

By Prof. DANIEL KIRKWOOD, LL.D.

THE theory that shooting-stars, meteoric stones, and even comets, consist of matter, which has been expelled with enormous force from the solar surface, was proposed by Prof. Hackley, as long since as 1860.[1] A similar hypothesis in regard to *comets* has also been advanced by Prof. William A. Norton.[2] In the present paper, it is proposed to consider, first, the evidence derived from recent discoveries in favor of this theory;[3] and, secondly, the indications afforded by observed phenomena in regard to the history of certain meteoric streams:

1. The observations of Zollner, Respighi, and others, have indicated the operation of stupendous eruptive forces beneath the solar surface. The rose-colored prominences, which Janssen and Lockyer have shown to be masses of incandescent hydrogen, are regarded by Prof. Respighi as phenomena of eruption. "They are the seat of movements of which no terrestrial phenomenon can afford any idea; masses of matter, the volume of which is many hundred times greater than that of the earth, completely changing their position and form

[1] Proc. Am. Assoc. for the Advancement of Science, Fourteenth Meeting, 1860.

[2] Treatise on Astronomy, fourth edition, Appendix, p. 437.

[3] The view that the fixed stars, as well as the sun, expel meteoric matter to the interstellar spaces, may be regarded as merely an extension of the theory here stated.

in the space of a few minutes." The nature of this eruptive force is not understood. If caused, as we may reasonably assume, by chemical combinations among the solar elements, it was probably in active operation long before the sun had contracted to its present dimensions.

2. With an initial velocity of projection equal to 380 miles per second, the matter thrown off from the sun would be carried beyond the limits of the solar system, never to return. With velocities somewhat less, it would be transported to distances corresponding to those of the aphelia of the periodic comets.

3. In the explosion witnessed by Prof. Young on the 7th of September, 1871,[1] the mean velocity between the altitudes of 100,000 and 200,000 miles was 166 miles per second. This indicates a velocity of about 200 miles per second at the lower elevation, and hence a considerably greater *initial* velocity. An equal force when the sun had but little more than twice its present diameter would have been sufficient to carry the projected matter beyond the orbit of Neptune.

4. This eruptive force, whatever be its nature, is probably common to the sun and the so-called fixed stars. If so, the dispersed fragments of ejected matter ought to be found in the spaces intervening between sidereal systems. Accordingly, the phenomena of comets and meteors have demonstrated the existence, in immense numbers, of extremely small cosmical bodies in the portions of space through which the solar system is moving. The origin of such masses, their collocations in groups, and their various physical characteristics, would seem to be satisfactorily accounted for by the theory under consideration.

5. According to Mr. Sorby,[2] the microscopic structure of the aërolites he has examined points evidently to the fact that they have been at one time in a state of fusion from intense heat—a fact in striking harmony with this theory of their origin.

6. The velocity with which some meteoric bodies have entered the atmosphere has been greater than that which would have been acquired by simply falling toward the sun from any distance, however great. On the theory of their sidereal origin, this excess of velocity has been dependent on the primitive force of expulsion.

7. A striking argument in favor of this theory may be derived from the researches of the late Prof. Graham, considered in connection with those of Dr. Huggins and other eminent spectroscopists. Prof. Graham found large quantities of hydrogen confined in the pores or cavities of certain meteoric masses. Now, the spectroscope has shown that the sun's rose-colored prominences consist of immense volumes of incandescent hydrogen; that the same element exists in great abundance in many of the fixed stars, and even in certain nebulæ; and that the star in the Northern Crown, whose sudden outburst

[1] *Boston Journal of Chemistry*, November, 1871.

[2] Proceedings of Royal Society, January, 1864.

in 1866 so astonished the scientific world, afforded decided indications of its presence.

Dr. Weiss, of Vienna, regards comets as the original bodies by whose disintegration meteor-streams are gradually formed.[1] In this respect his views differ somewhat from those of Schiaparelli.[2] "Cosmical clouds," he remarks, "undoubtedly appear in the universe, but only of such density that in most cases they possess sufficient coherence to withstand the destructive operation of the sun's attraction, not only up to the boundaries of our solar system, but even within it. Such cosmical clouds will always appear to us as comets when they pass near enough to the earth to become visible. Approaching the sun, the comet undergoes great physical changes, which finally affect the stability of its structure: it can no longer hold together: parts of it take independent orbits around the sun, having great resemblance to the orbit of the parent comet. With periodical comets, this process is repeated at each successive approach to the sun. Gradually the products of disintegration are distributed along the comet's orbit, and if the earth's orbit cuts this, the phenomenon of shooting-stars is produced."

The characteristics of the different meteor-streams afford interesting indications in regard to their relative age, the composition and magnitude of their corpuscles, etc. etc. Thus, if we compare the streams of August 10th and November 14th, we shall find that the latter probably entered our system at a comparatively recent epoch. We have seen that at each return to perihelion the meteoric cluster is extended over a greater arc of its orbit. Now, Tuttle's comet and the August meteors undoubtedly constituted a single cluster previous to their entering the solar domain. It is evident, however, from the annual return of the shower during the last 90 years, that the ring is at present nearly if not quite continuous. That the meteoric mass had completed many revolutions before the ninth century of our era is manifest from the frequent showers observed between the years 811 and 841. At the same time, the long interval of 83 years between the last observed display in the ninth century, and the first in the tenth, indicates the existence of a wide chasm in the ring no more than 1,000 years since.

The fact that the meteors of the November stream are diffused around only a small portion of their path, seems to justify the conclusion that the transformation of their orbit occurred at a date comparatively recent. Leverrier has calculated that the meteoric cloud passed very near Uranus about A. D. 126. He regards it, therefore, as highly probable that this was its first approach to the centre of our system.[3]

[1] *Astronomische Nachrichten*, Nos. 1710, 1711.

[2] For a condensed statement of Schiaparelli's theory, see an interesting article by Prof. Newton, in *Silliman's Journal* for May, 1867.

[3] *Comptes Rendus*, lxiv., p. 94.

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It is proper to remark, however, that Newton's period of the meteors exceeds Oppolzer's period of the comet by twenty-seven days, and that each is liable to some uncertainty. But for the authority of the distinguished French astronomer, the writer would have fixed upon the year 43 B. C. as the probable epoch at which the cometary mass was thrown into its present orbit. Be this as it may, it undoubtedly suffered considerable perturbation about A. D. 126.

The question of the planetary disturbance of the meteor-streams is one of great interest. The November group has its perihelion at the orbit of the earth; its aphelion at that of Uranus. Both planets, therefore, at each encounter with the current not only appropriate a portion of the meteoric matter, but entirely change the orbits of a large number of meteors. In regard to the devastation produced by the earth in passing through the cluster, it is sufficient to state that, according to Weiss, the meteor orbits resulting from the disturbance will have all possible periods from 21 months to 390 years. It may be regarded, therefore, as an additional evidence of the recent introduction of this meteor-stream into the solar system that the comet of 1866, which constitutes a part of the cluster, has not been deflected from the meteoric orbit by either the earth or Uranus. It is, moreover, interesting to remark that the comet and Uranus will be in close proximity about the year 1983; perhaps so close as to throw the former into a new orbit.

As the comets 1862, III., and 1866, I., were doubtless more brilliant in ancient than in modern times, and as the former was conspicuously visible to the naked eye, it seems not improbable that they may have been formerly observed. The epochs of their ancient returns agree in several instances with those of comets of which the recorded observations are insufficient to determine their elements.

The writer as long since as 1861 suggested the probable disintegration of Biela's comet and the distribution of its matter around the orbit.[1] The earth crosses the path of these cometary fragments about the 29th or 30th of November—a well-known aërolitic epoch. It is also worthy of notice that an extraordinary number of shooting-stars was observed by M. Heis, at Aix-la-Chapelle, on the 29th of November, 1850.

From the fact that the earth, about the 20th of April, very nearly crosses the orbit of the comet 1861, I., a connection between the latter and the meteors of that epoch has been suggested by some astronomers. The period of the comet is, according to Oppolzer, 415 years. The first recorded shower of the April meteors occurred in the year 687 B. C.; the last great display in 1803 A. D. The interval is equal to six periods of 415 years. It is evident, however, that, if these meteors and the first comet of 1861 originally constituted a single group,

[1] *Danville Quarterly Review*, December, 1861. *See* also "Meteoric Astronomy," pp. 54, 55, 126–128.

they must have entered the solar system at a very remote epoch. The writer has elsewhere given reasons for regarding 28 years as nearly the true meteoric period.[1]

In its descending node, the orbit of Halley's comet is but 3,000,000 miles from that of the earth. Our planet passes this point of nearest approach a little before the middle of May. Is it not probable that some of the meteoric stones of May 8th to 14th[2] have been moving in nearly the same cometary orbit?

It has been pointed out by Dr. Weiss that the height at which the meteors of different rings appear and disappear depends, to some extent, on their respective velocities. The meteors of November 14th, for instance, move much more rapidly than those of August 10th, and are also observed at a greater altitude. Further observations of this interesting cluster can scarcely be expected till near the close of the present century.

IRON AND CIVILIZATION.[3]

BY ABRAM S. HEWITT, ESQ.

MR. PRESIDENT AND GENTLEMEN: To me is assigned the honor of bidding you welcome to the city of New York, on this, the occasion of our first annual meeting, and I am sure that you will find yourselves made welcome by all who have the honor and prosperity of the city at heart. For New York, although far from being the cherished home of science and art, comprehends that its growth and its future greatness depend upon the development of the natural resources of the country of which it is the commercial metropolis; and it is sufficiently enlightened to understand the necessity of scientific knowledge and trained experience for the attainment of the most useful and profitable results from industrial enterprises. No body of men can understand better than you that capital is essential to the development of natural resources on the scale demanded by modern civilization; but capital does not always comprehend as fully that science and experience are essential for the profitable use of money in the vast industrial undertakings of our day, and hence result great waste of resources and disastrous failures. A few considerations may serve to shed some light on this subject, of such material consequence to science and capital; and, at the risk of overstepping the conventional limits of a formal welcome, I venture briefly to suggest them as the means of establishing a common ground of sympathy and fellowship

[1] Proceedings of American Philosophical Society, March 4, 1870.
[2] "Meteoric Astronomy," p. 72.
[3] An address before the American Institute of Mining Engineers.

between the men of science and the men of business, and I am sure that you will pardon me if I draw my illustrations from that subject with which I am most familiar—the production of iron.

In 1856 I had occasion to trace the history of the manufacture of iron, and established what may be termed its law of development, rather rude indeed, but plainly dependent upon the growth of population and the spread of civilization throughout the world. At that time the annual production of iron had reached about 7,000,000 tons, of which Great Britain produced 3,500,000 tons, and the United States about 1,000,000 tons. The consumption of Great Britain was 144 pounds, and of the United States 84 pounds, while the average consumption of the world was only 17 pounds, per head, of population. It was shown that the consumption per head was steadily on the increase, and that consequently the annual production was enlarging so rapidly as to double once in 14 years; and it was predicted, after making due allowances for all the drawbacks, such as the wars which have unhappily taken place in the interval, beyond any possible expectation, that in 1875 the production of iron would surely reach 14,000,000 tons. The actual returns show that in 1871 the production amounted to 13,500,000 tuns, and in 1872 the limit 14,000,000 will undoubtedly be passed, so that the estimate made in 1856 is more than realized. Meanwhile the consumption has risen in England to 200 pounds, in the United States to 150 pounds, and in the whole world to 30 pounds, per head. It is not possible to convey a more striking idea of the progress of the world, during the last 17 years, than this statement affords. The consumption of iron measures the progress of civilization, and it is impossible not to believe that the whole world will ultimately require as much iron per head as we now use in the United States, when a total annual production of over 70,000,000 tons will be required. But, if these figures seem to be at all wild, no one can for a moment doubt that the next 17 years will double the present annual production of iron, bringing it up to 28,000,000 tons per annum; and I feel quite safe in asserting that the beginning of the twentieth century, which some among you may hope to see, will witness an annual production of over 40,000,000 tons.

You need not be told that iron is produced at less money-cost in Great Britain than in any other quarter of the globe. This has enabled her to produce about one-half of the total annual make. Of the 7,000,000 tons made in 1855, Great Britain produced 3,585,906 tons, and, of the 13,500,000 tons produced last year, she turned out nearly 7,000,000 tons. It it is evident, however, that there are limits in the way of raw material and labor beyond which Great Britain cannot go. While I see no reason to doubt that there will be a steady increase in production, it is evident that she will not be able to supply hereafter, as heretofore, so much as half the annual wants of the world for iron. But, allowing this proportion to Great Britain, there will still remain

14,000,000 tons to be made by the rest of the world. The history of the trade, as well as the natural resources of the several nationalities, prove that the bulk of this additional product can only be made in the United States. We are, in fact, the only people who have kept pace with Great Britain in the ratio of increase. In 1855, when Great Britain produced 3,500,000 tons, we produced 1,000,000 tons. In 1872, when Great Britain will produce 7,000,000 we produce 2,000,000 tons —the quantity produced in Great Britian in 1847, showing that we are only 25 years in arrear of her magnificent production. At the same rate, therefore, we could make 7,000,000 tons in 1897. But, as Great Britain cannot possibly maintain her rate of increase, there does not seem room for a doubt that our annual production will reach at least 10,000,000 and will probably amount to 15,000,000 tons before the close of the present century. This means that 25,000,000 to 40,000,000, tons of iron ore shall be annually extracted from our mines, and that our coal-production will exceed 100,000,000 tons per annum, required for iron and other branches of industry. It means that an investment of capital to the amount of $500,000,000 at least, and probably $1,000,000,000, shall be made in opening mines, erecting works, and supplying the requisite machinery of production. New York is already the financial centre of the American Continent, and is destined to be the main distributor of capital for the world. This vast sum of money will therefore be drawn from the accumulations of capital controlled in New York, and its productive results will depend mainly upon the judgment and skill displayed in its expenditure. Here, then, is the common ground on which Capital and Science must meet and shake hands, and be henceforth inseparable friends. But, if it be the mission of science thus to reconcile capital with industry, it is the still higher and nobler mission of science to reconcile industry with capital. The world is full of the conflict between capital and labor. Where there should be peace, there is war. Where Nature intended an absolute harmony, there is utter discord. For one, I am free to say, after the most careful investigation, and very extensive observation, that iron has heretofore been made at too low a cost in foreign countries to allow the workmen engaged in its production a fair share of the necessaries and comforts of life. This is due to the fact that the possession of virgin resources in coal and iron made it easy to increase production beyond the present wants of society. The resulting competition has had the effect to reduce prices to so low a point that proper wages could not be paid, and mankind has been enabled to get cheap goods at the expense of humanity itself.

I thank God, reverently and with gratitude unspeakable, that this day has passed, I trust, forever. These virgin resources are mainly exhausted, and it is no longer possible in Europe, at least, to produce more iron than the world requires; prices have risen; the workmen are demanding and receiving a more reasonable reward for their labor, and it now only remains for them to fit themselves and their families for a rational use and enjoyment of the fruits of their toil. In looking back over the sad and gloomy fields of suffering among the European mines and works which I have traversed so often, and in looking forward to the more cheerful prospect now spread out before the sons of toil, I am tempted to exclaim with the patriarch: "Lord, now lettest Thou Thy servant depart in peace, for mine eyes have seen Thy salvation."

But cheap iron is a blessing to mankind, and to deprive the world of it is a calamity so serious that no one can contemplate it without a feeling of reluctance. Here, again, science steps in to reconcile high wages with cheap iron. It is the mission of science to cheapen processes, which enables wages to be raised without enhancing the cost of the product of the world. The history of industry is full of examples of the truth of this proposition, but for our purpose the Bessemer process affords its best illustration. By the genius of one man the whole world is enriched, its comforts enlarged, its progress promoted, and new fields of art and industry opened to its enterprise and energy. The annual saving in carrying on the business and transportation of the world can only be measured by millions; and when equal genius is applied to the proper distribution of the savings produced by the Bessemer process, by the Danks puddler, and other economical processes that have been and will be invented, the laboring classes all over the world will be lifted out of the depths, and this earth become the paradise it was intended to be, when the Great Giver of all endowed it with so much beauty and such boundless sources of wealth, and made the forces of Nature to be the servants of man, whenever he learns how to use and govern them. You, gentlemen, have limited yourselves to the study of physical laws and their application to industry, but I hope to see the day when all over this land, and throughout the world, there will be similar associations devoting themselves with equal zeal and intelligence to the discovery of the laws upon which society should be organized, and to the application of these laws to the proper distribution of the fruits of industry among those who labor for their production; so that nowhere in the world, and least of all in this land of boundless resources, shall it be said that there are idle hands because there is no work to be done, or that there are want and misery because there is not a just division of the proceeds of industry. If then, my views in regard to the dignity and importance of your mission be correct, you have not associated yourselves together one day too soon. You can derive encouragement from the magnificent results already achieved by your sister association, the British Iron and Steel Institute, only two years your senior, which has already given to the world several volumes of papers of inestimable value, and among them that admirable treatise of J. Lowthian Bell, on "the Chemical Phenomena of Iron Smelting," wherein the laws covering the operation of the blast-furnace are placed upon settled foundations, and two continents have been made his debtor—a debt which you will gladly join with me in recognizing on the first suitable public occasion which has occurred since the completion of his great work.

Having thus briefly traced out the mission of science in our day to bring capital into productive relations with labor, and to remove the just grievances of labor, not against capital, but against its ignorant administration, and to make commodities cheap for the benefit and not at the expense of humanity, let me, in conclusion, sketch the picture which will be presented at the beginning of the next century, when our mining interests will be developed on a scale somewhat commensurate with the area of the country and the extent of its resources. As New York will be the centre of capital, so will it be the initial point of our iron and steel industry. On the shores of the Hudson River, the ores of Lake Champlain, of the valleys of Connecticut, and of the highland ranges of New York and New Jersey, will meet the anthracite coals of Pennsylvania upon conditions so favorable that New York and its vicinity must become a great metallurgical centre. Thence the chain of fire, extending across New Jersey and following the banks of the Lehigh and Schuylkill to the Susquehanna, will lead us by the margin of the coal-fields, along the outcrop of the magnetic, hematite, and fossiliferous ores which extend through Pennsylvania, Maryland, Virginia, North and South Carolina, Tennessee, Georgia, and Alabama, nearly to the Gulf, so that the light of furnace answering to furnace will never be lost sight of in the long line of over 1,000 miles! Hence, turning to the West, Missouri, Kentucky, Western Tennessee, Ohio, Indiana, and Illinois, will be all aglow with furnaces, forges, and mills, fed by the admirable fuel of the inexhaustible coal-fields of the West, and the superb ores of Missouri and Lake Superior. The waters of the great lakes will reflect the flames which will light up their margin, while to the west, along the lines of the various Pacific Railways, the newly-found coal and iron of that hitherto trackless region will form an enduring basis for the growth of industrious communities, busy cities, and teeming farms. The West coast will not be behind in the race, but an iron industry, more valuable than its mines of gold and silver, will yet supply its growing millions with the fundamental basis upon which modern civilization rests. The growth of this vast industry will be accompanied by the school-master, the preacher, and the physician. Homes of which human nature may be proud will be established in its wake, labor and Christianity will march hand in hand, binding all interests and all classes so harmoniously and so indissolubly together, that peace and good-will between capital and labor shall prevail throughout the land forever.

NERVOUS CONTROL OF ANIMAL MOVEMENTS.

FROM THE FRENCH OF M. ONIMUS.[1]

SINCE the celebrated experiments of Flourens, we know for certain that all the acts of the vegetative life in animals are completely independent of the cerebral lobes, and that an animal deprived of these continues to live as well as before, with only this difference, that it loses all will and instinct. With superior as well as inferior animals the cutting away of the cerebral lobes does not put an end to the movements which were possible before; only these movements take on particular characters. In the first place, they are more regular, and may be regarded as the true normal type, for mental influences do not modify them. The locomotive apparatus acts without restraint, and we may, therefore, say that the movements are more normal than in the normal state. In the second place, when the cerebrum is removed the movements only commence after excitations; they cannot start themselves. The frog must be put in the water to swim, and the pigeon thrown in the air to fly. In animals without a cerebrum the physiologist can determine such or such an act, limit it, arrest it; he can foresee movements, and tell in advance what will take place in such conditions, as absolutely as the chemist knows in advance the reactions he will get on mixing certain bodies.

Another peculiarity of movements that take place when the cerebral lobes are removed is, their continuation when once commenced. On the earth a frog without a cerebrum, when irritated, makes two, three, or more leaps; he rarely stops with one. Placed in the water he continues to swim till he encounters an obstacle. The pigeon continues to fly, the duck and the goose to swim. The striking thing about it is, the continuation of the state determined at first by an impulse from without; and we cannot help associating these facts, about animals deprived of their cerebral lobes, with the characteristic properties of inorganic matter. Put agoing, the animal without a cerebrum continues to move till the exhaustion of the conditions of movement, or till it encounters resistance. Put in repose, it remains inert till some exterior cause sets it in motion. It is inert living matter.

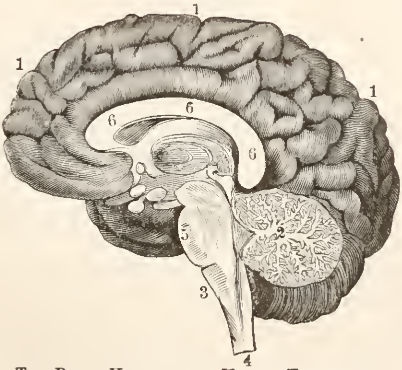
The phenomena we are about to consider are caused either by im-

[1] The importance of understanding the springs of animal movement and the conditions of their control is the reason for including the present article in THE POPULAR SCIENCE MONTHLY. It has been translated and abridged, from the *Revue Scientifique*, for the general reader, but those who wish for more detail in the presentation are referred to Dr. Hammond's *Quarterly Journal of Psychological Medicine*, for July, where the discussion will be given complete, and where kindred questions are elaborately discussed. Fig. 1 has been inserted to give a general notion of the parts of the brain referred to in the article.—ED.

pressions from without (excito-motor stimulation), or excitements from the sensorial centres (sensori-motor stimulation). In the frog, for example, the contact of the body with the earth makes him take his normal attitude, and when it is put in the water, says Vulpian, "the liquid produces a particular stimulation of all the surface of the body in contact with it; this stimulus calls into play the mechanism of swimming, and this mechanism ceases to move when the stimulus is withdrawn by taking the frog from the water."

The explanation of Vulpian is exact only within certain limits, for the frog remains motionless in the water when it encounters an obstacle, even when the stimulus of the water on its body is kept up; and, on the other hand, the surface of the pigeon's body is stimulated in the same way by the air, whether the wings are open or shut, and yet it is obliged to fly when it loses its point of support. There are,

Fig. 1.



The Right Half of the Human Encephalon.

Encephalon is the term applied to the entire nervous mass within the head—the brain with all its parts. 1, 1, 1, *cerebrum*, cerebral lobes, or hemispheres. In man, this part is large; in lower animals, much smaller; in the lowest, it is extremely small, or rudimentary. 2. *cerebellum*, or lesser brain, connected with the other parts by fibres called *peduncles;* 3, *medulla oblongata*, or bulb, which is continuous downward, as (4) the *spinal cord;* 5, the *pons Varolii* (bridge of Varoli), a mass of cross-fibres which conneet the two lobes of the cerebellum; 6, 6, 6, represent the *great commissure*, a body of cross-fibres which eonnects the two hemispheres and unifies the action of the brain. The lower portion of the brain consists of ganglia or centres of influenee, connected with sensation, motion, and the vital proeesses. In man, these parts are relatively small, and are all covered in by the hemispheres; in inferior animals, like fishes and reptiles, they form the chief portion of the brain. The reader will remember, in the following experiments, that the nervous fibres, going from the head to the body, *decussate* or cross each other at the medulla oblongata, so that the right side of the encephalon is in relation with the left side of the body, while the right side of the body is controlled by the left side of the brain.

then, other causes of stimulation besides the impression upon cutaneous nerves. These are—first, the combination or solidarity of the movements which exist among animals deprived of the cerebral lobes; and, second, the necessity of maintaining an equilibrium.

What do we mean by solidarity of movement? When a brainless frog is swimming, and we apply a solid body to one of his fore-feet, immediately the corresponding hind-foot bends and touches the body in contact with the fore-foot. It is the same if we stop the motion of the fore-foot. Reciprocally, if the frog is motionless on the surface of the water, and if we set the fore-foot in motion the hind-foot immediately begins to move, and the animal swims. In a word, to speak generally, when an animal is deprived of its cerebral lobes, if one limb begins to move the others immediately follow; if one comes to rest, the others tend to cease moving. Very seldom in these animals is the movement limited to a single member. This solidarity in the movements distinguishes animals deprived of the cerebral lobes, not only from animals with a brain, but also from those in which the spinal cord is severed at top.

In a frog with the cord cut near the cranial bulb, if we move a member, it produces no effect on the movements of the animal. If we excite one foot, only the subjacent muscles contract. If the impulse is stronger, the entire foot recedes, but the rest of the body is motionless. A lively excitation is needed to put the other feet in motion. In a word, each excitation, according to its energy, produces more or less extensive movement which may be limited to a single group of muscles. It is not so with a frog in which the spinal cord is unsevered; the movements which succeed a stimulus, whether it be strong or feeble, are always movements of the whole body.

If we put a drop of vinegar on the foot of a frog in which the cord is separated from the brain, the foot retires at first, then the other foot makes coördinated movements to get rid of the cause of irritation. The frog which has lost only its cerebral lobes commences, on the contrary, to make many leaps; afterward it moves only one or other of its feet. In the frog where the cord is severed, to each excitation succeed muscular contractions; these are always in proportion to the energy of the excitation. In the frog with the cord joined to the cerebellum alone, the excitation can take place without producing movement; but, be it feeble or strong, from the moment reflex action begins the result is the same—a movement of the body which produces a leap.

According to the excitation, to the kind of impression produced on the sensitive nerves of the skin, and on the nerves of muscular sense, there is formed among the different regions of the nervous centres a common purpose, which has for its regulator the *pons Varolii* (bridge of Varoli) and the cerebellum.

Another interesting effect now claims our notice. Among animals deprived of the cerebral lobes there is another curious and constant phenomenon, the forced and continual tendency to maintain an equilibrium. We have seen in the frog, the carp, the eel, the pigeon, the goose, mammals, etc., that every time we disturbed their centre of gravity, immediately there took place a series of coördinated movements which have the single aim of restoring the equilibrium. A decapitated insect remains always firmly posed on his feet and can take no other position. If a frog is motionless on a piece of board, and you slowly lower the board in the water so that he is immersed, in most cases, notwithstanding the stimulus of the water on the integuments, the frog will remain immovable. If, now, you slowly withdraw the board below the frog without disturbing his position, he will remain motionless; but, if you tip it one side, the frog at once wakes from his quietude. The loss of equilibrium acts more energetically than the stimulus of the water on the skin.

Tip a carp to the right or left, at once it recovers its normal attitude. If you place a duck on one of its sides, either on the ground or in the water, it at once corrects itself and comes upright. The cerebellum alone controls equilibrium, as is easily proved by experiment. When it is wounded or destroyed, the animals lie indifferently on one side or the other, and make no movements to recover the lost equilibrium. In certain cases, even, they cannot maintain an equilibrium, but tend to fall on one side.

Fig. 2.

A Frog in which the Cerebrum has been removed.

We may conclude that the movements of animals, whether superior or inferior, are produced by certain special mechanisms, or by locomotive centres, situated at the base of the brain. These centres are essentially passive; they have no spontaneous action, and come into activity only when excited by peripheral stimulus or by the brain.

We ought, then, no longer to admit, in the habitual movements which appear perfectly voluntary, a direct action of the brain on each muscle. We must remember that there exist at the base of the brain motor centres which serve to intermediate between the will and external acts. The will calls into action such or such centres, and these immediately determine the action of certain muscular groups. We know besides, that, according to the habits and education of the muscles, particular muscles can enter only with great difficulty upon isolated movements, and that the contraction of one muscle sometimes forces the contraction of others, even against the will.

There are, then, among the encephalic centres at the base of the brain, centres of coördination and direction of movement, which, so to speak, preside over the details of external acts (walking, swimming, flying, etc.), and which receive from the cerebrum only general orders to execute such or such bodily movements.

The motions of the body produced by the locomotive centres, under the influence of the brain, are of two orders: those of instinct or heredity, and those of habit. Both are inevitable, but they differ in this, that the first take place in all animals, whether young or old; while the second occur only in the old. To employ the usual expression, one is *nature;* the other, *second nature.* If you remove the cerebral lobes of a duck that has never been in the water, and then place it in water, it will swim regularly; but it will not, like an old duck deprived of its cerebrum, make certain habitual movements of the neck. The old pigeon, although without its cerebrum, when asleep places the head under the wing; and he often even dresses his feathers. Young pigeons have never been observed to perform these acts, while they execute other movements normally like old pigeons; their flight is very regular, even when they undergo the operation before leaving the nest.

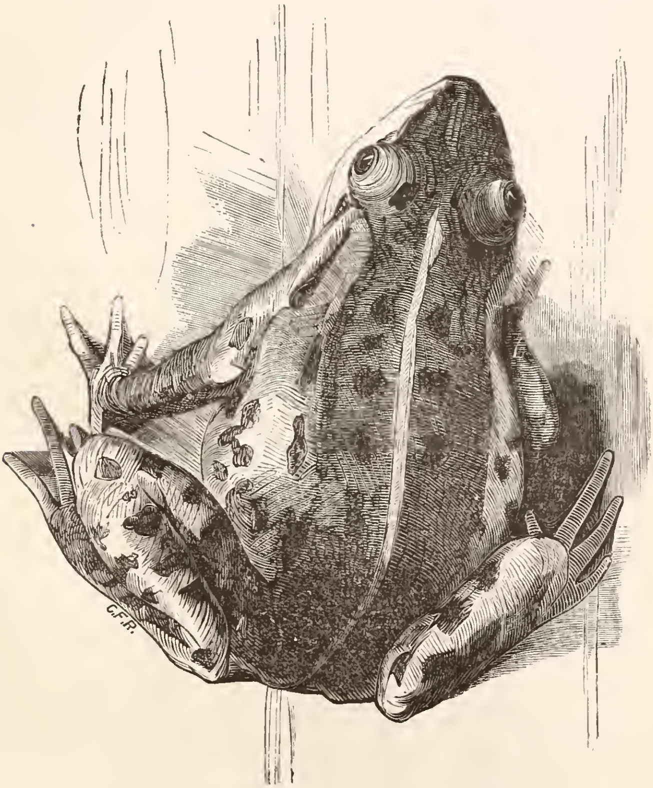
It is, then, probable that by habit there are formed in the nervous centres certain connections between cellular groups, which give rise to bodily movements that become as imperative as those which are due to instinct.

In animals deprived of the cerebrum, then, the locomotive centres are still complete, and, as we have already said, they differ from the unmutilated only by the impossibility of spontaneously beginning movement. To act, they must receive an impulse either from without or within. Exterior excitement we can produce artificially, by acting on the peripheral nerves; interior excitation is produced by the cerebrum, and we may say that, from the point of view of physiology, the cerebrum has no other function than to put in action the different motor centres. It is a simple excitant, with this important difference—that external impressions can determine only a certain number of movements, while the brain provokes an immense variety.

Let us now consider the movements of rotation, which follow from wounds of portions of the encephalon. They are of two distinct types: the one is a rotary movement round a circle, the other a motion of rolling or spinning. In the first case, the animal remains in his normal attitude, but tends always to go to one side, and describe an orbit more or less extended. In the second case, the animal can progress but little in moving himself. When he attempts to move, he is forced into a revolving motion, and turns on himself like a ball. The former movements are chiefly produced by lesions of the encephalon, and were obtained very neatly in a frog from which were removed the cerebral lobes of the left side. The movements were made from the left side toward the right.

What fixed attention at first in the attitude of this frog was, that all the right part of the body had the carriage and aspect of a frog without a cerebrum (Fig. 2). The hind-foot of this side approached the body more, and was gathered in a heap, as shown in Fig. 3, while the fore-foot was equally drawn up, and had the position that we have

Fig. 3.



A Frog that has lost the Left Half of the Cerebrum.

seen to be constant in frogs in which the cerebrum had been removed.

At the same time, the entire animal leaned a little to the right side. This inclination of the body is neither constant nor inevitable with animals which have only the movements in a circle; it is, on the contrary, constant and forced with those that have the turning motion.

The attitude of this frog changed, and was even reversed, when it was chloroformed; the left side, which was more drawn up, where the muscles experienced a tonic contraction predominating over those of the right side, became then more feeble. This effect became more and more pronounced in proportion as the chloroform took effect, up to the time when the two sides were completely affected; then the frog would no longer rest on his fore-feet, and the hind-feet remained extended and motionless. In proportion as the anæsthesia disappeared, the feet of the healthy side folded themselves and approached the body; those of the opposite side remained still extended. Then these folded themselves similarly. The attitude of the two sides was then identical, but, when the normal state was recovered, the limbs on the side affected by the cerebral lesion again became more drawn up, and the body leaned on that side.

In this frog we have again on one side the influence of the cerebral lobes, but, on the other side, the locomotive centres are completely independent, and they act alone on the movements which take place on the corresponding side of the body. What happens, then, when the animal attempts to move? From the healthy side the movements are made according to the desire and the will, they are limited to the end wished by the animal; but, on the other side, they are made *en masse*, automatically, invariably; they drag the animal from their side; at the same time, the mathematical regularity of their contractions becomes, so to say, a dynamic centre for the movements of the opposite side, which are less regular. In this way we explain the movement in a circle, the side in relation with the wounded part being in the interior of the circle made by the animal. This also is the reason why such movements, particularly when the circumference is small, occur only when the animal can change his place, and very often commence only after the first moments of locomotion.

In case the cerebral influence is abolished, the locomotive centres become absolutely independent, as is shown by the forced automatic movements. Again these centres may be excited by a tumor, or a prick, and then their dependence upon the cerebral lobes ceases at once, notwithstanding the anatomical communications which still exist. It is in these cases that the compulsion, from the instant of the lesion, becomes invincible, and forces the animal into movement. The locomotive centres become active, and, as long as the excitement lasts, the animal is completely under their influence. Neither the will, nor emotion, nor physical obstacles, can prevent the limbs from moving.

A hunter gave us the following account: From a considerable distance he had shot at some wild-ducks that were on the water; one of these ducks was not able to fly, and remained on the water, turning in a circle. This duck had received a superficial wound from a grain of lead in the side of its head; it had absolutely no other wound on its body. Now, the curious fact, and what astonished the hunter, was, that this duck could not fly, and yet neither the will nor the means

Fig. 4.

A Frog, in which the Left Side of the Cerebellum has been destroyed.

were lacking, nor could it even plunge, which wild-ducks usually do when wounded, if they cannot fly. Notwithstanding the approach of the dog, and the evident very energetic action which its brain sought to exert at this moment on its movements, it could only swim on the surface of the water with a forced movement of rotation.

When the lesion is made on the two sides, some of the same phenomena are seen; only, as the stimulus to activity on both sides is the same, the animal moves in a right line. We have injected mercury in an opening made with a trepan into the upper part of the cranium of a young cat. In a little while, the mercury, by its weight, having reached the base of the brain, the animal lifted himself up, and plunged forward against the wall, making vain efforts to go straight on; deviating to one side, he continued his course till he encountered a new obstacle, and so on. He stopped only when exhausted, and yet until his death from compression of the bulb, his limbs moved without interruption.

In a man who had all the symptoms of a cranial tumor, we have observed phenomena almost identical with these presented by this young cat. When he had a crisis, he would raise his haggard eyes, and walk straight in his chamber, being guided only by the reflex action of locomotion and by habit. After his crises, he could not remember having walked.

It is evident that, in these cases, it cannot be a question of paralysis, and that the phenomena are the result of excitation of the locomotive centres. If the influence of the cerebrum, on one side, is obliterated, and the locomotive centres are not irritated, they act only when they are solicited to activity by movements impressed by the opposite side, and then these movements are forced and automatic, but regular and without exaggeration. The result is, a movement in a circle, which occurs when the animal can change his place. If, on the contrary, the centres are directly excited, the impulse is forced, and the animal is obliged to move in the way impressed by the centres.

Better to comprehend the rolling movements, we must explain some facts which have not been dwelt upon, and which we observe in animals in repose. In lesions of the cranial centres, when we wound the *pons Varolii*, the animal has no longer the same exterior carriage; he leans to one side or the other, according to the side where the lesion is made. All the muscles of this side are then in a state of permanent contraction. The frog represented in Fig. 2, from which have been removed only the cerebral lobes of the two sides, is remarkable for the regularity and the symmetry of the position of his limbs. Placed in the water, he rests on its surface, and the right side is at the same level as the left side. But, if we wound the cerebellum on one side, whether the cerebral lobes are intact or removed, at once the exterior carriage becomes that which is represented in Fig. 4. In this frog, the cerebellum has been destroyed on the left side, and instantly the entire right side experiences a permanent contraction. This attitude is so regular in these lesions that, from simple sight, we can indicate the direction of the movement of rotation. The opposite side has also a constant and typical attitude; the throwing out of the fore-leg from the thorax is always as is shown Fig. 4.

When this frog is placed in water it turns on itself, the right side serving as the axis of movement. When it is at rest in the water, it takes the attitude represented in the figure. The right half of the body sinks in the water; the limbs of this side can never be on a level with those of the opposite side. These last, on the contrary, especially when the cerebral lobes are removed from the two sides, float on the surface and counterbalance the influence of the opposite side; the hind-foot of the uninjured side remains extended, and rests always at a higher level than that of the opposite side; the fore-foot comes out of the water, as well as the anterior part of the body. The limbs of the affected side are not really paralyzed, but, nevertheless, their movements are more limited, they are not so extended nor so various, and their action no longer coincides with that of the healthy side.

Fig. 5.

A Frog, in which the *Pons Varolii* has been mutilated on both Sides.

If, in place of pricking or deeply wounding one side of the *pons Varolii*, we prick or wound these nervous centres on each side, a little above the bulb, we obtain a tonic contraction of both sides of the body, and the frog takes the attitude represented in Fig. 5, an attitude due, without doubt, to a tonic contraction of all the muscles of the body. Put in the water, this frog falls to the bottom and remains motionless.

Considering successively the attitudes taken by the frogs from Fig. 2 to Fig. 5, we see perfectly that, when we get beyond the cerebral lobes, all lesion of the other parts of the encephalon leads to a sort of tonic contraction of the muscular groups corresponding to the wounded side. The nearer the lesion is situated to the bulb, the more pronounced are the phenomena, and the more the frog leans to one side.

In geese and ducks, on pricking or cutting the peduncles of th cerebellum, we can well observe phenomena analogous to these seen in frogs. When we remove the cerebellum of the two sides, there is no movement of rotation, but the animal plunges deeply into the water. In the uninjured duck, for example, the thorax penetrates the water but a little way; the duck, deprived of its cerebellum, penetrates it twice as far. The duck, represented at Fig. 6, is wounded in the right side of the cerebellum, and the animal has a movement of rotation toward the left side.

We think these phenomena are due to an irritation of the locomotive centres, and, with Brown-Séquard, we believe that the lesions of certain points of the encephalon engender a state of irritation, whence arises, whether directly or by reflex action, a tonic contraction of certain muscular groups, and chiefly of muscles of the thorax.

It is very easy to account for this influence of the muscles of the thorax in producing the movements of swimming. This easy experiment shows us, at the same time, that simple paralysis, or the loss of function of one side, does not occasion the movements of rotation. If we swim with one arm and one leg of the same side, we do not deviate, but advance in a right line; but, if we contract the muscles of the thorax of one side, at once we lean in the water on that side. If we increase this contraction, we draw over a little more in the same direction, until we come to lie completely on one side, and at this moment there supervenes a movement of rotation, almost instinctive, which makes us spasmodically take the normal position. It is something like this which occurs in animals that have movements of rolling.

By encephalic lesion, animals are led to lean strongly to one side, an attitude which they take even in repose. At the least movement, they are drawn over upon the back; at once, spasmodically, all the limbs concur in the effort to regain the former state; but, as soon as taken, the compulsion of the injured side is reproduced, and, as the animal has already acquired motion, this carries it beyond the normal attitude, and leads it on to its side and back; immediately it seeks to get on its feet, rises, is again drawn over on one side, and so on. When the cerebral lobes are removed, animals cannot remain lying on the back. They always seek to recover their normal attitude, and, consequently, when they have deviated from it, all their efforts go to recover equilibrium. It is at this moment that the four limbs concur to execute the gyratory movement. There are two factors in the motion of rotation: the first is the contraction of the muscles of the injured side which makes the animal lean over and bear down on that side; the second is the coöperation of all the members, as soon as the animal is reversed, to produce a half-revolution and recover the normal forced attitude. The first turn, particularly when the lesion is old, is slower and less regular; the second is rapid and spasmodic. The first is the consequence of the lesion, the second is the consequence of the regular action of all the nervous centres; and, the better to express this thought,

FIG. 6.

Duck, wounded in Right Side of the Cerebellum.

we may say that, in an animal from which have been taken only the cerebral lobes, we might obtain a movement of rotation if, as soon as the animal is on his fore-feet, we turn him on his back; external interference would replace in this case the action produced by lesion of the *pons Varolii.*

We think we have demonstrated that, in an animal deprived of the cerebral lobes, the integrity of the movements of the whole body is perfect; that it is due to the action of the locomotive centres of activity, which is inevitable and always the same after certain excitations: moreover, that in these conditions there are a complete solidarity and compulsion of the movements, and a necessity for the members all to concur in maintaining an equilibrium; finally, that the movements of rotation are due to a disturbance in the equilibrium between the different locomotive centres.

VENTILATION, AND THE REASONS FOR IT.

By ROBERT ANGUS SMITH, Ph. D., F. R. S.

IT is often asked how much fresh air we must allow to come into a room in order to keep it wholesome. The amounts vary so much that we shall never be able to answer the question as it arises in all its changes, unless we consider our reasons for ventilating.

The first is certainly the dislike to organic-smelling substances evaporated from living beings. As some of them are very volatile, a very little rise of temperature increases their amount; and, in warm weather, we require a change of air so frequently, that we cannot make any use of the carbonic-acid test. The amount of change is infinite; we require it for every breath, and we do not consider whether a door is sufficiently open; we open all doors and windows, or leave the house entirely.

Let us take the other extreme—a very cold room—an Esquimaux ice-hut. The amount of air wanted is wonderfully small; we do not know how much the carbonic acid may rise, but it must be very high. The organic matter is frozen, and is probably condensed on the ice; it may be inhaled as a solid, and in a form not to affect the smell. For a similar reason we require less ventilation in cold weather: it is not foolish, as some will endeavor to persuade us, to take less, but it is a natural instinct. We object to the cold, and we learn that heat is a more pressing want than even pure air, whether the organic matter affects our senses or not.

The next reason for ventilating is allied to the first; we say it is to produce freshness. This means that, although all the air of the room be quite new, it has received a something from the surfaces in the room which must be cleared out. This is the reason that housewives like to keep the doors and windows open, and allow the air for a time to blow through the house. This process removes the last particles from the furniture, and is that finish which polishing cannot give. If the undefined impurity exists in large quantities, only rubbing can remove it rapidly, and this is done when we clean thoroughly walls and furniture. If very bad, and time presses, while elegance is not a demand, we cover the whole, and find whitewashing to be a ready mode.

The other reasons for ventilating have arisen from scientific inquiries. We wish to remove the carbonic acid; we might be able to find this gas by the senses, if it were very abundant; but it is not so as a rule, until after our senses have informed us of the organic accompaniments. It furnishes, however, one of the most important and probably the most important of the reasons in every-day life, because carbonic acid is the most rapidly hurtful to animal life of all the emanations from the person. It lowers the vitality rapidly, and kills with indefinite warning. The best warning is the organic matter, which acts for both. The warning by carbonic acid is called indefinite, because people lose vitality, but do not observe that the cause is in the atmosphere, there being no smell connected with that gas. At night, when lights are burning, the carbonic acid warns better than the other impurities, by simply putting out the candles. This seldom occurs in private houses, but dim burning is common enough. Mr. James Napier, F. C. S., tells me that he has seen the candles beginning to go out in a small meeting-room in the country, which had a low ceiling and was crowded. It was needful to keep the door open. How blunt, then, is our perception of carbonic acid!

Another reason for ventilating is to remove solid floating bodies, including infectious matter, fungi, and peculiar emanations arising from disease or other anomalous conditions. These floating bodies can sometimes be distinguished by the sense of smell—in the case of mould, for example. If it were possible to describe a smell completely, this class would be largely subdivided, since experience has made many persons very learned on this subject. It is, however, a knowledge which we have not yet been able to receive from or communicate to others. This whole question requires careful examination. The knowledge of the smell cannot be taught, but it may guide us to much that can be taught. Ventilation for this class of bodies will be probably much more attended to in future; care must be taken to drive them to the nearest opening, and not to allow them to diffuse themselves through the room in which they may be produced. In some cases resort must probably be had to rapid artificial and heated currents.

We ventilate to remove smoke and ordinary dust; these are easily seen; and we use ventilation to procure dryness. Moisture rises constantly from the skin, and, if an inhabited apartment is not ventilated, that moisture accumulates. By opening the windows we cause floors to dry sooner, and we remove moisture from all the apartments, and that moisture has generally organic matter with it. If we ventilate with very moist air, we shall dry nothing; if we have very dry air, we may dry too thoroughly. It is, however, better for us to have what is called practically dry air—that is, air capable of containing much more moisture than it has. The amount of drying work done is according to the dryness, warmth, and speed of the air; with little of these qualities, a great bulk of air is required, where otherwise a small bulk might have sufficed. By warmth and dryness we have an advantage in requiring less rapid currents. I have said elsewhere that a climate has a certain advantage from being very rainy. To call dryness an advantage is not a contradiction. When rain falls and washes the air, we can feel the benefit; when the substances floating in the atmosphere are dried up, we can imagine the advantage; but when the air is kept loaded with moisture which does not fall as rain, and is not carried off by wind, we can easily understand why the results should be hurtful. That it is not the watery vapor itself that injures may be learned from dye-houses, where men spend their lives in all conditions of dampness, sometimes in steam dense enough to make it difficult to see to the distance of a yard. There they have not the heavily-laden moisture of hot, damp climates with rich vegetation, and they have abundant warmth, so that the moisture is not used for absorbing heat and producing colds.

The demands of ventilation would best be explained if we could reply to these questions: What is the smallest amount of carbonic acid which may be call injurious? and what is the smallest amount of organic matter?

The amount of carbonic acid in the air is under .04 per cent. in places that are healthy, but not above .032 in the most open and healthy places. About five times that amount affects a candle sensibly, a photometer being used, and it is extremely probable that less affects it also. Are human beings affected as readily? I rather avoid this question at present; we have not facts enough. We will now speak of the gas in conjunction with organic matter.

Let us take the two together, and we then find that much depends on the temperature also. If the day be warm, we may pass from a room having .06 in a hundred of carbonic acid to the air with .03, and feel refreshed. If the day is not warm, we do not feel the difference; at least, such persons as I have examined do not. *The conclusion is that, in the early stages of the want of ventilation, the organic exhalations are the most injurious.* Now, these increase with the temperature, while the acid does not. For this reason we ventilate in warm weather for the organic matter far more than for the sake of the acid. As the former has not hitherto been estimated by weight, we may view the subject only in relation to the carbonic acid. I think it probable that we shall be able to view it also in relation to other substances. For example, so much temperature will represent so much organic exhalation, and the volume of air will differ accordingly.

When the ventilation is desired to be very good, the amount required when pure air is supplied is much less than with imperfect air.

As the demand becomes less, the difference diminishes. If ozone were taken into consideration, the difference would probably be much greater; but I do not know what allowance to make for that body, and leave it out of consideration. In the smoky towns there is *none* at all.

The conclusion has been drawn by some scientific men that in all spaces, and under every circumstance, the same amount of air must be supplied. Now, it is true that the same amount is to be actually breathed, and, if this breath is thoroughly mixed with all the air of the room, the same amount must be supplied for ventilation, whatever the size of the room. But let us suppose—the most common case—that the thorough mixing does not take place, and we have at once a different amount of air required.

As to the imperfect mixing, it is so various and characteristic that we cannot reduce it to rules; we may hold a smoking substance in the midst of an apartment, and find the smoke go directly to an opening without mixing with the air of the room. It goes, too, with a velocity greater than that of the air of the room, otherwise an opening must be supposed sufficient to change the whole air of the room in a few seconds, that being the time required for the smoke to reach the opening. If we could drive the impure air in a similar way in a narrow current toward its exit, we might manage ventilation with a very small amount of air. To do this is a matter of great importance, because the expense of building is becoming so great, that very few men can afford to pay for a large enough house, and, while rents are rising, the rooms of the middle classes have actually diminished in some places, and within these few years. Yet the evil of small rooms is great, because rapid currents are required for ventilation; cold currents are hurtful, and the warm difficult to obtain. If, however, we could obtain warm-air currents, it would not be important for us to have the rooms so large. It is a question of price. I believe the warmth must be obtained as the first demand of Nature, and without it civilization will go back. When men are cold, they give themselves to physical exercise, and, if that is impossible, to discomfort, in which the mind refuses to do more than to complain, if it cannot forget. Which is cheapest for us? Is it to build large rooms and to have less warmth with slow currents, or to build small rooms and to have more warmth with rapid currents? It is to be wished that the former should be the rule for private houses; more comfort and convenience are promised, and mechanism is not required; if it were, it could not be obtained. For hospitals, the use of mechanism is more within possibility. The expense of large rooms, when the architecture is of a kind intended to ornament a capital city, is very great. Should we not gain by a judicious system of warming? Our methods of warming are very cumbrous, and we seem to be behind ancient Rome and modern Russia. We warm the air which changes in a moment when a door or window is opened, and we do not warm the house itself. Builders make the walls thinner in these days, and we sit at a fire very much as savages do over a blaze in the open air.

This is less the case with large rooms, where we require slower currents. We may next ask, Is there any advantage in rapid currents at any time? There is; in the case of infectious diseases, it would seem in the abstract to be of the greatest importance that the patient should be in a current, speaking as a chemist, and not a physician. The first reason is for his own sake. Even in health we poison ourselves, and in disease we tend more rapidly in the same direction. Infectious emanations may be collecting round a patient, and, if so, the still air will keep them more carefully near him. I speak only generally, and do not enter on the hospital controversy.

Perhaps we cannot have rapid currents in large rooms very easily, so much air is required; but we can have frequent changes of air. It is clear, however, that the rapid removal of the air collecting around patients with infectious diseases, and probably also non-infectious, is most likely to promote health, both in the patients and in the attendants. Few people can stand the rapid motion of cold air, and, if we must have rapid currents, they must be heated.

The source of the air with which we ventilate ought probably to be high in all cases, but even here we must move slowly. We are not quite sure that any infectious disease ever sends its emanations high into the air. Disease seems to creep along the ground; the causes may be at a considerable height, but we are compelled to suppose them very thinly disseminated there; and the action seems to be according to quantity as well as intensity; toward the surface they congregate and are active. This we see from the evening air, especially in marshy places; it is only after a certain repetition of the attack of the more thinly diffused wandering substances falling down from the atmosphere and accumulating, that men yield to the influence. As a rule, it would be unnecessary to purify the air of the daytime, if in an open place, even in average towns; and in most places it would be unnecessary to purify the air of the night in this country. It would, however, be better to warm it in northern and damp climates, and even in temperate climates, in order to produce a difference of temperature between the air entering the room and that within it, even if the necessity arising from the cold of rapid ventilation did not occur. In inhabited rooms the moisture increases as much as the organic matter, and the condition of the air is similar to that of the evenings of summer: whenever the temperature goes down a little, there is a deposit of dew; but, when the warmth increases, the air is laden with moisture, and the condition resembles that near a warm close vegetation. In both cases ventilation is wanted. Our walls become saturated with moisture if they are porous, if not porous they are covered with streams of water. The moisture has organic matter in it which is not removed by mere drying, and the effects are very long in leaving. We may know this from breathing the air of any bedroom in a London hotel, or in most private houses in towns. People are afraid to keep their windows open, because of the smoke without, and so they retain the organic matter. We can readily smell this, even if arising from healthy persons, and it has ceased to be a matter of surprise. If unhealthy persons are present, unhealthy matter may be expected to diffuse.

If, then, any disease is propagated by organic germs living on the organic matter of the atmosphere, or associated with it, it is not at all wonderful that the disease should lurk in corners of houses, in clothes, or other porous matters, simply because we can trace floating matter to its lodgment in such places.

It is remarkable how readily porous bodies absorb the moisture of the air, and substances with it. I find that the leather on the bookcases in my study, where gas has been used, is made rotten, and in exact proportion to the height, the highest being so frail that it can scarcely be handled, while the lowest is still pretty firm, although much less so than at first. The amount of sulphuric acid in the pieces is also in proportion. The intermediate are affected in an intermediate way. No better proof can be had of the absorptive action of these porous substances, and of the unequal state of the atmosphere in various parts of a room.

When rooms which have absorbed organic matter have been shut up, the original peculiar smell ceases, and a musty one takes its place; we recognize something which instantaneously brings that of mould to our minds. We cannot doubt that the air in such cases is full of the spores of such plants; the plants themselves grow in abundance, and we know well that when they grow they readily send out colonies. The leather of the bookcase was said to show the inorganic bodies; the books themselves are covered with the organisms when care is not taken, so that one small room gives an epitome of the whole subject. We have here, therefore, no mysterious agent, but one that is perfectly plain. Why should the agent be mysterious in the case of the infectious disease? It is only so far a mystery—we do not know the different plants or organisms, and so cannot tell whether we have health or disease in them by merely examining them through a microscope.

If porous substances have the characteristics alluded to, why use them? There are some difficulties here. If a wall is to be cleaned frequently, and rubbed when wet, it is better that it should not be porous. That seems quite clear; but when these processes cannot be undertaken, it really seems as if it were better to have it porous. Such substances absorb moisture in some seasons, and give it out slowly at others. Our clothes are of this kind. It is not possible to have warm coverings not porous. Porous bodies hold also a good deal of air, and they cause oxidation more readily. Nature has employed them for disinfection more than any others. The whole soil of the earth is a great disinfectant, kept in constant activity, being constantly required, holding in itself the most nauseous and unwholesome things, and still having healthy people living over it. However, the soil may be too full, and at times it becomes so, and therefore we run to places which cannot contain much impurity, such as bare rocks; and in such places we obtain pure air. If in houses we have too much organic matter for the porous substances to oxidize, we must resort to non-porous surfaces; but then they must, like the rocks, be often washed, or excessively exposed to the air or the warm sun.

To purify rooms the air must blow long into them, or every part must have the organic matter rubbed off by the hand. This is a sufficient rule for both hospitals and private houses. Good rubbing will purify furniture, and this our housewives know; long-continued currents of air are also known to be good, but better as a supplement to rubbing. The rules are very easy chemically, but mechanically they are difficult. This is merely a repetition of that which has been said elsewhere, and long ago, although it is here stated in other words. The world must be told every thing in ten thousand different ways before it learns, and it is wearisome to repeat the lesson. I am only saying, also, what every clean house-keeper carries out; and yet there is an apparent novelty in it when we compare it with the sayings and doings of many persons, intelligent and observing although they be. —*Air and Rain.*

PROF. JAMES D. DANA.

MODERN science, in giving rise to a new order of knowledge, fundamentally contrasted with the older eruditions, among its numerous influences cannot fail to give us a more satisfactory basis for the estimation of mental character and attainment. In proportion as the later knowledge is definite, positive, and universally accepted, does it become a better standard by which the intellectual greatness of men may be judged. In no sphere of mental performance can a man's work be brought to such decisive tests as in science. Each department has its special and authoritative cultivators who subject all new ideas to an inexorable ordeal of verification. While, in the various fields of literature and art, reputations may be made with little regard to substantive merit, because their appeal is to taste and feeling, and the canons of criticism are uncertain, in science, on the other hand, the rules of judgment are unmistakable, and men are measured by the quality and extent of what they have really accomplished. Human nature is, of course, imperfect, and in science, as elsewhere, its imperfections may

JAMES DWIGHT DANA.

often interfere with the awards of justice; but here, more than anywhere else, errors of personality are eliminated by the impersonal tribunal to which all questions are at last referred. A pretty definite idea is conveyed, when it is said that a man has "mastered a science." He must have made himself familiar with a certain body of facts and principles, with their historic growth and their degree of development. But the familiarity here implied is not that which is current in the walks of literature. It is not to be gained merely by reading. It implies a direct knowledge of the phenomena themselves—knowledge at first hand—and the exactions in this sphere of thought go further still. A man cannot be said to have mastered a science until he has thoroughly possessed himself of its method of research, and proved this thoroughness by successful, original work. He must have contributed to its advancement, to its original stock of observations and inductions, and done it so effectually that those who stand highest shall recognize the validity and value of his work. This condition being complied with, the number of sciences that have been successfully pursued, and the degree of their complexity, become fair measures of the mental breadth, grasp, and power of the minds engaged upon them. Humboldt was preëminent because of his conquest of many sciences. Helmholtz has a high place in European science because he is confessedly strong in mathematics, physics, and physiology, and has combined the researches of these sciences in carrying on his original investigations. Judged by this standard, the subject of the present sketch must be assigned an eminent position in American science, as he is an acknowledged master in the three extensive departments of mineralogy, geology, and zoology, having made original investigations of great value in all these fields of study.

Prof. Dana was born, in 1813, in Utica, New York, where he passed the first years of his life. He seems to have had an early inclination to the sciences, as at seventeen years of age he entered Yale College, attracted by the fame of Prof. Silliman (Sr.), the distinguished pioneer in American science. During the regular course of study at New Haven, Mr. Dana evinced an especial love for the natural sciences, without neglecting philological and mathematical pursuits, in the latter of which he was distinguished. He was graduated with honor, Bachelor of Arts, in 1833, and about the same time received the appointment of teacher of mathematics to midshipmen in the Navy of the United States. In that capacity, he sailed to the Mediterranean, in the United States ship-of-the-line Delaware, returning in 1835. During the two years following, he acted at Yale College as assistant to the distinguished professor whose successor in office he afterward became.

In December, 1836, he was appointed mineralogist and geologist of the Exploring Expedition then about to be sent by the Government of the United States to the Southern and Pacific Oceans. The five vessels of the squadron, under the command of Commodore Wilkes, sailed in 1838, on a voyage around the world. After extensive explorations, and suffering shipwreck, moreover, at the mouth of the Colum bia River, in Oregon, Mr. Dana returned home in 1842. The rare opportunities which this voyage afforded for scientific observation had been well improved. During the thirteen years after its termination, he was engaged in preparing for publication the various reports of this expedition committed to his charge.

Mr. Dana resided at Washington from 1842 to 1844, and then returned to New Haven, Connecticut, where he, soon after, married Henrietta Frances, third daughter of Prof. Benjamin Silliman, and where he has since resided. Before going to the Pacific, he published, in 1837, the first edition of his "Mineralogy," of which the fifth and last edition appeared in 1868. This is a work of high repute, both in America and Europe.

His first publication connected with his observations in the Exploring Expedition was a "Report on Zoophytes," which appeared in 1846, a quarto volume of 740 pages, with an atlas of 61 folio plates. In this work Mr. Dana reviewed the whole department of Polypes, combining his own observations with those of earlier authors, and proposed a new classification, bringing, for the first time, the Actiniæ and the Alcyonoid Polypes into their true relations to the Astræoid Polypes. The number of new species which he describes is 230.

The second work in the same series was a "Report on the Geology of the Pacific," published in 1849, a quarto volume of 756 pages, with an atlas of 21 plates. This work presents a view not only of the geology of parts of Australia, Western America, and the islands of the Pacific, but also treats at length, and with original views, of Volcanic Phenomena, Coral Reefs and Islands, and the General Features of the Globe.

The third work pertaining to this Government Exploring Expedition was a "Report on Crustacea," which appeared in 1852–'54—the text, 1,620 pages quarto; the atlas, 96 plates in folio: 680 species are described in this work, of which 658 are new. The subjects of Classification and Geographical Distribution receive in it special attention. These reports were published by the Government of the United States, and only 200 copies of each have thus far been issued. With few exceptions, the drawings in these atlases were made by Mr. Dana himself.

While engaged in preparing the last two of these reports, Mr. Dana has been the active editor of the *American Journal of Science and Arts*, founded in 1819, by Prof. Silliman, Sr., and well known as the great repository of the scientific labors of their countrymen. To this journal, which has now in 1872 reached its 103d volume, as well as to the Proceedings of the American Academy of Arts and Sciences, in Boston, the Lyceum of Natural History, of New York, and the Academy of Natural Sciences, of Philadelphia, Mr. Dana has contributed various important memoirs.

Soon after the resignation by Prof. Silliman of the chair of Chemistry and Geology in Yale College, Mr. Dana entered, in 1835, on the duties of the office of Silliman Professor of Natural History and Geology in that institution, to which place he had been elected in 1850; his brother-in-law, Prof. Benjamin Silliman, Jr., having been appointed to the chair of Chemistry. Prof. Dana is now engaged in discharging the duties of his professorship, and in editing the *American Journal of Science.*

In 1854 he was elected president of the American Association for the Advancement of Science, having been for many years one of the Standing Committee of that body; and in August, 1855, he delivered the annual address before that Association at its meeting in Providence.

Besides the works already referred to, Prof. Dana is the author of the following publications: "Manual of Mineralogy," 432 pp., 12mo. New Haven, 1851. 2d ed., 1857. "Manual of Geology," 1862. Rev. ed., 1869. 800 pp. "On Coral Reefs and Islands." 8vo, 144 pp. New York, 1853.

Mr. Dana's more important papers, in the *American Journal of Science and Arts*, are:

First Series, vol. xxx., 275, "On the Formation of Twin Crystals." xxxiv., 225, "Anatomy of the Caligus Americanus." xlv., 131, 310, "Areas of Subsidence in the Pacific indicated by the Distribution of Coral Reefs and Islands." xlix., 49, "Origin of the Constituent and Adventitious Minerals of Trap-rocks."

Second Series, ii., 335, "On the Volcanoes of the Moon." iii., 94, 176, 381; iv., 88, "On the Geological Effects of the Earth's Contraction and Origin of Continents." iv., 364; v., 100, "On Cohesive Attraction." ix., 220, 407, "On Isomorphism and Atomic Volume in some Minerals." xvi., 153, 314, "Isothermal Chart of the Ocean." xvii., 35, 210, 430, "Homœomorphism among Minerals." xviii., 85, 131, "Homœomorphism of Minerals of the Trimetric System." xviii., 314; xix., 6; xx., 168, 349, "Geographical Distribution of Crustacea." xxii., 305, 335, "Plan of Development in American Geological History." xxv., "On Cephalization." Continued in vols. xxxv., xxxvi., xxxvii., and xli. xliv., 89, 252, 398, "Connection between Crystalline Form and Chemical Constitution."

Third Series, i., 1; ii., 233, 305, 324, "On Glacial Phenomena in New England, and the Source of the New England Glacier."

In 1856–'57 Prof. Dana published, in the *Bibliotheca Sacra*, a series of four articles, entitled "Science and the Bible," called forth by a work of Prof. Tayler Lewis, on the "Six Days of Creation."

Prof. Dana's last work, "Corals and Coral Islands," 398 pages, with 279 cuts, is just published (1872).

EDITOR'S TABLE.

MAN AS AN OBJECT OF SCIENTIFIC STUDY.

IT will now scarcely be questioned that the law of progress in education is a tendency toward limitation of mental pursuits. Under the theory of education as a discipline, knowledge is held subordinate, but it is obviously rising in educational value, while it is beginning also to be understood that mental discipline may be acquired in any field of study by the vigorous and methodical exercise of the mental powers upon its subject-matter. But, with the increasing importance of knowledge, there comes a difficulty from its vast extent. Every thing cannot be learned; if some subjects are chosen, others must be passed by; indeed, but few can be taken, while many are left, and so study is inevitably specialized. This raises the further question of the rule of choice, or the relative value of the knowledges. What are the most necessary things to be generally studied, and which shall have the first place in any system of mental cultivation that goes beyond the barest rudiments? This we take to be now the urgent and fundamental problem of education.

Among the articles of our present number, we publish an abstract of an address before the theological students of Yale College, by Mr. Beecher, on the "Study of Human Nature." He presents, with his usual force, the claims of this subject upon students of his profession, but the reader will hardly fail to remark that his argument is much broader than its professional application. It is certainly necessary for clergymen, who aim to instruct and elevate their hearers, to understand their natures, if they would work effectually. It is, in fact, a simple business necessity; and, if neglected, it will entail the same consequences that ignorance of the material in which he works entails upon the artisan; that is, failure. But this necessity is a thousand times greater in the case of the teacher than in that of the preacher. For the teacher takes the human material directly in hand in its plastic period, to shape and inform, and he works at it day by day and all day long. That the study of human nature, systematic and prolonged, is incumbent upon the faithful teacher is self-evident, but what, then, shall we say of its necessity to the parents who give their life to the new being, and make those deep initial impressions that affect the unfolding nature more profoundly than all that is done afterward by teachers and preachers combined?

But it is not as fitting preachers, teachers, or parents, for their special functions, that we are now impelled to demand that the scientific study of human nature shall take a high and universal place in education. It should be done because this knowledge is of first and fundamental importance to all. Living in complex social relations, incessantly in contact with others, acting upon them and acted upon by them in innumerable ways that vitally involve the mutual welfare, it is certainly of the highest importance that each person shall comprehend the qualities of the natures that are thus brought into reaction. But it is needless to enforce the old injunction "know thyself," or to insist upon the correlative duty of knowing others also. The want will be freely admitted: the question is how it may be supplied.

Mr. Beecher maintains that "one of the prime constituents of clerical training should be a study of the human soul and body from beginning to end," and he insists furthermore that this study should be pursued by the method of science. The importance of this last requirement cannot be overestimated. The study of man should be first of all scientific, because that is the only method which aims solely and supremely to arrive at the truth. It is well to study human nature for the sake of professional utility; but it is better to study it for the intrinsic and exalted character of the knowledge itself. It is more important to insist upon this, because on no subject is the bias of prejudice and prepossession so all-disturbing as here. Human beings should be studied exactly as minerals and plants are studied, with the simple purpose of tracing out the laws and relations of the phenomena they present. Men should be analyzed to their last constituents, physiological and mental. They should be observed in their characters and actions, in their general attributes and peculiar traits; they should be apprehended in their growth, in their normal and abnormal manifestations, in their relations to inferior life, in their social and sexual attributes, and in their relations to vocations and institutions, and the whole inquiry should be pursued in that unimpassioned spirit of true science which cares little *what* the facts may be, but every thing to *know* what they are.

Human nature is certainly a very comprehensive and complicated subject, and as a science it is, of course, profoundly imperfect. It is by no means to be taken up as one of the ordinary sciences, and pursued separately, like mathematics or electricity. Those branches of science upon which it chiefly depends are to be acquired first as a foundation, and then they are to be combined in the direct and practical study of man himself, in his totality, and as a subject of systematic observation. Human nature, like geology, is dependent upon other sciences for its data, and then it offers large additional questions of its own, which require a scientific training to deal with them. When the geologist has mastered the laws of physics, chemistry, mineralogy, meteorology, zoology, and botany, he then goes out to commence the practical study of the rocky masses which compose the earth's crust. In the same way the scientific student of human nature will first get an acquaintance with the principles of biology, which throw light upon man's physical constitution and relations, and then he must master psychology, or the science of feeling and intellect, as manifested in the grades of life, and these will prepare him to form a right conception of the individual man in his bodily and mental unity. All this, however, is of little account in itself, and is but a preparation for the direct study of human beings, their characters and actions, as matters of habitual and methodical observation. What is required of our enlightened educators is, to arrange the scientific curriculum with a view to this great end, and then to pursue the study into its higher and practical applications. If it be said that we can never know the truth about people, as half of them give their lives to the art of keeping up false appearances, the reply is, then study that fact first, and get a cool scientific expression of the extent, limits, and value of this source of error; a long stride will thus be taken toward the end we propose.

This study is undoubtedly great, complex, and difficult, but it is, nevertheless, intrinsically practicable. Thanks to science, the knowledge exists. An immense body of truth of the character here indicated has been wrought out, but education as yet ignores it. Between the vast system of facts and principles which science has established, and the state of the general mind, there is a gulf wider than the Pacific, and it is still daily widening; for, while there is greater activity now than ever before in the world of scientific inquiry, the masses of the people are doing little or nothing to avail themselves of it.

Complex and difficult the scientific study of human nature may be, but it is demanded by the imperative exigencies of the age. What is wanted is a better knowledge of human relations in the social state; and that resolves itself immediately into a better knowledge of the beings which exist in that state, for society is what its human units make it. Ignorance of men, of the nature of their weaknesses and vices, and the springs and laws of their action, is at the root of the chief impostures by which society is scourged. The quackeries of the platform, the bar, the state-house, and the pulpit, the gigantic swindles of speculators, and the frauds of petty traders, the omnipresent over-reachings and deceptions by which people are victimized in the intercourse of life, are but legitimate consequences of the gross and wide-spread ignorance of human nature. We are deafened with the discordant cries of political and social reformers; but here is where they must begin, if any thing valuable and permanent is to be accomplished in the way of reform.

THE DISCOVERER OF OXYGEN.

Several thousand people assembled the other day in the Central Park to unveil the statue of Shakespeare. The ceremonies were impressive. The illustrious English poet, newly done in bronze, was celebrated prosaically by the most illustrious of American poets, and then he was glorified poetically by another distinguished American poet, while this effect was heightened by the fine vocalization of our eminent interpreter of the great dramatist, and altogether it was a most poetic and Shakespearian affair.

Such an event will suggest different reflections in different minds; we are in the mood of contemplating it chemically. As the symposium is ever qualified by the libations, it will be asked what they had to drink. As befitted the exaltation of the hour, they drank the invisible ether that is never conveyed in goblets—a solar distilment of the beautiful foliage of the park, and to this they owed all the inspiration of the occasion. The afflatus was an immediate effect of oxygen gas. It was through it and by it that the entire concourse lived, and moved, and had its poetic being. As the first condition of cerebral action is a constant stream of oxygenated blood driven through the brain, the broad current of thought and feeling in the assembled multitude was sustained by this element of the vital stream. That withdrawn, the prose of Bryant, the poetry of Stoddard, and the elocution of Booth, with the appreciative applause of the audience, would have suddenly and simultaneously ceased. For, whatever may be the case in other spheres of being, in *this* sphere the spiritual world of thought and feeling is created, instant by instant, by the chemical energy of oxygen. Let none accuse us of materialism, for this doctrine has high and sacred authority. In its account of human creation, the oldest scripture declares that God "breathed into his nostrils the breath of life, and *man became a living soul;*" and the breath of life we now know to be oxygen gas.

But, for many thousands of years, it was not known. Humanity had run through a vast career before this truth was reached. Mighty empires had come and gone; great cities had been built and had perished; civilizations had risen and passed away; arts, literatures, philosophies, and religions, had become ascendant and had declined before men found out the constitution of the air—what and why they breathe.

We owe this most brilliant and important of modern discoveries to Dr. Joseph Priestley, of England. He was a clergyman and a chemist, and in 1768 he went to Leeds, and was settled as pastor over a large congregation. He happened to reside near a brewery, and "accidentally observed that the beer, during its fermentation in the vats, gave forth a remarkable aërial substance. The flame of a lighted stick immersed in it was at once extinguished, and the smoke floating on the top of the stratum showed that it was very heavy, a result which was perfectly confirmed by the observation that, invisible and intangible as it was, it could be poured from vessel to vessel like water; and in the vats, in which it originally occurred, it would overflow their edges, and descend to the floor, along which it would run like a stream, its course being readily tracked by the expedient of putting a lighted stick into it, and observing the extinction of the flame. Moreover, he found that it would dissolve in water, for, if dishes of that liquid were placed where it had access, an agreeably acidulous and sparkling fluid, soda-water, was formed; and, that the agent which brought all these results about possessed a physiological potency, was proved by the fatal fact, too often known in such manufactories, that, if by accident it was breathed, death at once took place."

This substance was then called "fixed air," and is familiarly known as carbonic-acid gas. It is now exactly a hundred years since Priestley published a pamphlet "On impregnating Water with Fixed Air," and a year later he received the Copley medal from the Royal Society for his "Observations on the Different Kinds of Air." In the year 1774, he made the splendid discovery of oxygen, and, in allusion to its power as the sustainer of life, he applied to it the epithet "vital air." When it is remembered that this wonderful substance is the active element of the atmosphere, and essential to the existence and activity of the entire living world; that it enters largely into the composition of all the natural objects around us, forming three-fourths the weight of all living things, half the weight of the rocky strata, and eight-ninths of the oceans; and, moreover, that it is an element of great chemical energy, and is involved in nearly every transformation of matter in the laboratory of Nature, and in the processes of the arts, we shall be prepared to comprehend the significance of its discovery. It has given us a new chemistry and a new physiology, and it probably carries the mind of man deeper into the order of Nature than any other single scientific revelation ever made.

But the great discoverer had his troubles. He carried his independence and power of thought into theology and politics, and his life of course became a turbulent battle with sects and parties. In relation to this part of Priestley's career, Dr. J. W. Draper has well remarked: "We must not impute it to mental weakness, but rather to a pursuit of the truth, that in succession he passed through many phases of religious belief, and four different sects, the Presbyterian, Arminian, Arian, and Unitarian, received him as a votary. This is not the occasion nor the place to explain the causes which led him to this course. It is only for us to judge of so great a man with charity. But, imbued as he was with a deep religious sentiment, and feeling that even the most exalted objects of this life are not to be compared with the importance of another world, he regarded his philosophical pursuits as a very secondary affair, and gave much of his time and talent to controversial theology. He seems to have come to the conclusion that it was incumbent on him to make a religious war. As his biographer says, 'Atheists, Deists, Jews, Arians, Quakers, Methodists, Calvinists, Catholics, Episcopalians, had alike to combat him.' In more than a hundred volumes which he printed, each of these found an adversary of such force and vigor (and it was impossible with such a man that it could be otherwise), that their ablest theological writers were overmatched. By the established Church of England, he came to be regarded with such feelings, that instances occurred in which those who had successfully answered him were rewarded with the highest dignities; a circumstance which gave origin to his remark, that he appointed the bishops of England. Priestley forgot that the experience of all nations and of thousands of years has proved the utter impossibility of any one man convincing the whole human race, and converting them all to his views. He shut his eyes to that anarchy of opinion infesting the world, brought on in no small degree by such polemics as those in which he delighted. In an exact science, like chemistry, he could describe some new discovery, and every man in Europe at once admitted its truth. He never realized how different it is in politics and theology. The library of volumes he wrote on these topics has already dropped into that gulf of oblivion which has received all the works of the authors of the early and middle ages, and no man cares to learn what he wrote or what he thought of the matter. But not so with his philosophical labors: they stand out clear and distinct, monuments of the advance of the human mind in knowledge and power during the eighteenth century. His discovery of oxygen gas will last as long as the world endures."

But, if Priestley erred by meddling with men's political and religious opinions, he paid the full penalty of it. While living in Birmingham, the mob broke open and sacked his house. His philosophical instruments, most of them made by himself, were broken up; his library and original papers, the fruits of a frugal life, were destroyed, scraps of manuscript covered the floor several inches deep, and his books were strewn over the high-road for half a mile. His life was endangered; he was obliged to flee from the place with his family, and for three days one of the chief cities of the nation was the scene of riot. The blow was crushing. His society was avoided even by his philosophical associates, and, finding that further tranquillity in England was impossible, he resolved to come to America. He arrived in New York in January, 1794, and took up his residence in Northumberland, Pa., where he died in February, 1804.

Such was the career of the discoverer of oxygen; but, as Dr. Draper intimates, while oblivion has swallowed his theology and politics, his scientific fame grows brighter with the advance of knowledge. The rancorous feelings which drove him from his native country have subsided, and a more just generation is preparing to grant his memory the honor that is over-due. Subscriptions are being raised to erect a statue to Priestley in Birmingham.

Would it not be well for the country which gave him refuge to do the same? And apart from the question of doing justice to a great man's memory, which has been obscured for a century, what could be more fitting than to celebrate the centennial of a mighty discovery on August 1, 1874, by unveiling a monument to the illustrious discoverer?

LITERARY NOTICES.

Botany for Beginners. By Maxwell T. Masters, M. D., F. R. S., late Lecturer on Botany at St. George's Hospital. London: Bradbury & Evans.

In form, typographical execution, and illustrations, this is a beautiful book; in its scientific statements it is a sound and trustworthy book; but, for the purposes indicated in its title, it is a worthless book. Dr. Masters knows much about plants, but of the minds of children he seems to know nothing. How long will it take these educational book-makers to find out that there are two factors in the case, a subject to be presented and a mental organism to be affected, and that the latter, instead of being of small account comparatively, is in reality the first and principal thing? Botany, like the other sciences, can be so presented as to stupefy the mind instead of awakening it. Book-science and scientific books, as generally used in schools, are as often baneful as beneficial; they are merely new resources for loading down the memory with verbal acquisitions. The overshadowing influence, in education, of language which is learned entirely from books, and is mainly an exercise of pure memory upon arbitrary signs and empirical rules, has so determined the habits of education that the sciences have been forced into the same method of acquisition, and the absurd practice still prevails of acquiring them by memorizing the contents of books. Even in botany, where the objects treated of are everywhere—overhead, underfoot, by the way-side, in the gardens, fields, yards, and even in the house, soliciting the attention and kindling the admiration continually—we have still the preposterous habit of studying the subject by committing book-lessons in the school-room. To begin botany in this way with children is worse than an absurdity, it is an educational crime. It violates the law of the mind, by making them learn in a forced and unnatural way that which should be acquired in an attractive and natural way; and, by inducing indifference or actual repulsion, it defeats rather than promotes the true objects of education.

Nor is the case at all helped where the author begins with a general injunction to study the objects themselves, and then leaves the pupil to make his own way without guidance, or, in attempting to guide him, puts him on a false track. This is the sin of Dr. Masters. He puts the beginner at the most complex work of botany the first thing. It is the old story of commencing to pick flowers to pieces, "to ascertain of what parts they are constituted, their number, their shape, in what manner they are pieced together, whether they are separate or joined together, what is their relative size and position in regard to one another, and so forth." The object is to reach classification at the earliest moment, so that the child can begin to name flowers and show off his botanical accomplishments. Although professedly writing for beginners, Dr. Masters tacitly assumes them to be adults, and capable of grasping at first the generalized results of the science. That he begins with the simplest flowers is but little mitigation of his bad method. To attack the most complex part of plant-structure at the outset, using microscopes and making dissections, however possible it may be for matured minds, is neither possible for children, nor is it the true order in which the science should be considered. There is a wide range of observation of the simpler parts of plants which are open to easy inspection, and it is to these that the beginner's attention should first be directed. The earliest thing to be done is to cultivate the art and the habit of observation, and then the pupil will pass naturally to the comparison of these simpler characters, and thus advance imperceptibly to the higher complexities of form and structure. This course is equally necessitated by the order of unfolding of the child's faculties, and by the order of facts in the science itself.

Science Primers. "Chemistry," by Prof. Roscoe. "Physics," by Prof. Balfour Stewart. D. Appleton & Co.

In these little volumes the authors have tried very hard to adapt the treatment of their respective subjects to the juvenile capacity, and with very fair success. We think them by no means perfect, but they are probably better than any thing else of the kind that can be got. They were prepared for the English schools, and are the result of the recent commendable effort to infuse more of the scientific element into general primary instruction. The Rev. W. Tuckwell, an able advocate of this reform, thus speaks of them in *Nature:*

These little books illustrate an imperfectly-accepted truth, that systematic elementary teaching is a late and not an early product of educational energy. The best head-masters of our schools have discovered the fallacy latent in our ancient belief that the ablest men are required to teach the oldest boys, and have, in one or two famous cases, acted on their discovery. It is easy for a young man fresh from university honors to pour his knowledge into minds which have been well prepared, and which approach more or less to the level of his own; but to teach a class of little boys, to realize their difficulties and to appreciate their ignorance, to understand the perplexity which oppresses them in the presence of statements long since axiomatic to ourselves, require a mature and versatile intelligence, a mind which can communicate childish knowledge as readily and as joyously as it solves recondite problems; a combination of rare gifts with long and conscientious training.

And thus it is that the zeal for scientific teaching and the gathered scietnific experience of the last fifteen years have only issued now in the books which form the subject of our notice. Scientific class-books hitherto have been either too difficult or too easy. They have been unavailable for beginners without the intervention of a practical teacher; or, in their effort to be popular and simple, they have abdicated half their value as instruments of educational discipline. In these books both extremes are avoided. Every stage of their teaching is based upon experiment; no law is enunciated till it has been proved. From first to last the student finds himself in immediate contact with Nature. His empirical knowledge of external things is systematized; simple every-day phenomena reveal to him their principles and *rationale;* he walks forth with a new eye to discern the meaning and the beauty of familiar sights and sounds, and with a mind upon the stretch for fresh discoveries. And, on the other hand, no previous training is essential to the teacher who adopts them as his guide. Any man, ignorant even of the first principles of chemistry and physics, yet fairly dexterous and intelligent, who will patiently master the books, and try each experiment for himself, is in a position to transmit their contents successfully and clearly. The officer may lecture to the soldiers of his regiment, the clergyman to the artisans of his parish, the national school-master to the children of his school. Managers of schools, deterred as yet from including science in their course through lack of teachers and of text-books, will find their difficulty removed. . . . We tender them our hearty thanks for work which marks a stage in the advance of scientific education. Its lingering progress hitherto has been owing to the want, not of zealous champions, but of united action. The labors of its advocates are now beginning to converge. The leaders of science and the leaders of education are drawing close together—on the one side eager to impart, on the other ready to receive, advice and guidance. By the publication of these books the most serious of the obstacles which have kept them separate is removed.

MISCELLANY.

Length of Guns.—General Morin, in a discourse delivered before the Paris Academy of Science, noted this curious circumstance, that, though different kinds of powder may give equal speed to a projectile, they may differ very much from one another in the pressure they exert upon the walls of the cannon. He further remarked that all the grades of powder that have been tested undergo entire combustion, and consequently produce all their effect in pieces whose length is 12 times their calibre. But yet the greater part of the field-pieces in use have a length equal to 30 times their calibre. They might be cut down, therefore, without prejudice to their efficiency, and thus their portability would be increased.

Late Researches on the Gastric Juice.—The gastric juice of the human stomach has lately been made a subject of special study by Dr. Leube, of Erlangen, who gives the fruits of his work in an elaborate paper read at the recent Rostock Congress. He obtained the juice for his experiments by means of a tube introduced into the gullet. The gastric juice obtained from the stomach, empty and cleansed by an injection of water, is slightly acid, doubtless owing to the irritation caused by the injection and the contact of the instrument. Its digestive power is weak. In the course of his experiments with this fluid, Leube found that cheese is digested more rapidly than the albumen of a boiled egg, and the latter more rapidly than the albumen of a raw egg.

Experiments made with quassia demonstrate that this substance does not exert any special exciting action upon the secretion of the gastric juice. It excites it only as any other body might, which is brought into direct contact with the mucous coat of the stomach. The action of bitters upon the gastric secretion is, beyond doubt, a reflex action, having its point of departure in the mucous membrane of the mouth.

In the course of the discussion which ensued, Dr. Hoppe Seyler observed that in dogs, when fevered, the gastric juice suffers a diminution of its acid, but not of its pepsin. The white of the egg, in order to be dissolved, must first be transformed into syntonine, which process requires a gastric juice of great acidity. This fact accounts for the difficulty with which albumen is retained upon a disordered stomach. As concerns the digestibility of cheese, that substance is composed of different ingredients, and notably it contains one phosphoric substance, utterly indigestible, nuclein.

Sanitary Reform in India.—Lord Mark Kerr sends a communication to the (East) *Indian Medical Gazette*, in which he relates how he came to discover the cause and means of prevention of what is called the *Delhi Boil*, formerly the scourge of the denizens of Delhi, native and foreign. From a comparison of the situation and surroundings of Delhi with those of other Oriental cities similarly noted for the prevalence of boils and sores, he was led to conclude that the cause of the disorder was to be found in the existence, within the walls of the town, of a barren strip of land, two miles in length, by 500 yards in breadth, covered with foul weeds and ruined buildings, with the wells and water-courses choked up. He proposed to clear the water-courses and plant trees and grass. This was done in 1864, and now the Delhi Boil has entirely disappeared from the city. Lord Mark Kerr desires to have his experience tested throughout India, for he believes that pure irrigation and draining, with judicious planting and gardening, would greatly tend, not only to remove sores and such-like evils, but to prevent the approach of more serious and even fatal scourges.

A New Anæsthetic.—The *Medico-Chirurgical Circular* (German) calls attention to a new anæsthetic, which has received the name *Aethelid Chlorid.* Dr. Langenbeck has employed it in six operations, and found that it produced anæsthesia more rapidly than chloroform. He states that its use is unattended with any of those unpleasant effects which commonly attend the exhibition of chloroform. Also a new method of producing anæsthesia with morphine has been discovered. In this method hypodermic injections of the chlorhydrate of morphine are given, followed up with light inhalations of chloroform. Three cases were cited where this method had been employed satisfactorily. The anæsthesia, in this case, is not attended by sleep, and it leaves the action of the mind, the senses, and the voluntary muscles intact.

Liebig's Extract of Meat.—Liebig's process of obtaining meat extract is found to yield only 14 per cent. of the dry, solid material of the meat. The remaining 86 parts are the really nutritive constituents of meat, and the 14 contained in the Liebig extract are merely stimulative, not nutritive. This is, with ingenuous candor, admitted by Liebig himself. An English pharmaceutist, Mr. Darby, claims to have invented a process of obtaining, in concentrated, soluble form, *all* the constituents of the meat. His process, which has been patented, is this: Lean meat, finely sliced, is digested with pepsin, in water previously acidulated with hydrochloric acid, at a temperature of from 96 to 100° Fahr., until the whole of the fibrine of the meat has disappeared.

The liquor is then filtered, separating small portions of fat, cartilage, or other insoluble matters, and neutralized by means of carbonate of soda; and finally carefully evaporated to the consistence required, namely, that of a soft extract.

The resulting extract represents, in all its constituents, the lean meat employed, but with the fibrine, albumen, and gelatine, changed into their respective peptones, or soluble forms. This change is effected solely by the pepsin and hydrochloric acid, or artificial gastric juice, without the evolution or absorption of any secondary products.

But this process, whatever care be taken, leaves the fluid meat with a strong *bitter* taste, which always attaches to meat digested with pepsin. "In order to remove this bitter taste, I have made," says the patentee, "very many experimental researches, and at length have discovered that the purpose is completely and satisfactorily effected by the addition, in a certain part of the process, of a small portion of fresh pancreas."

The fluid meat so prepared is entirely free from any bitter flavor. One ounce is the equivalent of 20 ounces of meat.

Do Planets vary in Color?—In a note to the Royal Astronomical Society, Lieutenant-Colonel Strange, F. R. S., suggests that the changes of color which have been observed at distant intervals in some of the planets, may after all be an affair of the optical instruments through which the light is made to pass, rather than any real alteration in the aspect of the planet itself. That optical instruments do sometimes give the impression of a color different from that belonging to the object from which the light proceeds, appears from the following, which we quote from Colonel Strange's communication:

"I was, within the last few days, at a theatre with two young ladies. They drew my attention to 'the lady opposite in pink.' Turning my glass to her, I replied, 'You mean the lady in yellow.' 'No,' replied both, 'her dress is pink.' Having ascertained that we all spoke of the same person, I begged my companions to use their glasses. On doing so they both at once admitted the color to be yellow, as I had said. But they assured me that to their naked eye it was pink as before. One of the young ladies, my own daughter, is considered to have a remarkably fine eye for color, with the faculty of matching and remembering tints very strongly developed. The other, also a near relative, is likewise an excellent judge of color, and a born artist. The dress about which the above doubt arose was not all colored. It was white, with a great deal of the doubtfully-colored trimming, and the tint (whatever it really may have been) was very pale. There was strong light upon it, and the distance was that of the whole greatest diameter of a small theatre. Such are the facts, on which I do not propose to theorize. But they certainly point at least to one practical consideration—namely, the influence of optical power on color impressions, and the necessity of great caution in pressing observations on the color of heavenly bodies into the service of speculations regarding cosmical changes."

Of the three elements—form, size, color—Colonel Strange believes that color is the least permanently fixed in the "sensorial memory;" so that, even if the light reached the eye of the observer unchanged, the comparison of a recent color-impression with one that was received a long time before must at best give but a doubtful result.

A New Writing-Machine.—The *Mechanics' Magazine* figures and describes a new form of writing-machine, the invention of the Rev. Malling Hansen, superintendent of the Royal Deaf and Dumb Institution of Copenhagen. The machine is designed for rapid writing, and is also capable of being used by the blind. The work is done by means of a series of keys, moved by the fingers something in the same way as the keys of a concertina, each key leaving the impress of its proper letter or character on the paper below when it is struck by the finger. The keys are so disposed that the imprint of each type, when struck, is directed to, and received upon, a central spot, over which the blank paper is made to travel by means of suitable machinery.

Besides offering great facilities for copying purposes, the machine is said to rival stenography as a means for reporting speeches or taking down dictated composition. Rapid writing rarely exceeds four letters per second, while in ordinary speaking from nine to ten, and in rapid speech from fifteen to twenty, letters are uttered per second. This machine, with a little practice, enables the operator to take down an average of twelve letters per second, and an expert manipulator can considerably exceed this. The instrument is in use in London, and its performances are said to be very satisfactory.

Weather-Waste of Coal.—The *Engineer* states that Dr. Varrentrapp has made the weather-waste of coal the subject of an investigation, and as a result asserts that the amount of loss suffered by coal from exposure to weather is considerable, far greater, indeed, than is generally known. The results of his analyses show in some cases a total loss in weight of a specimen, from this cause, amounting to 33.08 per cent., while its deterioration in quality, for purposes of fuel or gas-making, reached a still higher figure. This change consists in a slow combustion, in which the volatile constituents—which are most valuable combustible elements—are gradually eliminated, while the relative proportions of carbon-ash and sulphur are comparatively augmented. It might be expected, now that the nature of this change is indicated, that anthracite (which has already gone through a very similar process in becoming what it is by the loss of its bituminous matter) should suffer least of all coals from this action, and the result of analysis shows this to be the case. The density and compactness of this variety, aside from its chemical character, protect it in no inconsiderable degree. The cannel coals rank next in their power to resist deterioration from this source, while the bituminous varieties are the most susceptible. The experiments of Dr. Varrentrapp are of such direct and practical importance that all who are engaged in the mining, transportation, storage, or consumption of coal, can study them with profit. It appears from accurate tests of a number of samples before and after exposure, that all the valuable properties of the coal had deteriorated. The coking quality of the weathered coal diminishes with its gas-yielding quality, the author informing us that a sample of coal, yielding when freshly mined a firm, coherent coke, after eleven days' exposure yielded a coke of no coherence, and in all the samples tested the rule was absolute that the longer the coal had been exposed the greater was the inferiority in the quality of the coke it produced. The gas-yielding quality decreased in one instance 45 per cent., and the heating power 47 per cent.; while the same sample under cover lost in the same time but 24 per cent. for gas purposes, and 12 per cent. for fuel. These experiments go far to explain the almost universal inferiority of the slack or waste coals in heating power when prepared for burning, even though some combustible material like pitch or tar is used in their cementation. It indicates, too, the imperative necessity of keeping coals amply protected from the deteriorating action of the air and moisture, by keeping them constantly dry and under cover.

Anecdotes of Rats.—A gentleman, who has passed many years of his life at St. Helena, told me lately several stories about rats, so curious that I thought them worthy of record. He said that at one time the common brown rat was extremely common all over the island, in fact, a perfect pest; and, to avoid its attacks, his father had constructed a large store, rat-proof; i. e., a rat once in could not get out again. A number, however, came in with produce and goods from the ships, and bred there. Around this store were venetian blinds to the windows, and one day one of his men, when it was raining, watched a rat sitting on the venetian, and putting out his tail to collect on it the drippings of water at the edge; he then withdrew it and licked it. The servant told his master, who immediately understood that the rats could get no water inside the store, and therefore directed that a butter firkin should be cut down to four or five inches, and in the top a large circular wire rat-cage trap should be fixed. Several small planks were placed for the rats to get up to the entrance to the cage, which exactly fitted the firkin. No food would have induced the rats to enter the trap, but water did, and many were thus captured. When caught they were given to the dogs; but there was one rat which would not leave the trap for many days. He was well identified day by day, till, becoming incautious, he leaped down, and was immediately killed. There is one peculiarity with these rats, viz., their very often building or making their nests in the trees. I have in India several times found rats'-nests in trees; but then they have always been stolen nests, such as deserted abodes of the squirrel or sparrow; but here my friend, who is no naturalist, tells me that they construct them principally of fir spines, on the ends of the boughs, some twelve or fifteen feet from the ground, in the common fir-trees. The spots selected are just where the overlapping bough nearly meets the lower one. He said that all know the rats'-nests, and that he had seen them fired at, when many rats were killed, and fell out to the ground. He could tell me no more, and I think that, if original nests, as he held them to be, some grass must be woven in during their construction, as fir-spines have but little power of cohesion. The situation of these nests was worthy of notice, although there is scarcely a situation where a rat's-nest has not been found.—*C. Horne, F. Z. S., in Science Gossip.*

Spontaneous Explosions of Gun-cotton.—Fired in the open air, gun-cotton burns with great rapidity, but does not explode. It has accordingly been the practice to store the manufactured article in more or less open sheds, in boxes containing twenty-five or thirty pounds each. In this condition, however, several explosions have taken place; the most serious being one that occurred at Stowmarket, in England, something less than a year ago. In this case the ignition of the gun-cotton was shown to be due to the presence of a large quantity of sulphuric acid in the stored material; but why it should explode when ignited, instead of burning up in the ordinary way, was not so readily explained. To clear up this point, a set of experiments has lately been carried out, the results of which are given in a recent number of the *Engineer.*

The "service-boxes" in which the gun-cotton is kept are made of inch boards, and, when filled, the cover is tightly screwed on. Twenty-four such boxes were piled in a light wooden hut, similar in construction to the sheds in which gun-cotton is ordinarily stored, and twenty-four others were placed in a close-built brick magazine. Two boxes in each building were left partially open to facilitate ignition of the cotton. The wood hut was ignited by a bonfire of shavings, cotton, and petroleum. It smouldered for about seven and a half minutes, and then broke into the full characteristic gun-cotton flame, when in nine seconds more explosion took place. The cotton in the brick magazine was next ignited; smouldering followed for one minute, fierce gun-cotton flame for ten seconds, then an explosion. Experiments with the wood hut were afterward tried, with the cotton in light wooden boxes, and the lids partially open. It burnt in every experiment without explosion. The results are thus summed up: "Gun-cotton in service-boxes, packed in a close brick magazine, when ignited exploded; gun-cotton in service-boxes tightly screwed down, packed in a wooden hut, exploded; gun-cotton packed in light ½-in. boxes, with lids only partly screwed on and left partly loose, packed in a wood hut, burnt *without* explosion twice. The same experiment, differing only in the cotton being damped, caused *no* explosion." The inference therefore is, that confinement of the gases generated by burning, in tight, strong, wooden boxes, was the cause of the explosions, as, when not so confined, the burning went on as in the open air. "Apparently, the tendency of the experiments is to recommend, as the condition likely to be safest against explosion, that boxes should not be tightly closed or packed in high piles."

Culture of Wild-Plants.—A daughter of Dr. Lockwood, of Freehold, N. J., planted last year in the garden a root of the wild-violet, known to botanists as *Viola sagittata.* It had, during the first ten days of May of this year, borne over *three hundred* flowers, and was at that date a mass of cerulean bloom, with prospect of producing as many hundred more of flowers. The great advantage of this violet is, that its leaves do not grow so high in generous culture as do those of the species *V. cuculata*, or its variety *V. palmata.* Hence the luxuriant mass of flowers is always uppermost, and the rich blue is thus kept conspicuous. This same young lady, at the Monmouth County Fair last year, exhibited a case of living and growing wild-plants under the name "A Cryptogam Garden," which elicited great admiration. It was composed of rare indigenous ferns, all gathered in the wilds of the county. Among these was that graceful rarity, the climbing fern, *Lygodium palmatum.* There were mosses and lichens, and fungi of *recherché* forms and brilliant colors. The effect was very fine, and showed how rich are the resources at hand where there is a little taste to turn them to account.

Chameleonization in Frogs and Reptiles.—We published, in a previous number, a curious and interesting article by a German oculist, showing how the colors of paintings are affected by changes in the eye of the painter. M. Pouchet matches this discovery with the curious fact that the lower animals change their own colors through the action of the eye. In a recent work on change of color in crustacea, this author shows that in fishes, especially the turbot, notable changes of color take place, due to the quantity of luminous rays which fall upon the eyes of these animals. The eye is the point of departure for a nervous shock which is transmitted to the skin, and which finally results in a change, more or less complete, of the color of the animal. This shock, starting from the eyes, is transmitted by nerves to the skin; so that, if certain of these nerves be severed, the animal will become striped with clearly-defined bands, the shock being intercepted by the severed nerves, and transmitted by the others. If the animal is deprived of sight, it ceases to change color, and preserves the same tint, whether it be placed on a black or on a white ground. In the course of his researches at Concarneau, M. Pouchet confirmed these results in the case of crustacea.

The skin of the frog becomes clearer when the cutaneous nerves are severed. Prof. Goltz, of Halle, shows that primarily the action of the nerves affects the vessels, and that the change in the pigment-cells is a secondary result, and due to a modification of the circulation. In the active state, these cells are star-shaped, or branching; in repose, they are round. Having removed the spinal cord and brain, if then you sever the nerves leading out to one portion of the skin, that portion will become clearer, the pigment-cells then first assuming the condition of repose. Dr. Witlich thinks this change of color is owing to the decay of the color-bearing cellules, and says it would take place equally in shreds of skin separated from the body. Dr. Mendel, of Berlin, has observed one-sided pigmentation frequently in the insane.

Observations on the Hydrogen-Flame.—Besides the phenomena common to ordinary burning, such as luminosity, the disappearance of oxygen, and of the substance burned, the production of water and carbonic acid, or some other of the various oxides, there are also certain other phenomena that differ with different substances, and that, when known, often become an important means of distinguishing these substances. Thus, burning sodium gives a yellow flame; burning potassium, a flame of a purple color; burning arsenic, a strong odor of garlic; burning sulphur, suffocating fumes of sulphurous acid, and so on. Burning hydrogen also has its peculiar phenomena, which have lately been made the subject of further investigation by Mr. W. F. Barrett, who contributes an interesting account of his researches to a recent number of *Nature*.

To study these phenomena to the best advantage, three things, he says, are requisite: 1. That the gas be purified and stored in the ordinary way; 2. That it be led through red or black India-rubber tubing to a platinum, or, better, a steatite jet; 3. That it be burnt in a perfectly dark room, and amid calm and dustless air. In this way, the flame gives a faint, reddish-brown color, invisible in bright daylight. Issuing from a narrow jet in a dark room, a stream of luminosity more than six times the length of the flame is seen to stretch upward from the burning hydrogen. This weird appearance is probably caused by the swifter flow of the particles of gas in the centre of the tube. The central particles, as they shoot upward, are protected awhile by their neighbors; metaphorically, they are hindered from entering the fiery ordeal which dooms them finally to a watery grave.

Brought in contact with certain solid bodies, the flame gives rise to phosphorescent effects. Thus, allowing it to play for a moment on sand-paper, and then promptly extinguishing the gas, a vivid-green phosphorescence remains for some seconds. A similar appearance follows when the flame is directed upon white writing-paper, marble, chalk, granite, or gypsum.

A much more general effect than the one last mentioned is, the production of a magnificent blue image of the flame, that starts up on almost every substance with which the flame is brought into contact. When directed either vertically or sideways, say upon a white plate, or block of marble, there instantly appears a deep-blue and glowing impression of the exact size and shape of the hollow flame. The moment the gas is extinguished, or the flame removed to the slightest distance from the solid, the effect ceases. This appearance, and the blue tinge which is said to be peculiar to the hydrogen-flame, are really due, according to Mr. Barrett, to the presence of sulphur, and so delicate is the reaction with this substance, that, without the greatest care in purifying the gas, and cleansing the surfaces with which, when burning, it is brought in contact, sufficient sulphur will be present to perceptibly color the flame. The least trace of phosphorus is also made apparent by the hydrogen-flame, by the production of a vivid-green light. When made to play upon the surface of clean tin, or some alloy of tin, a fine scarlet color is almost instantly produced, though the appearance is less vivid than with either sulphur or phosphorus.

Many gases also impart color to the hydrogen-flame; hydrochloric-acid gas giving a reddish-brown flame; ammonia gas a yellow flame, etc. Carbonic-acid gas, even in the smallest proportions, gives the flame a pale lilac tinge, the color being most marked at the base of the flame.

Mr. Barrett suggests that the delicacy of these various reactions makes it possible to turn them to valuable practical account, in the detection of the substances named. When, for example, the air of a room has become vitiated by the accumulation of an undue amount of carbonic acid gas, the hydrogen-flame, by means of suitable apparatus, will readily make the condition known. This practical side of the subject is now engaging Mr. Barrett's attention.

Recent Cave Explorations.—Some highly-important discoveries have lately been made in a cave near Luchon, France, by M. Piette, of the Geological Society. The soil of the cavern consists of several layers—the lowermost ones being characterized by the bones of the reindeer, and by dressed flints like those of the grotto of Laugeric-basse. These layers enclose, in addition to human bones, a large fauna, and particularly a considerable quantity of carved bones and stones. Nowhere else has so great an accumulation of prehistoric works of art been found. The figures often cannot be recognized; still on the bones are seen some designs of considerable finish. M. Piette mentions, among other carvings, some that represent flocks of wild-goats, and herds of reindeer, the head of a rhinoceros, a wolf, horses, a lion's head with mane, etc. These valuable remains are buried in a black soil, filled with ashes. Near the surface of this layer the fauna is the same as it is below, but the carvings are very different from those underneath, and show a very marked decadence. While the lower ones reproduce Nature exactly, with extreme care and a certain minuteness of observation, the upper ones are fantastical and not after Nature, as well as ruder than the others. All the human bones, especially the bones of the skull, are reduced to small fragments, and all have notches and incisions more or less deep. This, M. Piette takes as an evidence of cannibalism. The topmost layer is hard and compact.

Relation of Death-rate to Temperature.—In a little work on the climate of Uckfield (England), Mr. J. Leeson Prince has the following concerning the influence of temperature on the death-rate:

"The mean annual temperature varies 5°.3, viz.: from 51°.93 in 1857, to 46°.62 in 1845, and although at first sight this difference may not appear considerable, yet it is sufficient to exert an enormous influence upon the general character of the seasons, the produce of the soil, and the health of the population. The registrar-general's interesting returns have fully established the important fact that there is a very intimate connection between temperature and mortality. Whenever the mean temperature falls to 45° or thereabouts, the number of deaths from diseases of the respiratory organs increases; and, should it fall below 40°, the death-rate from such diseases is still higher. When a period of intense cold prevails, so that the temperature scarcely rises above the freezing-point for two or three weeks, the number of deaths will be found to exceed what takes place during an epidemic of cholera or scarlet fever. But, when the mean temperature rises to 55°, there will be an increase in the number of deaths from diseases of the abdominal viscera, and this number will fluctuate as the temperature fluctuates between 55° and 65°. Hence we are informed that the mortality from all causes is least when the temperature is about 50°, which is very little above our mean annual temperature."

The Late Eruption.—A correspondent of the London *Athenæum*, writing, May 2d, from Naples, graphically describes the late eruption. He says: A tempest of fine ashes poured down upon us, covering the streets and houses, filling our lungs, and almost blinding us. We all, from necessity, carried umbrellas, a slight protection, however, except to break the brunt of the driving shower as we met it. I have seen cabmen with handkerchiefs hanging in front of their caps, and some men with fine handkerchiefs tied over their faces. Last Friday and Saturday it was, as it were, one continuous roll of artillery, so loud that it could be heard full 20 miles distant; but after the sandstorm set in, if not so sharp and violent, it was, I think, more appalling. Vesuvius roared night and day; it rendered sleep impossible; its reverberations shook our windows and our houses, and great has been the exodus from Naples of the foreigners who came to admire, and now have fled in fright.

It is impossible adequately to describe the beauty and grandeur of the spectacle. In its totality it met the eye—one could watch the swelling growth of the eruption, its every movement, and mark all the exquisite proportions of that wonderful creation, whereas close under the mountain there was a terrific confusion of forms. On the afternoon of Wednesday week there was a grand display, which would have been sufficient for one season, and foreigners might have dispersed to their homes, delighted that they had at last witnessed a brilliant eruption of Vesuvius. On the Thursday it was less active, but in the night there was a cannonade, a loud continuous roar, which never ceased a moment for 48 hours. At the distance of 20 miles it shook the windows and murdered sleep; and one thought only of the havoc which was then being committed on fair lands and populous villages. Like a gigantic cauliflower rose up that vast mass of fire and smoke. Do not smile at the homeliness of the comparison, for it is the only one which really represents its form. Its thousand involutions, round and swelling, are well imaged by the sections of the plant, and as they emerged from the volcano they grew in height and magnitude, and intermingled and rolled one over the other until they ascended to the zenith, and then toppled over, section after section, and fell by their own weight. I could see the showers of dust on either side, and in the midst, burning stones like stars; yet the height of this marvellous form was never lessened, for underneath curled up continually fresh supplies, while the thunder, which rolled fearfully, gave a never-failing impulse to their ascent. A slight wind from the northwest detached portions of the column on one side, and sent them down the coast for miles, in one long cloud; as the wind varied, it was swept inland, or across the sea. And then the colors, how exquisite they were! There were artists with me who positively raved. We had the pure white of the homely plant on the summit, while each section was divided from the other by a shade of black. As the setting sun cast its light upon it, we had all the prismatic colors of the rainbow, and then night fell, and the entire mountain, the heavens above and the sea beneath, were on fire.

Eastern Thibet.—According to Dr. Campbell, from whose papers on Eastern Thibet *Nature* gives an interesting abstract, the *dong* or wild-yak of that country is the fiercest of all known ruminants, rarely allowing a man to escape if it can come up with him. Like the American buffalo, this animal is generally hunted on horseback. The domesticated yak and the sheep are used for the transportation of salt, which is brought from all but inaccessible districts, having an elevation of some 22,000 feet, and where it is so cold that salt can only be obtained from April to November. The sheep carries a load varying in weight from eight to twenty-four pounds, according to the character of the route; the salt is thus conveyed to places accessible by yaks, which are capable of bearing a load of 160 pounds.

There are no leeches or mosquitoes in

Thibet, nor are maggots or fleas ever seen there; and in Dingcham, or Thibet proper, there are no bees or wasps.

Of the mineral productions of the country, a form of carbonate of soda called *pen*, borax, saltpetre, common salt, gold, and arsenic, are spoken of by Dr. Campbell. There are no mines of iron, silver, copper, quicksilver, lead, or coal; the latter substance is, however, imported from China.

The turquoise, real or artificial, is universally worn in rings, necklaces, etc., and large amber-like beads are a favorite ornament, but it is uncertain whether they are natural products of Thibet. The latter are apparently composed of turpentine, mixed with some hardening material. Numerous imitations of turquoise are imported from China; and real but not valuable stones are sent, *via* Cashmere (but from what locality is not stated). The only test of a real stone that is resorted to by the Thibetans is to make a fowl swallow it; if real, it will pass through unchanged.

Dr. Campbell gives some very interesting information regarding the food of the Thibetans. During the summer months they use very little fresh meat. They do not like it boiled, and are not partial to it raw, unless it has been dried. In November there is a great slaughter, and a wealthy man, who has perhaps 7,000 sheep, will kill 200 at this time for his year's consumption. The animal after being killed is skinned and gutted, and then placed on its feet in a free current of air. In a couple of days it becomes quite hard, and is then ready for eating. It is kept in this way for more than a year without spoiling, even during the rainy periods. When long exposed to the wind of Thibet it becomes so dry that it may be rolled into powder between the hands. In this state it is mixed with water and drunk, and used in various other ways. The Thibetans eat animal food in endless forms, and a large portion of the people live on nothing else. The livers of sheep and other animals are similarly dried or frozen, and are much prized, but to strangers they are very distasteful for their bitterness and hardness. The fat is dried, packed in the stomachs, and then sent to market or kept for home use.

With regard to edible vegetables, it is stated that wheat, barley, and buckwheat, sown in April or May, and irrigated, are reaped in September, barley in Thibet taking the place of potatoes in Ireland, four-fifths of the population living on it. Besides these, the other crops are composed of peas, turnips, and a little mustard. The grain is ground in water-mills. The bread is all unleavened, and cooked on heated stoves or gridirons. The sweet, pure farinaceous taste of the fine flour equals the best American produce. The staple food of the country is *champa*, called *suttoo* in India; it is finely-ground flour of toasted barley. It is much eaten without further cooking; mixed up with hot tea it is called *paak*, and when prepared with tepid water it is known as *seu.* If any of our readers wish to enter upon "pastures new" in the breakfast department, they may try *tookpa*, which, to be properly appreciated, should be taken at daybreak before any matutinal ablutions. It is a sort of broth made with mutton, champa, dry curds, butter, salt, and turnips.

Goats are also reared in considerable flocks, but for their milk rather than their flesh. The milk of yaks, cows, sheep, and goats, is used alike for making dried curds and the various preparations of milk used by these people. Mares' milk is not used in Eastern Thibet.

Among the afflictions of the Thibetans Dr. Campbell mentions *groomtook*, or *the laughing disease*, which consists of violent fits of laughter, with excruciating pain in the throat. It equally attacks men and women, and often proves fatal in a few days.

Flying Reptiles of the Chalk Formations in Kansas.—Prof. E. D. Cope, whose industry and genius have done great service in making us familiar with the strange animal forms of the reptilian age in this country, describes two species of flying saurians found by himself in the chalk-deposits of Kansas. One of these had probably been discovered previously by Prof. Marsh, of New Haven, and described under a name different from that given by Prof. Cope.

These belong to a genus which comprises the largest of the pterodactyles or flying saurians, a class of reptiles long since found in Europe, but not until recently discovered in this country.

One of the Kansas species measures 18 feet between the tips of its wings, while the expanded wings of the other would cover an expanse of 25 feet.

These animals had strong, claw-bearing digits, and a short tail, with slender heads, and teeth indicating carnivorous habits.

"We may imagine them," says Prof. Cope, "flapping their leathery wings over the waves, and plunging, often seizing many an unsuspecting fish; or, soaring at a safe distance, viewing the sports and combats of the more powerful saurians of the sea. At nightfall they may have suspended themselves from cliffs by the claw-bearing fingers of their wing-limbs."

Origin of Cholera.—According to a recent paper by Mr. B. G. Jenkins, on the origin and distribution of cholera epidemics, of which *Nature* gives an interesting abstract, the ancients were not so far wrong, after all, in their belief that the heavenly bodies were intimately connected with the origin and course of disease. Instead of one "home" of the cholera in the delta of the Ganges, this writer holds that there are seven, all situated on or near the Tropic of Cancer. These are equally distant from each other, and, while that at the mouth of the Ganges is the most important, the others, which are to the east of China, to the north of Mecca, on the west coast of Africa, to the north of the West India Islands, to the west of Lower California, and among the Sandwich Islands, are well marked, and have all been the starting-point of "cholera-streams" 1,400 miles in breadth, which took either a northwesterly or southwesterly direction, or both. After pointing out the rise and progress of the disease within the limits of these several streams, the author mentions the curious cases of ships at sea being suddenly attacked by cholera; and again, the instances of ships sailing along the coast of India being struck by the disease when at the same place, explaining them on the supposition that the ships had been sailing within the limits of the cholera-streams; for, when they got outside the limits, the disease suddenly ceased. He called attention also to the fact that all the places recorded by Dr. Gavin Milroy as unaffected hitherto by cholera, lie outside these streams, or in their possible, but not actual, extension.

Leaving this part of the subject, he next discusses the origin of the disease, declaring that "cholera is intimately connected with auroral displays and with solar disturbances." Instancing the observed periodicity of the sun-spots, of the diurnal variation in the amount of declination of the magnetic needle, of the earth-currents, and of the auroræ, he traces a curious coincidence in the periodicity of cholera epidemics, expressing the belief that they have a period equal to a period and a half of sun-spots. He adds: "My own opinion, derived from an investigation of the subject, is that each planet, in coming to, and in going from, perihelion—more especially about the time of the equinoxes—produces a violent action upon the sun, and has a violent sympathetic action produced within itself—internally manifested by earthquakes, and externally by auroral displays and volcanic eruptions, such as that of Vesuvius at the present moment; in fact, just such an action as develops the tail of a comet when it is coming to, and going from, perihelion; and, when two or more planets happen to be coming to, or going from, perihelion at the same time, and are in, or nearly in, the same line with the sun—being, of course, nearly in the same plane—the combined violent action produces a maximum of sun-spots, and in connection with it a maximum of cholera on the earth. The number of deaths from cholera in any year—for example, the deaths in Calcutta during the six years 1865–'70—increased as the earth passed from perihelion, especially after March 21st, came to a minimum when it was in aphelion, and increased again when it passed to perihelion, and notably after equinoctial day; thus affording a fair test of my theory."

The Yellowstone National Park.—Interesting details of the Yellowstone National Park reservation are given by F. V. Hayden, United States Geologist, in his fifth annual report on the Geology of the Territories, just published.

By act of Congress, approved March 1, 1872, a tract of land in the Territories of Montana and Wyoming is set apart and reserved for a national park. It is situated between 44° and 45° of north latitude—nearly the same as are the White Mountains and the Adirondacks—is 65 by 55 miles in area, and comprises 3,575 square miles.

Every portion of this area is more than 6,000 feet above the level of the ocean, or nearly as high as the summit of Mount Washington. In it is a beautiful sheet of water, the Yellowstone Lake, 330 square miles in area, and 7,427 feet above the sea. Tremendous gorges, chasms, cañons, waterfalls, and forest, make this whole tract surpassingly wild. It is walled on every side by mountain-ridges, from 10,000 to 12,000 feet high. On these elevated summits lie perpetual snows, which feed three of the largest rivers in North America.

The sources of the Yellowstone and Missouri, which empty into the Mississippi, and thence into the Gulf of Mexico—of the Snake River, which flows westward to the Columbia and the Pacific—of the Green River, which discharges its waters through the Colorado into the Gulf of California—are among these mountains.

This whole region was in recent time volcanic. The mountains are of volcanic origin. A vast number of hot springs, mud-volcanoes and geysers of a temperature from 100° to 195° Fahrenheit, indicate the close proximity of the unextinguished fires.

On account of its great elevation, frost forms every month in the year. In summer the thermometer falls to 26°, but the air is clear and invigorating. The reservation of this wild and magnificent tract, so abounding in the most wonderful phenomena of Nature, was a wise foresight, and a tribute to Science in the highest degree honorable to our government.

At a recent dinner of the London Academy of Art, Prof. Tyndall thus happily expressed himself touching the relations of art and science: "There is no reason why art and science should not dwell together in amity; for, though they are both suitors of the same mistress, Nature, they are so in a sense and fashion which preclude the thought of jealousy on either side. You love her for her beauty, we for her order and her truth; but I trust that neither of us is so narrow-hearted as to entirely exclude from himself the feelings which belong to the other. Indeed, each is necessary to the completion of the other. The dry light of the intellect, the warm glow of the emotions, the refined exaltation of the æsthetic faculty, are all part and parcel of human nature; and to be complete we must be capable of enjoying them all. Trust me that we, whose light on earth is for the most part that dry light to which I have referred, often seek, and sometimes have, 'glimpses that make us less forlorn' of those aspects of Nature which reveal themselves in all their fulness to the eyes of art. We need such glimpses as a compensation for much that the times have taken away from us. There are some of us workers in science who largely share the poet's yearning to 'hear old Triton blow his wreathèd horn,' and who, nevertheless, in opposition to natural bias, have been compelled to give up, not only Triton, but many later forms of the power which for a time assumed his shape. Emptied of the hopes and pleasures flowing from such conceptions, we stand in more special need of all that Nature has to offer in the way of grandeur and beauty, of all that history has to offer in the way of strength and inspiration, and of such interpretations, by men of genius, of Nature, history, and contemporary life, as at this moment adorn these walls. If I might employ, in a sense so qualified as to render me sincere in using it, a form of language familiar to you all, I would say that we interpret these works of genius, these achievements in which our best men embody their highest efforts, as the outcome of the cultivated, but at the same time inborn and unpurchasable gift of God. For, though the laborer be worthy of his hire, and though the leaders both in arts and science may now by good right make pleasant terms with the world, they reached the position which enables them to do this through periods of labor and resolute self-denial, during which their arts and their science were to them all in all; and reward was the necessary incident and not the motive power of their lives."

Mr. James Geikie, in a fourth paper on "Changes of Climate during the Glacial Epoch," thus states his views as to the sequence of climates in England during this time: First, a succession of alternate glacial and temperate conditions, but associated with the great continental ice-sheets; second, a temperate climate with removal of the ice-sheets from low grounds; third, a period of subsidence, with temperate climate, and much denudation of moraines; fourth, a period of emergence, with arctic conditions, floating ice dispersing erratics, and deposition of clays with arctic mollusca; and, fifth, a period of local glaciers in Britain and Ireland, with gradual amelioration of climate.

Dr. Cobhold says that, when once the trichina has gained admission to our muscles, all hopes of dislodging it are at an end; but, if a person suspects that he has eaten diseased or trichinized meat, he should lose no time in seeking assistance. Immediate advice, followed by suitable remedy, might be the means of saving his life, whereas a few days' delay would perhaps prove fatal. While the worms are in the intestinal canal, we can get rid of them; but, when once the trichinal brood migrates into the flesh, no means are known by which their expulsion can be effected.

A Berlin lithographer, after years of study, is said to have at last succeeded in producing a paper for printing money which it is impossible to imitate. The color of the paper is the only secret on which the invention rests. The inventor says the colors cannot be chemically analyzed; with the magnifying-glass they can be distinguished from all other colors, and in their quality as colors they cannot be imitated by photography, nor in any other way.

NOTES.

According to the observations of a writer in *Land and Water*, the time required for fish-eggs to hatch varies greatly with different seasons. He states that in 1869 ova from the trout hatched in 55 days, in 1870 they were 92 days hatching, in 1871 95 days, and in 1872 they hatched in 82 days. With the exception of temperature, the conditions were identical in the different years. The first year there was no frost, and the ova were in a house with a glass roof, and consequently at a high temperature. The second and third years there were long frosts after the eggs were placed in the boxes, and this year there was also some frost.

Catoptric lamps, or lamps provided with reflectors, are being introduced in London for lighting the streets. The reflectors are so placed in the top of the lamp that those portions of the light ordinarily passing skyward are made to illuminate the foot-ways. The light is evenly distributed; and from the same jet, as shown by the photometer, three times as much illuminating power is obtained as by the old-fashioned lamp.

Prof. Pepper, of ghostly fame, is giving in London a popular scientific entertainment, followed by a lecture on "spiritualism." The professor announces himself as ready to give all the "manifestations" usual at "spirit *séances*." He "tips" the tables, and "scratches" the same, with all the airy grace of a disembodied sprite. The "hand of glory" is to be seen at his entertainments, and a violin is made to float in the air. Mr. Pepper has not yet perfected his arrangements for "floating" himself *à la Home*, but that feat is "on the bills," and will be performed in a few days. The means by which he performs these marvels he keeps secret at present, but promises to publish them after a few months.

The use of rubber plates and rings, for making connections between steam and other pipes, is often attended with much annoyance, owing to the leakage of the joints. This may be prevented by employing a cement prepared by dissolving shellac in ammonia. The pulverized gum-shellac is soaked in ten times its weight of strong ammonia, when a slimy mass is obtained, which in three or four weeks will become liquid without the use of hot water. This fastens well both to the rubber and to the metal or wood, and becomes, by volatilization of the ammonia, hard and impermeable to either gases or fluids.

Coloring Matter in Fungi.—Mr. H. C. Sorby has determined the existence of at least 30 distinct coloring substances in fungi. The majority contain at least two, and many of them several, different kinds. Twenty of these have such well-marked optical qualities that they could be recognized without difficulty in other plants, but only one of them, a fine orange-color, is known to exist in any plant not a fungus. As far as Mr. Sorby's observations extend, there is little or no specific agreement between the substances found in fungi and those met with in algæ and lichens, though the two latter orders are closely related in this respect.—*Science Gossip.*

Prof. Herman, in a paper published in *Pflüger's Archiv*, states that living muscle offers very much greater resistance to an electric current passing in a direction across the fibres, than to one transmitted along them, the average difference being as seven to one. In muscles that have passed into the condition of *rigor mortis* (stiffening of death), this difference almost entirely disappears. A similar difference in the amount of resistance offered to the passage of an electric current is observed in the case of the nerves, though the ratio is somewhat less, being about five to one.

New Fossil Fish.—Sir Philip Egerton has just described a new genus of fossil fish from the lias of Lyme Regis, to which he has given the name *Prognathodus*. Dr. Günther is of opinion that in its dentition it establishes an additional piece of evidence in favor of the connection between the Ganoid and Chimæroid forms.

The liability of glued articles to come to pieces when exposed to the action of water, especially hot water, is familiar to every one. By adding to the water, with which the glue is mixed when required for use, a small quantity of bichromate of potash, and afterward exposing the part to which it is applied to light, the glue is rendered insoluble, and articles fastened with it resist the action of water. The proportion of bichromate of potash to be taken must be determined by experiment, but for most purposes one-fiftieth of the amount of glue employed will be sufficient.

The Emperor William, who, during the late war, became noted for his disinterested generosity in ascribing the numerous German successes to the favoring hand of Providence, is now furnishing more substantial, and if possible more high-sounding tokens of his regard, in the shape of church-bells, which the *Builder* tells us are being cast in great numbers from the cannon captured from the French, for use in German churches.

Certain minerals, such as rose-colored silex, native arsenic, and red arsenic, undergo a change when the solar ray falls upon them. The last-named mineral is reduced to a powder, and its red crystals change to orange-color. M. Jannetay, of the French Geological Society, has studied the action of the various luminous rays in this regard, and finds that the red rays alone do not alter the minerals in question.

M. Louvel proposes to store grain in air-tight granaries from which the air may be partially exhausted by means of a powerful air-pump. He claims that in this way grain may be much better preserved from decay, and the ravages of insects are effectually stopped. The cost of such a granary capable of holding 300 bushels of wheat would be, in France, about 150 dollars.

The subcutaneous injection of morphia in cholera has been satisfactorily tried by Dr. Augustus Werry, of Constantinople. In from 15 to 20 minutes after the injection, the patients fell into a calm sleep, and awoke in two or three hours bathed in a warm perspiration, and saying that they were "well again." Dr. Werry treated in this way 22 cases of cholera, presenting almost every phase of the disease, violent vomiting and cramps, dyspnœa, reduced temperature of the body, diarrhœa, weakened circulation, etc., and always with beneficial results. The dose of morphia injected varied from one-twelfth to one-half of a grain.

According to a correspondent in *Harper's Weekly*, the horned frog of our Western plains is ovoviviparous, that is, producing eggs that are hatched before leaving the mother's body, the young being brought forth alive. He states that, while crossing the plains some years ago, he carried with him several of these animals, and, on examining them one night, found that 24 young ones had suddenly made their appearance, each one about the size of a dime, and all very lively.

A certain M. Donac has recently laid before the French Academy of Sciences a project for liquefying dead bodies and transforming them into a syrup without color or smell. According to his calculations, a moderate-sized man could be got into six bottles. The size of each bottle is not stated, but the *Paris Journal* appears charmed with the idea, and exclaims, "What an opening for the exercise of filial piety!"—*Lancet.*

One of the ostriches in the Zoological Gardens, London, recently dying, an examination of the stomach showed the cause of death to be copper-poisoning, that organ containing a number of copper coins, and pieces of coins in a much-worn state.

The death is announced of Professor von Mohl, the eminent botanist, who expired on the 1st of April last, at Tübingen, aged sixty-seven. At thirty years of age he was appointed Professor of Botany and Director of the Botanic Garden, at Tübingen, retaining the position until his death. Since 1843 he has been editor of the *Botanische Zeitung*, and for the last thirty-five years was one of the foreign members of the Linnæan Society. Giving special attention to the study of vegetable anatomy and physiology, he has written extensively on these subjects; his works contain the result of much original observation.

Nature records the occurrence of seven earthquakes in January last. Two were in Central and one in South America, three in India, and one in Asia Minor.

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THE AUGUST AND NOVEMBER METEORS.

By Dr. H. SCHELLEN.

WHOEVER has observed the heavens on a clear night with some amount of attention and patience, cannot fail to have noticed the phenomenon of a falling star, one of those well-known fiery meteors which suddenly blaze forth in any quarter of the heavens, descend toward the earth, generally with great rapidity, in either a vertical or slanting direction, and disappear after a few seconds at a higher or lower altitude. As a rule, falling stars can only be seen of an evening, or at night, owing to the great brightness of daylight; but many instances have occurred in which their brilliancy has been so great as to render them visible in the daytime, as well when the sky was overcast as when it was perfectly cloudless. It has been calculated that the average number of these meteors passing through the earth's atmosphere, and sufficiently bright to be seen at night with the naked eye, is not less than 7,500,000 during the space of twenty-four hours, and this number must be increased to 400,000,000 if those be included which a telescope would reveal. In many nights, however, the number of these meteors is so great that they pass over the heavens like flakes of snow, and for several hours are too numerous to be counted. Early in the morning of the 12th of November, 1799, Humboldt and Bonpland saw before sunrise, when on the coast of Mexico, thousands of meteors during the space of four hours, most of which left a track behind them of from 5° to 10° in length; they mostly disappeared without any display of sparks, but some seemed to burst, and others, again, had a nucleus as bright as Jupiter, which emitted sparks. On the 12th of November, 1833, there fell another shower of meteors, in which, according to Arago's estimation, 240,000 passed over the heavens, as seen from the place of observation, in three hours.

Only in very rare instances do these fiery substances fall upon the surface of the earth; when they do, they are called balls of fire; and occasionally they reach the earth before they are completely burnt out or evaporated; they are then termed meteoric stones, aërolites, or meteoric iron. They are also divided into accidental meteors and meteoric showers, according as to whether they traverse the heavens in every direction at random, or appear in great numbers following a common path, thus indicating that they are parts of a great whole.

It is now generally received, and placed almost beyond doubt by the recent observations of Schiaparelli, Le Verrier, Weiss, and others, that these meteors, for the most part small, but weighing occasionally many tons, are fragmentary masses, revolving, like the planets, round the sun, which in their course approach the earth, and, drawn by its attraction into our atmosphere, are set on fire by the heat generated through the resistance offered by the compressed air.

The chemical analysis of those meteors which have fallen to the earth in a half-burnt condition in the form of meteoric stones proves that they are composed only of terrestrial elements, which present a form and combination commonly met with in our planet. Their chief constitutent is metallic iron, mixed with various silicious compounds; in combination with iron, nickel is always found, and sometimes also cobalt, copper, tin, and chromium; among the silicates, olivine is especially worthy of remark as a mineral very abundant in volcanic rocks, as also augite. There have also been found, in the meteoric stones hitherto examined, oxygen, hydrogen, sulphur, phosphorus, carbon, aluminium, magnesium, calcium, sodium, potassium, manganese, titanium, lead, lithium, and strontium.

The height at which meteors appear is very various, and ranges chiefly between the limits of 46 and 92 miles; the mean may be taken at 66 miles. The speed at which they travel is also various, generally about half as fast again as that of the earth's motion round the sun, or about 26 miles in a second: the maximum and minimum differ greatly from this amount, the velocity of some meteors being estimated at 14 miles, and that of others at 107 miles in a second.

When a dark meteorite of this kind, having a velocity of 1,660 miles per minute, encounters the earth, flying through space at a mean rate of 1,140 miles per minute, and when through the earth's attraction its velocity is further increased 230 miles per minute, this body meets with such a degree of resistance, even in the highest and most rarefied state of our atmosphere, that it is impeded in its course, and loses in a very short time a considerable part of its momentum. By this encounter there follows a result common to all bodies which, while in motion, suddenly experience a check When a wheel revolves very rapidly, the axletree or the drag which is placed under the wheel is made red-hot by the friction. When a cannon-ball strikes suddenly with great velocity against a plate of iron, which constantly happens at target-practice, a spark is seen to flash from the ball even in daylight; under similar circumstances a lead bullet becomes partially melted. The heat of a body consists in the vibratory motion of its smallest particles; an increase of this molecular motion is synonymous with a higher temperature; a lessening of this vibration is termed decreasing heat, or the process of cooling. Now, if a body in motion, as for instance a cannon-ball, strike against an iron plate, or a meteorite against the earth's atmosphere, in proportion as the motion of the body diminishes and the external action of the moving mass becomes annihilated by the pressure of the opposing medium upon the foremost molecules, the vibration of these particles increases; this motion is immediately communicated to the rest of the mass, and by the acceleration of this vibration through all the particles the temperature of the body is raised. This phenomenon, which always takes place when the motion of a body is interrupted, is designated by the expression *the conversion of the motion of the mass into molecular action or heat;* it is a law without exception that, where the *external* motion of the mass is diminished, an inner action among its particles, or heat, is set up in its place as an equivalent, and it may be easily supposed that, even in the highest and most rarefied strata of the earth's atmosphere, the velocity of the meteorite would be rapidly diminished by its opposing action, so that shortly after entering our atmosphere the vibration of the inner particles would become accelerated to such a degree as to raise them to a white heat, when they would either become partially fused, or, if the meteorite were sufficiently small, it would be dissipated into vapor, and leave a luminous track behind it of glowing vapors.

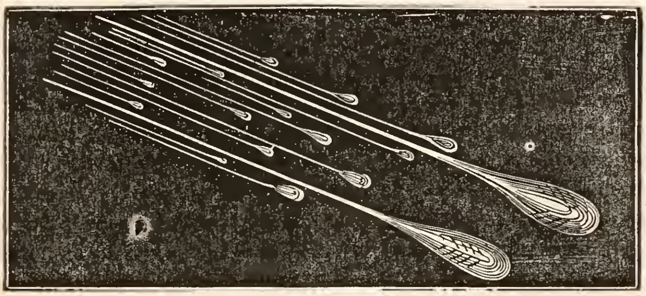
Haidinger, in a theory embracing all the phenomena of meteorites, explains the formation of a ball of fire round the meteor, by supposing that the meteorite, in consequence of its rapid motion through the atmosphere, presses the air before it till it becomes luminous. The compressed air in which the solid particles of the surface of the meteorite glow then rushes on all sides, but especially over the surface of the meteor behind it, where it encloses a pear-shaped vacuum which has been left by the meteorite, and so appears to the observer as a ball of fire. If several bodies enter the earth's atmosphere in this way at the same time, the largest among them precedes the others, because the air offers the least resistance to its proportionately smallest surface; the rest follow in the track of the first meteor, which is the only one surrounded by a ball of fire. When by the resistance of the air the motion of the meteor is arrested, it remains for a moment perfectly still; the ball of fire is extinguished, the surrounding air rushes suddenly into the vacuum behind the meteor, which, left solely to the action of gravitation, falls vertically to the earth. The loud, detonating noise usually accompanying this phenomenon finds an easy explanation in the violent concussion of the air behind the meteor, while the generally-received theory, that the detonating noise is the result of an explosion or bursting of the meteorite, does not meet with any confirmation.

The circumstance that most meteors are extinguished before reaching the earth seems to show that their mass is but small. If the distance of a meteor from the earth be ascertained, as well as its apparent brightness as compared with that of a planet, it is possible, by comparing its luminosity with that of a known quantity of ignited gas, to estimate the degree of heat evolved in the meteor's combustion. As this heat originates from the motion of the meteor being impeded or interrupted by the resistance of the air, and as this motion or momentum is exclusively dependent on the speed of the meteor as well as upon its mass, it is possible, when the rate of motion has been ascertained by direct observation, to determine the mass. Prof. Alexander Herschel has calculated by this means that those meteors of the 9th and 10th of August, 1863, which equalled the brilliancy of Venus and Jupiter, must have possessed a mass of from five to eight pounds, while those which were only as bright as stars of the second or third magnitude would not be more than about ninety grains in weight. As the greater number of meteors are less bright than stars of the second magnitude, the faint meteors must weigh only a few grains, for, according to Prof. Herschel's computation, the five meteors observed on the 12th of November, 1865, some of which surpassed in brilliancy stars of the first magnitude, had not an average weight of more than five grains; and Schiaparelli estimated the weight of a meteor from other phenomena to be about fifteen grains. The mass, however, of the meteoric stones which fall to the earth is considerably greater, whether they consist of one single piece, such as the celebrated iron-stone discovered by Pallas in Siberia, which weighed about 2,000 pounds, or of a cloud composed of many small bodies which penetrate the earth's atmosphere in parallel paths, as shown in Fig. 1, and which, from a simultaneous ignition and descent upon the earth, present the appearance of a large meteor bursting into several smaller pieces. Such a shower of stones, accompanied by a bright light and loud explosion, occurred at L'Aigle, in Normandy, on the 26th of April, 1803, when the number of stones found in a space of 14 square miles exceeded 2,000. In the meteoric shower that fell at Kŭyahinga, in Hungary, on the 9th of June, 1866, the principal stone weighed about 800 pounds, and was accompanied by about a thousand smaller stones, which were strewed over an area of 9 miles in length by 3¼ broad.

It must not be supposed, however, that the density of such a cosmical cloud is as great when out of the reach of the attraction of the sun and the earth as when its constituents fall upon the earth's surface. Schiaparelli calculates, from the number of meteors observed yearly in the month of August, that the distance between any two must amount, on the average, to 460 miles. As the cosmical clouds which produce the meteors approach the sun in their wanderings from the far-off regions of space, they increase in density some million times, therefore the distance between any two meteors, only a few grains in weight, before the cloud begins to be condensed, may be upward of 40,000 miles.

The most striking example of such a cosmical cloud composed of small bodies loosely hung together, and existing with hardly any connection one with another, is exhibited in the meteoric showers occurring periodically in August and November. It is an ascertained fact that on certain nights in the year the number of meteors is extraordi-

FIG. 1.



Balls of Fire seen through the Telescope.

narily great, and that at these times they shoot out from certain fixed points in the heavens. The shower of meteors which happens every year on the night of the 10th of August, proceeding from the constellation of Perseus, is mentioned in many old writings. The shower of the 12th and 13th of November occurs periodically every 33 years, for three years in succession, with diminishing numbers; it was this shower that Alexander von Humboldt and Bonpland observed on the 12th of November, 1799, as a real rain of fire. It recurred on the 12th of November, 1833, in such force that Arago compared it to a fall of snow, and was lately observed again in its customary splendor in North America, on the 14th of November, 1867. Besides these two principal showers, there are almost a hundred others recurring at regular intervals; each of these is a cosmical cloud composed of small dark bodies very loosely held together, like the particles of a sand-cloud, which circulate round the sun in one common orbit. The orbits of these meteor streams are very diverse; they do not lie approximately in one plane like those of the planets, but cross the plane of the earth's orbit at widely different angles. The motion of the individual meteors ensues in the same direction in one and the same orbit; but this direction is in some orbits in conformity with that of the earth and planets, while in others it is in the reverse order.

The earth in its revolution round the sun occupies every day a different place in the universe; if, therefore, a meteoric shower pass through our atmosphere at regular intervals, there must be at the place where the earth is at that time an accumulation of these small cosmical bodies, which, attracted by the earth, penetrate its atmosphere, are ignited by the resistance of the air, and become visible as falling stars. A cosmical cloud, however, cannot remain at a fixed spot in our solar system, but must circulate round the sun as planets and comets do; whence it follows that the path of a periodic shower intersects the earth's orbit, and the earth must either be passing through the cloud, or else very near to it, when the meteors are visible to us.

The meteor-shower of the 10th of August, the radiant point of which is situated in the constellation of Perseus, takes place nearly every year, with varying splendor; we may therefore conclude that the small meteors composing this group form a ring round the sun, and the earth every 10th of August is at the spot where this ring intersects our orbit; also that the ring of meteors is not equally dense in all parts: here and there these small bodies must be very thinly scattered, and in some places even altogether wanting.

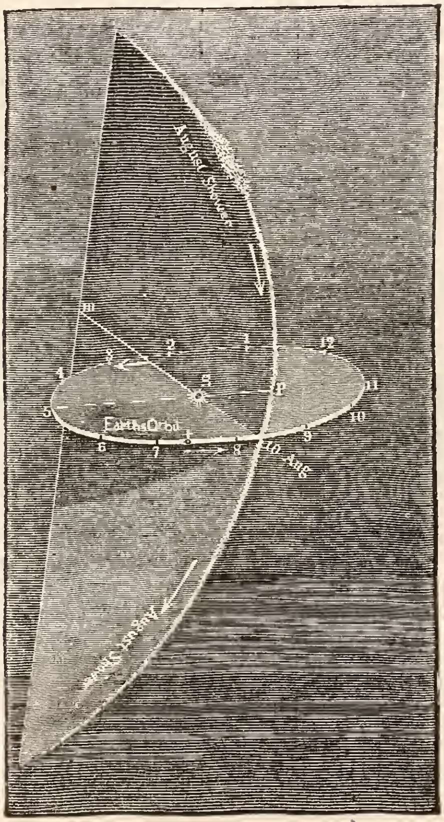
Fig. 2 shows a very small part of the elliptic orbit which this meteoric mass describes round the sun S. The earth encounters this orbit on the 10th of August, and goes straight through the ring of meteors. The dots along the ring indicate the small dark meteors which ignite in our atmosphere, and are visible as shooting-stars. The line *m* is the line of intersection of the earth's orbit and that of the meteors; the line P S shows the direction of the major axis of their orbit. This axis is fifty times greater than the mean diameter of the earth's orbit; the orbit of the meteors is inclined to that of the earth at an angle of 64° 3′, and their motion is retrograde, or contrary to that of the earth.

The November shower is not observed to take place every year on the 12th or 13th of that month, but it is found that every 33 years an extraordinary shower occurs on those days, proceeding from a point in the constellation of Leo. The meteors composing this shower, unlike the August one, are not distributed along the whole course of their orbit, so as to form a ring entirely filled with meteoric particles, but constitute a dense cloud, of an elongated form, which completes its revolution round the sun in 33 years, and crosses the earth's path at that point where the earth is every 13th of November.

When the November shower reappears after the lapse of 33 years, the phenomenon is repeated during the two following years on the 13th of that month, but with diminished splendor; the meteors, therefore, extend so far along the orbit as to require three years before they have all crossed the earth's path at the place of intersection; they are, besides, unequally distributed, the preceding part being much the most dense.

A very small part of the elliptic orbit, and the distribution of the meteors during the November shower, is represented in Fig. 3. As shown in the drawing, this orbit intersects that of the earth at the place where the earth is about the 14th of November, and the motion of the meteors, which occupy only a small part of their orbit, and are very unequally distributed, is retrograde, or contrary to that of the earth. The inclination of this orbit to that of the earth is only 17° 44′; its major axis is about 10½ times greater than the diameter of the earth's orbit, and the period of revolution for the densest part of the meteorites round the sun S is 33 years 3 months.

Fig. 2.



Orbit of the Meteor-Shower of the 10th of August.

From all we have now learned concerning the nature and constitution of comets, nebulæ, cosmical clouds, and meteoric swarms, an unmistakable resemblance will be remarked among these different forms in space. The affinity between comets and meteors had been already recognized by Chladni, but Schiaparelli, of Milan, was the first to take account of all the phenomena exhibited by these mysterious heavenly bodies, and with wonderful acuteness to treat successfully the mass of observations and calculations which had been contributed during the course of the last few years by Oppolzer, Peters, Bruhns, Heis, Le

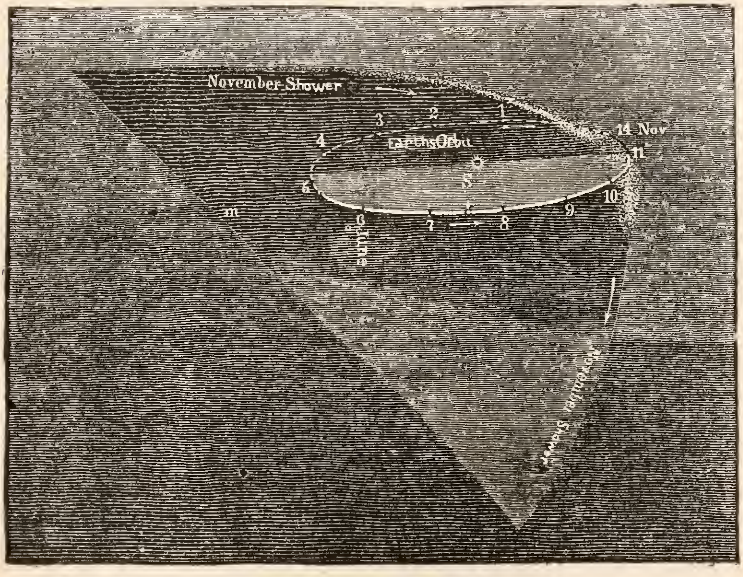
Verrier, and other observers. He not only shows that the orbits of meteors are quite coincident with those of comets, and that the same object may appear to us at one time as a comet, and at another as a shower of meteors, but he proves also by a highly-elegant mathematical calculation that the scattered cosmical masses known to us by the name of nebulæ would, if in their journey through the universe they were to come within the powerful attraction of our sun, be formed into comets, and these again into meteoric showers.

We should be carried away too far from our subject were we to enter fully into the consideration of this bold and ingenious theory of the Milan astronomer, supported though it be by a series of facts; but while we refer the reader to vol. xx. of "Naturwissenschaftlichen Volksbücher," by A. Bernstein, in which this subject, "die Räthsel der Sternschnuppen und der Kometen," is fully treated of in a very clear and attractive manner, we shall confine ourselves to the following short statement of Schiaparelli's theory:

Nebulæ are composed of cosmical matter in which as yet there is no central point of concentration, and which has not become sufficiently dense to form a celestial body in the ordinary sense of the term. The diffuse substance of these cosmical clouds is very loosely hung together; its particles are widely separated, thus constituting masses of enormous extent, some of which have taken a regular form, and some not. As these nebulous clouds may be supposed to have, like our sun, a motion in space, it will sometimes happen that such a cloud comes within reach of the power of attraction of our sun. The attraction acts more powerfully on the preceding part of the nebulæ than on the farther and following portion; and the nebula, while still at a great distance, begins to lose its original spherical form, and becomes considerably elongated. Other portions of the nebulous mass follow continuously the preceding part, until the sphere is converted into a long cylinder, the foremost part of which, that toward the sun, is denser and more pointed than the following part, which retains a portion of its original breadth. As it nears the sun, this transformation of the nebulous cloud becomes more complete: illuminated by the sun, the preceding part appears to us as a dense nucleus, and the following part, turned away from the sun, as a long tail, curved in consequence of the lateral motion preserved by the nebula during its progress. Out of the original spherical nebula, quite unconnected with our solar system, a comet has been formed, which in its altered condition will either pass through our system to wander again in space, or else remain as a permanent member of our planetary system. The form of the orbit in which it moves depends on the original speed of the cloud, its distance from the sun, and the direction of its motion, and thus its path may be elliptical, hyperbolical, or parabolical; in the last two cases, the comet appears only once in our system, and then returns to wander in the realms of space; in the former case, it abides with us, and accomplishes its course round the sun, like the planets, in a certain fixed period of years. From this it is evident that the orbits of comets may occur at every possible angle to that of the earth, and that their motion will be sometimes progressive and sometimes retrograde.

The history of the cosmical cloud does not, however, end with its transformation into a comet. Schiaparelli shows in a striking manner that, as a comet is not a solid mass, but consists of particles, each possessing an independent motion, the head or nucleus nearer the sun must necessarily complete its orbit in less time than the more distant portions of the tail. The tail will therefore lag behind the nucleus in

Fig. 3.



Orbit of the November Meteor-Shower.

the course of the comet's revolution, and the comet, being more and more elongated, will at last be either partially or entirely resolved into a ring of meteors. In this way the whole path of the comet becomes strewed with portions of its mass, with those small, dark meteoric bodies which, when penetrating the earth's atmosphere, become luminous, and appear as falling stars. Instead of the comet, there now revolves round the sun a broad ring of meteoric stones, which occasion the phenomena we every year observe as the August meteors. Whether this ring be continuous, and the meteoric masses strewed along the whole course of the path of the original comet, or whether the individual meteors, as in the November shower, have not filled up entirely the whole orbit, but are still partially in the form of a comet, is, in the transformation of a cosmical cloud through the influence of the sun, only a question of time; in course of years the matter composing a comet which describes an orbit round the sun must be dispersed over its whole path; *if the original orbit be elliptical, an elliptic ring of meteors will gradually be formed from the substance of the comet, of the same size and form as the original orbit.*

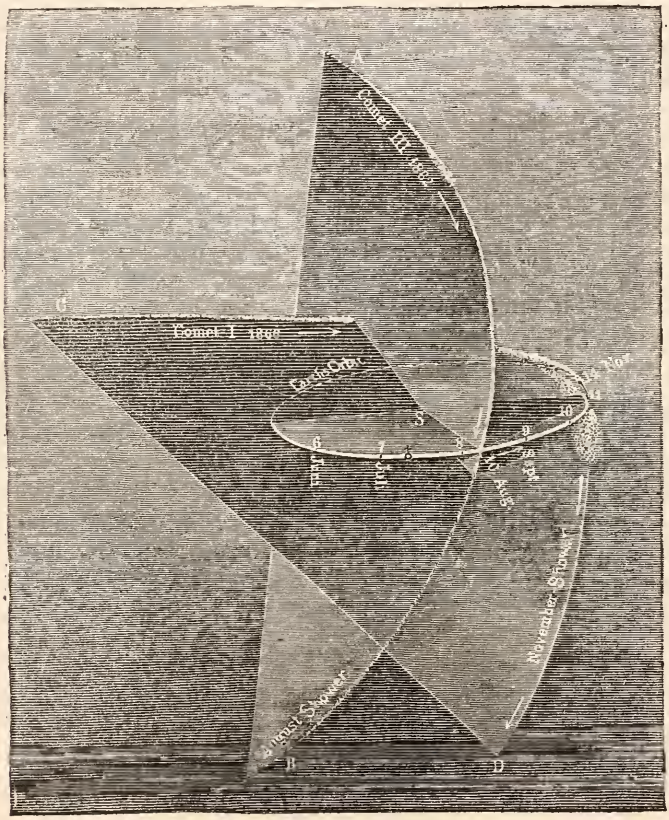
Schiaparelli has, in fact, discovered so close a resemblance between the path of the August meteors and that of the comet of 1862, No. III., that there cannot be any doubt as to their complete identity. The meteors to which we owe the annual display of falling stars on the 10th of August are not distributed equally along the whole course of their orbit; it is still possible to distinguish the agglomeration of meteoric particles which originally formed the cometary nucleus from the other less dense parts of the comet; thus, in the year 1862 the denser portion of this ring of meteors through which the earth passes annually on the 10th of August, and which causes the display of falling stars, was seen in the form of a comet, with head and tail as the densest parts, approached the sun and earth in the course of that month. Oppolzer, of Vienna, calculated with great accuracy the orbit of this comet, which was visible to the naked eye. Schiaparelli had previously calculated the orbit of the meteoric ring to which the shooting-stars on the 10th of August belong before they are drawn into the earth's atmosphere. The almost perfect identity of the two orbits justifies Schiaparelli in the bold assertion that *the comet of* 1862, No. III., *is no other than the remains of the comet out of which the meteoric ring of the* 10*th of August has been formed in the course of time.* The difference between the comet's nucleus and its tail that has now been formed into a ring, consists in that, while the denser meteoric mass forming the head approaches so near the earth once in every 120 years as to be visible in the reflected light of the sun, the more widely-scattered portion of the tail composing the ring remains invisible, even though the earth passes through it annually on the 10th of August. Only fragments of this ring, composed of dark meteoric particles, become visible as shooting-stars when they penetrate our atmosphere by the attraction of the earth, and ignite by the compression of the air.

A cloud of meteors of such a character can naturally only be observed as a meteor-shower when in the nodes of its orbit—that is to say, in those points where it crosses the earth's orbit—and then only when the earth is also there at the same time, so that the meteors pass through our atmosphere. The nebula coming within the sphere of attraction of our solar system would, at its nearest approach to the sun (perihelion), and in the neighboring portions of its orbit, appear as a *comet*, and when it grazed the earth's atmosphere would be seen as a *shower of meteors.*

Calculation shows that this ring of meteors is about 10,948 millions of miles in its greatest diameter. As the meteoric shower of the 10th of August lasts about six hours, and the earth travels at the rate of eighteen miles in a second, it follows that the breadth of this ring at the place where the earth crosses it is 4,043,520 miles. In Fig. 4, A B represents a portion of the orbit of the comet of 1862, No. III., which is identical with that (Fig. 2) of the August shower.

The calculations of Schiaparelli, Oppolzer, Peters, and Le Verrier, have also discovered the comet producing the meteors of the Novem-

Fig. 4.



Orbits of the August and November Meteor-Showers.
(Orbits of Comets III., 1862, and I., 1866.)

ber shower, and have found it in the small comet of 1866, No. I., first observed by Tempel, of Marseilles. Its transformation into a ring of meteors has not proceeded nearly so far as that of the comet of 1862, No. III. Its existence is of a much more recent date; and, therefore, the dispersion of the meteoric particles along the orbit, and the consequent formation of the ring, is but slightly developed.

According to Le Verrier, a cosmical nebulous cloud entered our system in January, A. D. 126, and passed so near the planet Uranus as to be brought by its attraction into an elliptic orbit round the sun. This orbit is the same as that of the comet discovered by Tempel, and calculated by Oppolzer, and is identical with that in which the November group of meteors make their revolution.

Since that time, this cosmical cloud, in the form of a comet, has completed fifty-two revolutions round the sun, without its existence being otherwise made known than by the loss of an immense number of its components, in the form of shooting-stars, as it crossed the earth's path in each revolution, or in the month of November in every 33 years. It was only in its last revolution, in the year 1866, that this meteoric cloud, now forming part of our solar system, was first seen as a comet.

The orbit of this comet is much smaller than that of the August meteors, extending at the aphelion as far as the orbit of Uranus, while the perihelion is nearly as far from the sun as our earth. The comet completes its revolution in about 33 years and three months, and encounters the earth's orbit as it is approaching the sun toward the end of September. It is followed by a large group of small meteoric bodies, which form a very broad and long tail, through which the earth passes on the 13th of November. Those particles which come in contact with the earth, or approach so near as to be attracted into its atmosphere, become ignited, and appear as falling stars. As the earth encounters the comet's tail, or meteoric shower, for three successive years at the same place, we must conclude the comet's track to have the enormous length of 1,772,000,000 of miles. In Fig. 4, C D represents a portion of the orbit of this comet which is identical with the orbit (Fig. 3) of the November meteors.—*Spectrum Analysis.*

MODERN LITERATURES IN THE HIGHER EDUCATION.

By Dr. J. B. MOZLEY,

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THERE is no one who, coming for the first time to a knowledge of our English system of education, would not be very much surprised by the fact that, while we take the greatest trouble to instruct young men in the language, history, and institutions of nations that lived two thousand years ago, and whose whole being belongs to a past stage in the world's existence, we take no trouble at all to instruct them concerning the nations who now live, with whom we have an every-day intercourse, on whom we depend for so many benefits, as well material as spiritual, whose temper, character, and friendly or inimical feelings toward us are of the very highest importance. If we can imagine such a person giving free expression to his feelings at the first sight of such a phenomenon (a phenomenon observable in all other European states equally with our own), what he would say would probably be something after this manner: "These nations of Europe present some very singular anomalies. Their newspapers, of whatever country, are full of complaints of the absolute inability of all foreigners to gain the least comprehension of the institutions of that particular country. The English and Germans alike speak of the French as a nation wholly swallowed up in themselves, and ludicrously ignorant of every thing outside themselves. The French retaliate by calling the Germans barbarians and the English shopkeepers. The Americans say that no foreigner, except a certain De Tocqueville, has ever gained the smallest glimpse of their character; while the English affirm that the Americans themselves are blinded to every thing except what they think their national grandeur. And what is more," the observer might go on to remark, "these complaints are, for the most part, not only true, but obvious, and obviously disastrous in their results. Witness the fact that the leading English newspaper, not many years ago, inserted a leading article on what turned out to be an absurd mistake of its own respecting one of the chief institutions of Germany—the Zollverein—a mistake which it had to acknowledge the day after. Or, again, witness the fact that one of the chief French authors can hardly employ an English word in his books without a ludicrous misspelling. Or, again, the more serious fact that the French enter upon a war in the firm belief that they will find allies in the States of South Germany; instead of which, they find them enthusiastic enemies. This being the case," he might conclude by saying, "I naturally looked to those bodies in these countries whose office it is to attain and diffuse knowlenge to the widest degree possible—the universities—assuming that the means of remedying so great a defect in knowledge, and one so universally complained of, would at any rate be under their consideration. To my surprise, I find that they had hardly even noticed the subject at all. Every one of these nations seemed to me to be in the position of a man whose whole time was occupied in investigating the biography of his great-grandfather, while with his relations, connections, friends, and acquaintances, he only transacted the most barely necessary business for the shortest possible space of time."

An observer who spoke in this way would, it may be granted, be speaking in ignorance of many of the causes of the phenomenon he wondered at, and of the practical necessities that might be held to justify it. But he would surely not have in the least exaggerated the strangeness of the phenomenon. Every conceivable branch of knowledge—physical science, mathematics, philosophy, theology—all ancient culture, is thought in England worth systematic study, except this. It is only the condition, material and spiritual, of the nations with whom we come into immediate contact, whose disposition toward us constantly elicits from us the greatest interest and anxiety, that we do not think worthy of systematic study. It is of this alone that we are notoriously ignorant.

The best way, perhaps, of appreciating how wide the extent of this ignorance is, will be by considering how great is the variety of knowledge which an Oxford or Cambridge first-class man will often possess respecting the whole national being of Greece and Rome. To begin with, he will know the whole political development of those countries; he will trace with accuracy the consistent progress of Athens to an equal liberty among her citizens, through Solon, Cleisthenes, Aristides, Pericles; he will know by what causes she finally fell from her strength and supremacy. From Demosthenes, he will know a good deal of the nature of her laws, in their application to the manifold interests of men—to the injuries which one man may suffer from another, in person or property, by fraud or violence. He will know something from the same source of the way in which the rich Athenians managed their properties, of the number of their slaves, of their commerce, of their loans. He will know how the Athenian navy was provided and kept up, what was the pay of the sailors, how they manœuvred against the enemy. He will be intimately acquainted with every incident in the external history of Athens; and in the geography of Greece he will know the situation of the minutest villages, the least important islands. All the varied history of the Greek colonies, and their relations to their respective mother-cities, will be familiar to him. Besides this, he will know how the Greeks themselves felt, thought, and theorized, on all these matters of their national existence; he will have read the "Republics" of Plato and of Aristotle; he will be no stranger to their religious feelings, or to their deepest speculations in philosophy. Finally, in their poetry—epic, tragedy, or comedy—he will have felt the flow of their fancy and imagination. All this, and much more, our first-class man will be in a position to know about Greece; and in Rome he will have no less rich a field of information; for, if the philosophy and poetry of Rome do not possess an equal interest with those of Greece, the law, politics, and military system of Rome possess much more.

Such and so great a thing is it to know the whole being of a nation. And this knowledge is actually held by no inconsiderable number of people in England; and there are many more who, though they do not have it at their fingers' ends, would yet be readily able, by means of excellent text-books and their own previous knowledge, to test in half an hour any random assertions respecting the ancients made by an incompetent authority.

Now, let it be considered that there are five modern nations—England, France, Germany, Italy, and Spain—who have each a history of equal length with the authentic history of Greece or Rome, a literature (at least in the first four cases) not greatly inferior, institutions and a manner of life far more complex, and it will be admitted that here we have a subject well worthy of systematic and regular treatment. These are not topics that can be handled satisfactorily in the idle leisure of a summer tour, in a long vacation. They deserve that a far more steady attention should be devoted to them. Let this first be recognized fully—the importance, which cannot be exaggerated, of a kind of study in which no man in England has had a regular training—and then we may proceed to consider the method by which this study may be raised to the prominence which it deserves. That there are difficulties in the way of its assuming this position is not to be denied. It will be the endeavor of the present essay to remove, not the whole of these difficulties, but so many of them as bar the way to any practical consideration of the subject in its entirety.

First, however, it is necessary to consider what is actually done at our schools and universities toward giving students a knowledge of modern languages and literatures. It is a little curious that the question excites more attention in relation to schools than in relation to the universities. Already, there is hardly any (if any) school of high rank in the country in which French, at least, does not form a regular part of the instruction. Whereas at the universities there are only incidental exceptions to the general neglect with which the subject is treated. And this very fact shows that the whole significance of the question is misunderstood. As languages, French and German (especially the former) are less powerful instruments of training, for the abler boys, than Latin and Greek. As literatures—that is, as summing up the whole thought and history of a nation—they would, if properly managed, be much more powerful instruments (in proportion to the much greater variety of modern life as compared with ancients), and are, besides, much more important for us to know. Now, schoolboys have more need to apply themselves to languages as languages than to the wide field of information comprised in a literature; for linguistic study gives a constant yet not too fatiguing exercise to the intellect, an exercise quite indispensable in the first formation of the mind, without demanding on the part of the student any experience of actual realities. And this is the principal benefit gained at present in schools by the study of French and German, that the slower boys have something more within the range of their capacity than they had formerly; a benefit which, though it may in time receive augmentation, is in itself no inconsiderable gain. At the universities, however, the importance of linguistic study, as compared with material study, is much less. A youth of twenty will have the fibre of his mind, his actual mental grasp and capacity, in a great measure, determined; it is not so important, though it is not unimportant, that he should be subjected to an incessant intellectual stimulus. On the other hand, he will now begin for the first time to take an interest in a variety of topics; knowledge will seem to him worth acquiring for its own sake;

and it is very important that his researches should be rightly directed. In a word, he is now ripe for understanding, or beginning to understand, more than a language—a literature, or the records of a nation. That he is ripe for so much as this is obvious from the fact that the students at our universities do learn more than the mere Latin and Greek of the classics—they learn the subject-matter of the books; and this, especially at Cambridge, is taking place more and more. When, then, we see that modern languages are studied at schools, and not at the universities, it is obvious that the question respecting them has been very incompletely apprehended; it has been quite forgotten that they are connected with a very wide and important field of knowledge.

It is, therefore, the study of modern literatures rather than the study of modern languages that is here discussed; and for this reason the question relates rather to universities than to schools. Let us, then, consider what is the value of those incidental exceptions to which allusion was made just now; what, in short, is the actual amount of instruction in modern periods given at the universities. In such examinations as the law and modern history examination at Oxford, the law tripos and the moral science tripos at Cambridge, a good deal of acquaintance with certain aspects of modern times is required. And there have been at Cambridge, at different times, proposals for a history tripos, to comprise all history, ancient and modern; proposals which, however, did not obtain any large acceptance, and were, perhaps, rather made by those who wished to see the historical element eliminated from the classical tripos than by those who wished to see it introduced anywhere else.

Those, however, who think that any or all of the examinations above-mentioned will give those who prepare for them an adequate acquaintance with the nations of the modern world, take a very mechanical view of that which is meant by a nation. Nations, like individuals, or rather much more than individuals, extend far beyond any particular line of their action. The most accurate student of the law and philosophy of modern times will not thereby know any thing about military, commercial, and educational systems. Nor is it reasonable to think that there can be a separate course of study for each separate branch of national existence. The branches are much too numerous; it is necessary that all but the few that are of most extreme importance should be combined in a general system, having its centre in that which is the voice of the nation, in that which comes nearest to the very heart and being of the nation, namely, the literature. It is quite possible in such a mode of study to go far beyond the mere *littérateur*, the dabbler in criticism and politics. However much it be true that the literature must be the centre, yet that the researches of the student should stop with the literature need not and ought not to be the case. To take a single instance from English authors. How full is Milton, both in his prose works and in his poetry, of allusions to the persons, circumstances, and problems of his time! how far less likely are these to be forgotten, how much more vividly must they come before us, if connected with the thoughts of a great man, than if learned in the bare lines of a history! Or, to come to a still more special example, the "Areopagitica" opens out into a world of inquiries respecting the growth of freedom of speech in England, to enter upon which is certainly no superficial thing. Milton is, no doubt, exceptional among authors for the closeness of his connection with the total life of his country. But Schiller, from his ardent patriotism, would not come far behind him; and even in the more artistic Goethe many links of the kind could be found.

By nothing which is said here is there intended to be implied the slightest disparagement of the examinations in law and philosophy at Oxford and Cambridge, or the least idea that it is possible to supply their place by a more general examination in modern literatures. Law and philosophy, like science, are subjects that cannot be studied otherwise than on their own basis; they demand a stringent rigidity of consecutive reasoning that is wholly alien from the wide knowledge and free play of the mind that deals with literatures, whether ancient or modern; moreover, the treatment of them cannot be limited to modern times, deriving, as they do, their origin, the one from Greece, the other from Rome. But history stands on a different ground; and that it is felt so to stand may be seen by the difficulty which has lately been experienced at Cambridge in assigning a place to modern history among the other studies. A few years ago it was united in an incongruous tie with metaphysics, political economy, and jurisprudence; now, by a decision which certainly cannot be thought unwise, it has dropped out of this connection; but, though it has sought admission in many quarters, it is up to this day excluded from the honor examinations of the university. And the reason is clear. Pure historical study does not try the intellect very deeply; the subjects with which it deals are so various that it cannot bestow on any of them more than a somewhat superficial glance. There are, of course, special kinds of history that may go deeply into special subjects, of which Hallam's work is an example; but these, by the very fact of their being special, are narrow; nor is it possible to make of any of them a backbone whereto the immense number of topics comprised in an ordinary history, geography, military service, the personal character of statesmen, theological disputes, artistic progress, etc., would naturally attach themselves. The authors of a nation are the natural centre of the history of the nation. To know a man it is necessary to hear what he says with his own mouth, as well as what others have to record about him; and in the same way the history of a nation is an insufficient means of getting acquainted with that nation, unless it be supplemented by that more intimate acquaintance implied in a knowledge of its authors.

Thus there are two lines of argument which meet in the same conclusion. There is a kind of study—namely, the study of modern literatures—which is neglected at the universities, because it is not seen that there is substance enough in it to give matter for an examination. There is a kind of study—namely, modern history—which it has been eagerly sought to introduce at the universities, which has an even too great abundance of matter, but which is cast out because it wants some thread of unity to run through the whole. Is it not clear that the two belong to each other?—that they ought to be studied side by side? And, indeed, this is what is actually done by the student of Latin and Greek.

In fact, what is here proposed, is an examination to run precisely parallel to the classical tripos at Cambridge, or the final classical examination at Oxford. There is no great depth in an ordinary first-class man's knowledge of Plato and Aristotle; neither would there be any great depth in the knowledge of Descartes and Machiavelli possessed by the first-class man in this proposed examination. But the knowledge attained would be miles above utter ignorance, and it would form a public opinion, which, though not deep itself, would be capable of judging of depth, and distinguishing true merit from pretentious talk. Is not this very sadly wanted at the present day? Let the reader think what is the average knowledge of modern authors, modern history, and the institutions of foreign countries, possessed by his personal friends. It is pretty safe to say that it will be found very small indeed. The German or French works, which it is politely assumed that "every one" has read, will turn out perhaps to have been read by one out of every ten well-educated men. There are many who lament their ignorance, but yet, owing to the press of work in active life, cannot remove it. Is it not a hardship that they should not have had an opportunity of removing it in the course of their education? Very few people, when they have settled into a sphere of work, are able, even when they go abroad for their holidays, to do much beyond walking and seeing celebrated sights.

No doubt, an examination in modern literatures would differ in some material respects from an examination in ancient literatures. The languages being less hard, there would be less in them of a stringent intellectual test. Yet this is a difference too often exaggerated as to its extent. The difficulties which lie at the threshold of French and German are considerably less than those which lie at the threshold of Latin and Greek. But the idiosyncrasies of authors furnish a species of difficulty independent of the structure of the language. This species is, indeed, in the case of French authors, reduced to a minimum by the admirable lucidity of their style. But in German authors difficulties of this kind are even considerably above what they are in Latin and Greek. The thoughts of Richter lie less on the surface than those of Tacitus. And, in such works as political or legal orations, no easiness of the language can take away the inherent complexity of the subject. However, were it even granted that for the best men Latin and Greek, as being harder in their grammar, are better instruments of training, does it follow that French, German, and Italian, should be neglected altogether? In point of the variety of the knowledge connected with them, they stand above Latin and Greek; and it may be suspected that even their comparative easiness as languages would benefit some men, who, though possibly of very sufficient ability, have not the linguistic faculty very strong. Mathematics are even a more severe intellectual gymnastic than Latin and Greek; but the superior variety of knowledge connected with the classical languages is considered to make them not inferior as means of education. The same argument, taken a step further, serves to defend modern literatures from the charge brought against them in this point of view. But, at the worst, let them, in the distribution of the prizes of the university, be considered inferior; not, therefore, as of no account whatever.

A frequent objection to the proposal here made is the advantage it would give to those who had happened to have been educated abroad. The stress sometimes laid on this objection is quite ludicrous. The advantage is one analogous to that which richer men have over poorer, in being able to command the services of better instructors. It would, however, be considerably diminished by the fact that, in such an examination, more regard must necessarily be paid to substance than to style or language. And if the effect were that of inducing parents to take all possible means of giving their children an early acquaintance with foreign languages, could this be said to be a bad result?

It is probable that modern literatures would require a greater exercise of judgment in the examiner than Latin and Greek. They verge more on controversial questions; it is more easy in them to win credit for a petty sharpness, a flimsy mode of dealing with great subjects. But this is merely a danger which it is needful to point out, not a solid and final objection.

This is not the place to discuss what should be the precise form of an examination in modern literatures. Of course, definite authors would have to be selected by the university; it would be impossible to leave the student to wander at his own sweet will over George Sand, Alfred de Musset, and Heinrich Heine—the kind of authors which, it is to be guessed, are more read than any other by the present students of French and German. Of these definite authors, some might be permanent, others changed every year. Then, as to the composition in modern languages; this, it is probable, would take the form as much of essays on special points connected with the authors read, as of direct translation into those languages. English literature and composition would itself come in for a share in the curriculum; and it is possible some modern Latin works might be admitted, as those of Erasmus or Reuchlin. Experience would guide toward the right mode of treatment; nor is it to be expected that every thing would drop into its place neatly at once. It is not unnecessary to say this, for every one connected with our universities knows the severe criticism which new schemes have to undergo, when they do not do what it is absolutely impossible that they should do—namely, start at once in as full perfection as systems that have been matured for many generations.

It has been assumed, throughout this essay, that the best way of introducing the study of modern literatures into the universities is to establish them as a subject wholly distinct from the ancient literatures. Some might think that the two courses might beneficially be amalgamated; but on the whole it seems an unnecessary risk to endanger old and well-established systems by an extensive and violent intrusion of unproved and untried material.

In conclusion, as the course of instruction here advocated involves a smaller amount of intellectual sharpening, and a larger and more various acquisition of positive knowledge, than the generality of the systems in use at the present day, it will not be beside the point to observe that the tendency of modern education has for four centuries been in this direction—that is, rather to encourage wealth and variety of mental possessions, than extreme acuteness in their employment. Not that mental acuteness is not cultivated at the present day as much as ever it was; for putting a point on the mind, nothing can excel the mathematical course at Cambridge. But the value assigned to width of knowledge has increased in a much greater ratio, as will be plain by looking back a little in European history. The Schoolmen were in modern times the earliest educationalists of Europe. Their educational system was like their philosophy—the most simply, purely, and nakedly intellectual that the world has ever seen. They paid no regard to the storing of the mind with material, to the preparation of it for efforts to which it was at present unequal, to the laying broad foundations of fact and experience, not for the sake of immediate argument, but as food to be gradually appropriated and assimilated in the insensible silent workings of the growing man. They made men discuss. They were like a person who should expect a plant to grow by its own intrinsic power, without the nutriment of earth and water. They put the greatest strain on the intellect; but they did not bid the student to know. It was the revival of the classical literatures, and especially of Greek literature, that produced the first step in advance from this state of things. With them a flood of experience, novel, exciting, and illuminating, was poured upon the world. Nor was it long afterward that the great discoveries in mathematics and astronomy opened out a vast sphere of fresh knowledge in another direction. So vigorous an outburst could not be gainsaid. The intellect of the student was no longer left isolated; it was brought in contact with human action, the material world, and substantial reality. Educated men were no longer disputative machines; they were invigorated by the records of noble actions, they caught again the fire of orators long since dead, they felt what it must have been to live in the Athens of Pericles and Plato, or in the Rome that withstood the victorious army of Hannibal; or, turning to modern times, they saw in the new-born science of the age that which excited the highest curiosity and hope. That complete severance and sharp-dividing line which lay between the men of speculation and the men of action in the Middle Ages was annulled in the sixteenth century, to the immense advantage of both, and has never since been revived. But, since the sixteenth century, there has been a fresh development of science, a fresh creation of noble literature. Science is sure to have its advocates, and to them it may safely be left. But shall we make no systematized effort to reap the full benefit of the writings of those great authors, the lives of those transcendent statesmen, soldiers, and discoverers by land and sea, that have adorned the annals of Europe since the birth of its present order? It is incredible that we should not. And few, indeed, must they be who have not reason to lament that they have not been furnished with better means for acquainting themselves with that whole family of nations among whom our lives are cast. We walk in the dark at present, and, as any one may know who considers our recent political history, with tottering feet and uncertain steps. Surely no further argument can be necessary to prove that all knowledge which tends to throw light on our national relations is a most important acquisition.

And all our schools, all our educational bodies, except the old universities, are doing their best to remedy these our present defects. But the universities are the keystone of the whole system; all training to which they do not give the final touch is defective and aimless; and, governed as they are by men of the highest ability and experience, it stands to reason that they have advantages for organizing a scheme of instruction which no ordinary school-master can have. Heavy are the difficulties which oppose the cultivation of modern languages, even in schools which take them up most zealously. Is it not the inevitable conclusion that the universities are imperatively bound to supply some central system of instruction in modern literatures?—*Contemporary Review.*

THE NUTRITIVE SALTS OF FOOD.

By Prof. VOIT.

[ABSTRACT OF VOIT'S REPORT, BY M. ANDRÉ SANSON.]

IN order to understand the importance of the nutritive salts in food, we must first ascertain how far its mineral elements are nutritious, how far they are indispensable, and when they may be considered as in excess.

The investigations of Liebig, who first studied this question, and those of his school, demonstrate that certain salts are closely combined with the other elements of living bodies, forming integral parts of them. In all the tissues of the organism is found potash in combination usually with phosphoric acid. In the blood the salts of soda predominate. When we reduce the organs to ashes, these vary but very little in quality or in quantity. It is unquestionable that without these salts no organ is developed, and that there is no secretion by the glandular cellules. All the secretions contain certain salts, most of them characteristic. These salts have definite functions to discharge in the animal economy. Still, we do not know the quantity of these salts which must enter into the food, to support the body, though this is a highly-important question in the hygiene of alimentation. Direct experiments alone could decide, for Voit shows that those made by Magendie, and which are so frequently referred to, do not establish the points they are supposed to establish. Recent studies upon the nutritive value of gelatine have shown that Magendie failed to take into account some of the principal points of the question he was considering.

"For a long time," says Voit, "it had been my purpose to ascertain by thorough experimentation the value of salts in nutrition, with a view to examining how long an animal could live without them, and what symptoms it would manifest. For this purpose I had accumulated a quantity of the residuum of meat-extract. In the mean time appeared a remarkable work by Kemmerich, in which were proposed other questions, having a bearing, in many respects, upon those I had proposed to myself. Kemmerich starts out with the supposition, which Liebig, too, admits, that the residuum of the meat, without the extract, has no value as nutriment. According to his investigations, the action of meat-extract is attributable to the potash it contains, whence he concludes that the residuum is of no value for nutrition, owing to the absence of the potash. He therefore attempted to utilize it by adding to it the salts contained in meat. To this moist residuum, three times exhausted by boiling, he adds an artificial mixture of the salts of meat and common table-salt; and on this food exclusively he fed two dogs six weeks old, they devouring it ravenously. The experiment was continued for three months, and at the end of that period the dogs had gained considerably in weight."

Kemmerich repeated his experiments on the same animals, giving them now the residuum without the mixture of salts. He now observed that the animals consumed less and less from day to day, even when suffering from hunger. Again, experimenting on two dogs six weeks old, he fed to the one the residuum mixed with the salts; to the other the residuum mixed only with common table-salt. After twenty-one days a wide difference was observable between the two animals. The first one weighed much more than the second, was stronger and more intelligent. The second one had gained a little in weight, it is true, but his condition was pitiable. He could hardly walk; his eyes were dull and expressionless; his body appeared emaciated, and he took his food reluctantly and without relish.

Voit here makes an objection to the conclusions drawn by Kemmerich; but his objection is not valid, because he does not advert to the fact that the dogs in question, owing to their age, must necessarily gain considerably in weight. His objection would hold good only in the case of full-grown animals. However, to remove all doubt as to the increase of weight when the salts of meat are added to the residuum, Kemmerich gave the second dog the residuum with these salts; and to the first dog the same, with table-salt only; the quantity of residuum being in both cases equal. The result was, that the dog which had before got only common salt, now gained much faster than the other, which latter, however, gained 530 grammes in thirty-two days.

There is no need to give in full Voit's argument on the results of Kemmerich's experiments. It is enough for us to state, with Voit, that these experiments demonstrate the fact that a carnivorous animal can live on meat-residuum, provided that there be added to it the salts of meat and common salt. Still, these experiments do not answer the principal questions we have put, viz., How long can an adult organism live without salts? and, What are the symptoms they manifest, when thus deprived? So the attempt was made to study, in adult animals, the changes that occur in albuminoid substances, when the salts are extracted.

Dr. J. Zörster made the experiments. The purpose was to sustain animal life as long as it was possible, on food very poor in salts. The animals experimented upon were never given albuminous substances alone, but always mixed with a sufficient quantity of non-nitrogenous elements, such as fat, starch, or sugar. The albuminate employed was the residuum of meat dried in the oven, pulverized, and then boiled three times in water. Cheese, also, deprived of the salts, was given. Pigeons and mice took this food, in small morsels, for some time. Dogs also took it for a short time, but then refused it. Then they were compelled to take it. The mice lived from twenty-one to thirty days; the pigeons from thirteen to twenty-nine days; the dogs from twenty-six to thirty-six days.

Digestion went on regularly for the greater part of the time. The excreta, whether in quantity or in quality, were as usual. Consequently neither the process of digestion, nor the absorption of the materials digested, is influenced by the absence of salts from the food. In the case of a dog with a gastric fistula, fed on food deprived of the salts, direct evidence was obtained of the fact that the secretion of acids in the stomach goes on. After having been kept for a considerable period on this diet, the dog commenced to reject it from his stomach. What was thus rejected, though it had been in the stomach several hours, was not soured, nor had it the least unpleasant odor. It looked like food that had suffered no change. It is, therefore, only at a late period in such dieting that the absence of the salts makes itself felt.

This was altogether unexpected; but the examination of the ex creta, more especially of the urine, led to a conclusion of still greater moment. This urine contains traces only of the chloride of sodium, but little phosphoric acid, etc., although in amount the urine was the same as before the experiment. The residuum of meat which was given was not entirely deprived of its salts. There will always remain a small amount of phosphates. When, therefore, the organism is stinted in these salts, it daily parts with a small quantity of them through the excrement and the urine, but retains the greater part. The organs are tenacious of these salts. When we add salt to the food, it goes first into the blood, but it is not then immediately thrown off by the kidneys, etc. It is distributed through the system, and each one of the organs takes according to its wants. In the blood are also to be found the salts evolved in the destruction of the animal's substance, under the influence of abstinence. All these salts are then distributed, as we have already said, and thus that portion of them which is not thrown off serves again and again for the needs of the tissues. On this account their quantity varies but little in the system. We will not follow our author in his attempt to account theoretically for these phenomena, inasmuch as it belongs to the province of pure reasoning. We must be content to continue in the domain of experiment.

After a period of complete abstinence from salts, certain remarkable phenomena are to be observed in dogs. Though they may not decrease in weight, nor lose flesh or fat, they still become weak, dull, and lie down in a corner, languid and indifferent. On one occasion, even, as in the case of a dog of Dr. Bischoff's that was for a long time fed on bread alone, the animal apparently went mad. He fell into a rage, and ran round and round, heeding neither the voice nor the whip. The attack did not return, but the nervous system became more and more unstrung; paralytic symptoms were manifested in the hinder extremities; the animal's hind-legs failed him at every step, and he fell on his side: in the head were observable oscillatory movements, particularly when he ate or drank. On pushing the experiment still further, the animals invariably succumbed. If, however, instead of continuing the experiment, we give the dog the ordinary mixed food, he will commence gradually to recover his strength, and finally will be quite restored to health. During the period of recovery he will consume an unusual amount of food.

Thus is it demonstrated, in accordance with the views which Liebig was the first to maintain, that the salts are absolutely necessary. Without them the organism fails, even though it were to receive all the other elements. It will not, however, succumb instantaneously, but only after the lapse of a certain period of time. The salts differ in many respects from organic substances. When the latter are decomposed, the residuum cannot be utilized by animals, and must consequently be evacuated. Not so with the salts, which, according to Voit, are not transformed. This view will not pass unchallenged, when we call to mind the later researches of W. Marcet with regard to the constitution of muscular tissue, wherein the English physiologist has found that the phosphates enter into the nutritive process in the colloid state, but quit it in the crystalloid state.

Klein and Verson, according to Prof. Voit, have claimed that common salt is not a nutritive salt, but a mere condiment, and that it may be altogether wanting in the body without inconvenience. These two gentlemen lived for eight days, consuming the while only 1.4 gramme of salt per day, without experiencing any indisposition. They, in fact, threw off, in the eight days, 46.9 grammes of chloride of sodium in the liquid and solid excreta; but we have to observe that they had been in the habit of consuming salt very freely (about 27 grammes per day). Still the common salt in the system was not exhausted.

Voit states, in a note, that in the case of dogs which have the normal supply of nitrogen, the addition of common salt to their food increases the amount of urine, as also the proportion of water in the same. Klein and Verson thought that, when they are deprived of this salt, the urine must decrease; whereas they found, on the contrary, that it increased. The salt only excites indirectly the increase of urine, by promoting the transformation of the albumen; and it may well be that, when the supply of salt is deficient, this transformation is similarly accelerated by other influences. Klein and Verson have not determined what are the necessary conditions for recognizing the action of any substance in this respect. We cannot tell whether or not the nitrogenous elements of the food, during their experiments, were a constant quantity, for they say "taking about 420 grammes of beef, etc." Nor could they say whether the nitrogen in their system was in normal quantity. But, aside from this, I do not find that an increased quantity of urine is by their figures shown to follow the privation of salt.

After reciting the facts which are ascertained with regard to the use of salt by domestic animals, the author adds that the constituent salts of the organs, of which we spoke above, are as necessary for the support of the organism as albumen, water, or the organic non-nitrogenous elements; but that, notwithstanding, no symptoms of scurvy or of disease in the bones is observable, even where animals are for a long period deprived of salt. He calls particular attention to this fact: Kemmerich, on one occasion, gave a dog during seventeen days the residuum of meat, with the salts of potash only, that is, the phosphate of potash and the chloride of potassium. He had deprived the food of its salts of soda. And yet the serum of the blood was found to contain these soda-salts almost exclusively, while in the urine were found only the salts of potash. The salts of soda thus were altogether retained, as in the case where the salts were withheld.

It is not the functions of the nutritive salts that have been exaggerated hitherto, but rather the proportion in which they must enter into the food. They might be withheld for as many as forty days, for they are found in sufficient quantity in all substances which contain the other elements of nutrition. Haubner has stated that pigeons fed on grain, without lime, quickly die; but Voit has kept them on such food for a whole year. On food deprived of salts a pigeon can live for about thirty days.

When it is said that, without the nutritive salts, the residuum of meat, or any other kind of food, possesses no nutritive value whatsoever, the statement is true only in a certain sense, and as far as the duration of complete nutrition is concerned. Within a certain period of time, in the absence of the salts, the albuminates will cease to be assimilated, as also the fats and the hydrates of carbon. It is the salts that render the organic elements nutritive. The author hence concludes that none of these elements, whether organic or mineral, have any absolute nutritive value, and that they cannot be considered apart by themselves. They coöperate mutually in nutrition, and so are all equally indispensable to constitute proper food, such as may support life and strength. This is the most important datum of the numerous and varied physiological experiments made in Germany during the past few years, and it is a new discovery for us. Our physiologists and hygienists had no suspicion of such facts.

As we consume, with our food, considerably more of these salts than is needed to support the body, the question arises, Is this simply surplus, or are we benefited by it, as being a flavoring for the food? Much has been said about the *extractive* elements of meat, and it has been supposed that these elements form the true distinction between animal and vegetable food. According to this view they constitute the peculiar action of meat and of meat-extract. Here we must make a distinction between the nutritive element and the condiment.

The extractive elements of flesh-meat are the products of regressive change, and are not necessary for the constitution and formation of the organs; nor can they, when taken with food, add to the substance of those organs. The elements of this extract have been got in isolated forms, as creatine, sarkine, taurine, urea, uric acid, tyrosine, lactic acid, acetic acid, etc.; each organ has its own characteristic extractive principles, or its own products of decomposition, the conditions of this decomposition varying for the various organs.

THE PHYSIOLOGY OF SLEEP.

By B. W. RICHARDSON, M.D., F.R.S.

"THE twinkling of oblivion," as Wordsworth exquisitely defines the phenomenon of sleep, has, from the time of Hippocrates to the present hour, engaged the attention of thoughtful minds. Poets have found in the phenomenon subject-matter for some of the most perfect of their works. Menander exalts sleep as the remedy for every disease that admits of cure; Shakespeare defines it, "The birth of each day's life, sore labor's bath;" Sir Philip Sidney designates it, "The poor man's wealth, the prisoner's release;" and wearied Dryden sings of it—

> "Of all the powers the best.
> Oh! peace of mind, repairer of decay,
> Whose balms renew the limbs to labors of the day."

As to the philosophers and the physicians who have said and written on sleep, I dare hardly think of them, lest I should commit myself to an historical volume instead of a short physiological essay; so I leave them, except such as are simply physiological, and proceed on my way.

Perfect sleep is the possession, as a rule, of childhood only. The healthy child, worn out with its day of active life, suddenly sinks to rest, sleeps its ten or twelve hours, and wakes, believing, feeling, that it has merely closed its eyes and opened them again; so deep is its twinkle of oblivion. The sleep in this case is the nearest of approaches to actual death, and at the same time presents a natural paradox, for it is the evidence of strongest life.

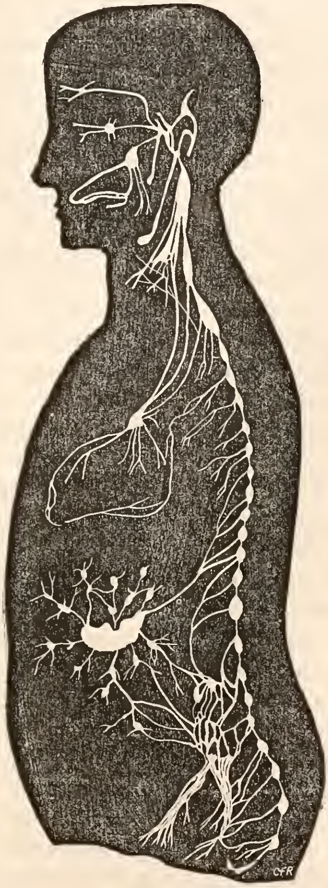
During this condition of perfect sleep, what are the physiological conditions of the sleeper? Firstly, all the senses are shut up, yet are they so lightly sealed that the communication of motion by sound, by mechanical vibration, by communication of painful impression, is sufficient to unseal the senses, to arouse the body, to renew all the proofs of existing active life. Secondly, during this period of natural sleep the most important changes of nutrition are in progress; the body is renovating, and, if young, is actually growing; if the body be properly covered, the animal heat is being conserved and laid up for expenditure during the waking hours that are to follow; the respiration is reduced, the inspirations being lessened in the proportion of six to seven as compared with the number made when the body is awake; the action of the heart is reduced; the voluntary muscles, relieved of all fatigue and with the extensors more relaxed than the flexors, are undergoing repair of structure and recruiting their excitability; and the voluntary nervous system, dead for the time to the external vibration, or as the older men called it "stimulus" from without, is also undergoing rest and repair, so that when it comes again into work it may receive better the impressions it may have to gather up, and influence more effectively the muscles it may be called upon to animate, direct, control.

Thirdly, although in the organism during sleep there is suspension of muscular and nervous power, there is not universal suspension; a narrow, but at the same time safe, line of distinction separates the sleep of life from the sleep of death. The heart is a muscle, but it does not sleep, and the lungs are worked by muscles, and these do not sleep; and the viscera which triturate and digest food are moved by muscles, and these do not sleep; and the glands have an arrangement for the constant separation of fluids, and the glands do not sleep; and all these parts have certain nerves which do not sleep. These all rest, but they do not cease their functions. Why is it so?

The reason is, that the body is divided into two systems as regards motion. For every act of the body we have a system of organs under the influence of the will, the voluntary, and another system independent of the will, the involuntary. The muscles which propel the body, and are concerned in all acts we essay to perform, are voluntary; the muscles, such as the heart and the stomach, which we cannot control, are involuntary. Added to these are muscles which, though commonly acting involuntarily, are capable of being moved by the will: the muscles which move the lungs are of this order, for we can if we wish suspend their action for a short time or quicken it; these muscles we call semi-voluntary. In sleep, then, the voluntary muscles sleep, and the nervous organs which stimulate the voluntary muscles sleep; but the involuntary and the semi-voluntary muscles and their nerves merely rest: they do not veritably sleep.

This arrangement will be seen, at once, to be a necessity, for upon the involuntary acts the body relies for the continuance of life. In disease the voluntary muscles may be paralyzed, the brain may be paralyzed, but, if the involuntary organs retain their power, the animal is not dead. Sir Astley Cooper had under his care a man who had received an injury of the skull causing compression of the brain, and the man lay for weeks in a state of persistent unconsciousness and repose; practically he slept. He did not die, because the involuntary system remained true to its duty; and, when the great surgeon removed the compression from the brain of the man, the sleeper woke from his long trance and recovered. Dr. Wilson Philip had a young dog that had no brain, and the animal lay in profound insensibility for months, practically asleep; but the involuntary parts continued uninfluenced, and the animal lived and, under mechanical feeding, grew fat. Flourens had a brainless fowl that lived in the same condition. It neither saw nor heard, he says, nor smelled nor tasted nor felt; it lost even its instincts; for however long it was left to fast, it never voluntarily ate; it never shrunk when it was touched, and, when attacked by its fellows, it made no attempt at self-defence, neither resisting nor escaping. In fine, it lost every trace of intelligence, for it neither willed, remembered, felt, nor judged: yet it swallowed food when the food was put into its mouth, and fattened. In these cases, as in that of the injured man, the involuntary systems sustained the animal life. It is the same in sleep.

FIG. 1.



Organic Nervous System which controls the Heart and the Organic Processes, and never sleeps.

When we look at these phenomena, as anatomists, we find a reason for them in structure and character of parts. The involuntary muscles have a special anatomical structure; and the nervous organism that keeps the involuntary muscles in action is a distinct organism. There are, briefly, two nervous systems: one locked up in the bony cavity of the skull and in the bony canal of the spine, with nerves issuing therefrom to the muscles; and another lying within the cavities of the body, with nerves issuing from it to supply all the involuntary muscles. The first of these systems, consisting of the brain, the spinal cord, and the nerves of sense, sensation, and motion, is called the cerebro-spinal or voluntary system of nerves; the second, consisting of a series of nervous ganglia with nerves which communicate with the involuntary muscles and with nerves of the voluntary kind, is called, after Harvey the vegetative, after Bichat the organic system: a sketch of this organic system is depicted in the accompanying diagram.

In sleep, the cerebro-spinal system sleeps; the organic system retains its activity. Thus in sleep the voluntary muscles and parts fail to receive their nervous stimulation; but the involuntary receive theirs still, and under it move in steady motion; while the semi-voluntary organs also receive sufficient stimulation to keep them in motion.

Of all the involuntary organs, the heart, which is the citadel of motion, is most protected. To itself belongs a special nervous centre, that which feeds it steadily with stimulus for motion; from the cervical ganglia of the organic nervous system it receives a second or supplementary supply; and from the brain it receives a third supply, which, passive under ordinary circumstances, can under extraordinary circumstances become active and exert a certain controlling power. Then the arteries which supply the heart with blood are the first vessels given off from the great feeding arterial trunk, and the veins of the heart winding independently round it empty their contents direct again into it. Thus is the heart the most perfect of independencies: thus during sleep and during wakefulness it works its own course, and, taking first care of itself in every particular, feeds the rest of the body afterward; thus, even when sleep passes into death, the heart in almost every case continues its action for some time after all the other parts of the organism are in absolute quiescence; thus, in hibernating animals, the heart continues in play during their long somnolence; and, thus, under the insensibility produced by the inhalation of narcotic gases and vapors, the heart sustains its function when every other part is temporarily dead. Next the heart in independent action is the muscle called the midriff or diaphragm; and, as the diaphragm is a muscle of inspiration, the respiratory function plays second to the circulatory, and the two great functions of life are, in sleep, faithfully performed. In sleep of illness bordering on sleep of death, how intently we watch for the merest trace of breath, and augur that, if but a feather be moved by it or a mirror dimmed by it, there is yet life!

In natural sleep, then, sleep perfect and deep, that half of our nature which is volitional is in the condition of inertia. To say, as Blumenbach has said, that in this state all intercourse between mind and body is suspended, is more perhaps than should be said, the precise limits and connections of mind and body being unknown. But certainly the brain and spinal cord, ceasing themselves to receive impressions, cease to communicate to the muscles they supply stimulus for motion, and the muscles under their control, with their nerves, therefore sleep. And so, to the extent that the acts of the brain and cord and their nerves are mental, and the acts or motions of the voluntary muscles are bodily acts, to that extent, in sleep, the intercourse between the mind and the body is suspended.

In sleep the condition of the involuntary muscles and of the voluntary nervous system is, we must assume, in some manner modified, since these organs are transformed from the active into the passive state. Respecting the condition of the muscles in sleep, no study of a systematic sort has been carried out, but in relation to the brain there has been much thoughtful study, upon which many theories have been founded.

The older physiologists regarded sleep as due to the exhaustion of the nervous fluid; during sleep, they held, this fluid accumulates in the brain; and, when the brain and the other centres and nerves of the cerebro-spinal system are, to employ a common expression, re-charged, the muscles are stimulated and the body awakes; the brain prepared to receive external impressions and to animate the muscles, and the muscles renovated and ready to be recalled into activity. This theory held its ground for many years, and, perhaps, still there are more believers in it than in any other. It fails to convince the skeptical because of its incompleteness, for it tells nothing about the nature of the presumed nervous fluid, and we know nothing as yet about this fluid. The primary step of the speculation is consequently itself purely hypothetical.

Another theory, that has been promulgated, is that sleep depends on the sinking or collapse of the laminæ of the cerebellum or little brain. This theory is based on the experiment that compression of the cerebellum induces sleep; but the argument is fallacious, because pressure on the larger brain, or cerebrum, is followed by the same result. The theory of pressure has been proposed again in a different way; it has been affirmed that the phenomenon of sleep is caused by the accumulation of fluids in the cavity of the cranium, and by pressure, resulting from this accumulation, on the brain as a whole. We know well that pressure upon the brain does lead to an insensible condition resembling sleep, and in some instances, in which the skull has been injured and an artificial opening through it to the brain has been formed, pressure upon the exposed surface has led to a comatose condition. I once myself saw a case of this nature. But the evidence against this explanation is strong, because the sleeping brain has been observed to be pale and too free of blood to convey any idea of pressure.

In opposition to the pressure theory, Blumenbach contended that sleep is due to a diminished flow and impulse of blood upon the brain, for he argued the phenomenon of sleep is induced by exhaustion, and particularly by exhaustion following upon direct loss of blood. Recently Mr. Arthur Durham, in a very able communication, has adduced a similar view, and the general conclusion now is, that during sleep the brain is really supplied with less blood than in waking hours.

To account for the reason why the brain is less freely fed with blood in sleep, it has been surmised that the vessels, the arteries, which feed the brain, and which for contractile purposes are supplied with nerves from the organic nervous system, are, under their nervous influence, made to close so that a portion at least of the blood which enters through them is cut off on going to sleep. This view, however, presupposes that the organic nervous centres, instead of sharing in the exhaustion incident to labor, put forth increased power after fatigue, an idea incompatible with all we know of the natural functions.

Carmichael, an excellent physiologist, thought that sleep was brought on by a change in the assimilation of the brain, and by what he called the deposition of new matter in the organ, but he offered no evidence in proof: while Metcalfe, one of the most learned physicists and physicians of our time, maintained that the proximate cause of sleep is an expenditure of the substance and vital energy of the brain, nerves, and voluntary muscles, beyond what they receive when awake, and that the specific office of sleep is the restoration of what has been wasted by exercise: the most remarkable difference between exercise and sleep being, that during exercise the expenditure exceeds the income; whereas during sleep the income exceeds the expenditure. This idea of Metcalfe's expresses, probably, a broad truth, but it is too general to indicate the proximate cause of sleep, to explain which is the object of his proposition.

My own researches on the proximate cause of sleep—researches which of late years have been steadily pursued—lead me to the conclusion that none of the theories as yet offered account correctly for the natural phenomenon of sleep; although I must express that some of them are based on well-defined facts. It is perfectly true that exhaustion of the brain will induce phenomena so closely allied to the phenomena of natural sleep, that no one could tell the artificially-induced from the natural sleep; and it is equally true that pressure upon the brain will also lead to a state of sleep simulating the natural. For example, in a young animal, a pigeon, I can induce the deepest sleep by exposing the brain to the influence of extreme cold. I have had a bird sleeping calmly for ten hours under the local influence of cold. During this time the state of the brain is one of extreme bloodlessness, and, when the cold is cautiously withdrawn and the brain is allowed to refill gently with blood, the sleep passes away. This is clear enough, and the cold, it may be urged, produces contraction of the brain-substance and of the vessels, with diminution of blood, and with sleep as the result. But if, when the animal is awaking from this sleep induced by cold, I apply warmth, for the unsealing of the parts, a little too freely, if, that is to say, I restore the natural warmth too quickly, then the animal falls asleep again under an opposite condition; for now into the relaxed vessels of the brain the heart injects blood so freely, that the vessels, in like manner as when the frozen hand is held near the fire, become engorged with blood, there is congestion, there is pressure, and there is sleep.

The same series of phenomena from opposite conditions can be induced by narcotic vapors. There is a fluid called chloride of aonyl, which, by inhalation, causes the deepest sleep; during the sleep so induced, the brain is as bloodless as if it were frozen. There is an ether called methylic, which, by inhalation, can be made to produce the deepest sleep; during this sleep the vessels of the brain are engorged with blood.

We are therefore correct in supposing that artificial sleep may be induced both by removal of blood from the brain, and by pressure of blood upon the brain; and in the facts there is, when we consider them, nothing extraordinary. In both conditions, the natural state of the brain is altered; it cannot, under either state, properly receive or transmit motion; so it is quiescent, it sleeps. The experimental proof of this can be performed on any part of the body where there are nerve-fibre and blood-vessel; if I freeze a portion of my skin, by ether-spray, I make it insensible to all impression—I make it sleep; if I place over a portion of skin a cupping-tube, and forcibly induce intense congestion of vessels, by exhausting the air of the tube, I make the part also insensible—I make it sleep.

The two most plausible theories of sleep—the plenum and the vacuum theories I had nearly called them—are, then, based on facts; but still I think them fallacious. The theory that natural sleep depends on pressure of the brain from blood is disproved by the observations that have been made of the brain during sleep, while the mechanism of the circulation through the brain furnishes no thought of this theory as being possibly correct. The theory that sleep is caused by withdrawal of blood from the brain, by contraction of its arterial vessels, is disproved by many considerations. It presupposes that at the time when the cerebro-spinal nervous system is most wearied the organic system is most active; and it assumes that the great volume of blood which circulates through the brain can be cut off without evidence of increased volume of blood and tension of vessel in other parts of the body, a supposition directly negatived by the actual experiment of cutting off the blood from the brain.

There is another potent objection applicable to both theories. When sleep is artificially induced, either by subjecting the brain to pressure of blood, or to exhaustion of blood, the sleep is of such a kind that the sleeper cannot be roused until the influence at work to produce the sleep is removed. But, in natural sleep, the sleeper can always be roused by motion or vibration. We call to a person supposed to be sleeping naturally, or we shake him, and if we cannot rouse him we know there is danger; but how could these simple acts remove pressure from the brain, or relax the contracted vessels feeding the brain?

These two theories set aside, the others I have named need not trouble us; they are mere generalizations, interesting to read, worthless to pursue. Know we then nothing leading toward a solution of the question of the proximate cause of sleep? I cannot say that, for I think we see our way to something which will unravel the phenomenon; but we must work slowly and patiently, and as men assured that, in the problem we are endeavoring to solve, we are dealing with a subject of more than ordinary importance. I will try to point out the direction of research.

I find that to induce sleep it is not necessary to produce extreme changes of brain-matter. In applying cold, for example, it is not necessary to make the brain-substance solid in order to induce stupor, but simply to bring down its temperature ten or twelve degrees. I find also that very slight direct vibrations, concussions, will induce stupor; and I find that, in animals of different kinds, the profoundness of sleep is greater in proportion as the size of the brain is larger. From these and other facts, I infer that the phenomenon of natural sleep is due to a molecular change in the nervous structure itself of the cerebro-spinal system, and that in *perfect* sleep the whole of the nervous structure is involved in the change—the brain, the cord, the nerves; while in imperfect sleep only parts of this nervous matter are influenced. This is in accord with facts, for I can by cold put to sleep special parts of the nervous mass without putting other parts to sleep. In bad sleep we have the representation of the same thing in the restlessness of the muscles, the half-conscious wakings, the dreams.

Suppose this idea of the change of nervous matter to be true, is there any clew to the nature of the change itself? I think there is. The change is one very closely resembling that which occurs in the solidification of water surcharged with a saline substance, or in water holding a hydrated colloid, like dialyzed silica, in trembling suspension. What is, indeed, the brain and nervous matter? It is a mass of water made sufficiently solid to be reduced into shape and form, by rather less than twenty per cent. of solid matter, consisting of albuminous substance, saline substance, fatty substance. The mechanism for the supply of blood is most delicate, membranous; the mechanism for dialysis or separation of crystalloidal from colloidal substance is perfect, and the conversion of the compound substance of brain from one condition of matter to another is, if we may judge from some changes of water charged with colloidal or fatty substances, extremely simple. I do not now venture on details respecting this peculiarly interesting question, but I venture so far as to express what I feel will one day be the accepted fact, that the matter of the wakeful brain is, on going to sleep, changed, temporarily, into a state of greater solidity; that its molecular parts cease to be moved by external ordinary influences, by chemical influences; that they, in turn, cease to communicate impressions, or, in other words, to stimulate the voluntary muscles; and that then there is sleep which lasts until there is re-solution of structure, whereupon there is wakefulness, from renewed motion in brain-matter, and renewed stimulation of voluntary muscle, through nerve.

The change of structure of the brain which I assume to be the proximate cause of sleep is possibly the same change as occurs in a more extreme degree when the brain and its subordinate parts actually die. The effects of a concussion of the brain from a blow, the effects of a simple puncture of nervous matter in centres essential to life—as the point in the medulla oblongata which Flourens has designated the vital point—have never been explained, and admit, I imagine, of no explanation except the change of structure I have now ventured to suggest.

Here, for the moment, my task must end. My object has been to make the reader conversant with what has been said by philosophers upon the subject of sleep and its proximate cause, and to indicate briefly a new line of scientific inquiry. I shall hope on some future occasion to be able to announce further and more fruitful labor.

CHARACTERISTICS OF THE CALMUCKS.

AN ETHNOLOGICAL STUDY.

By J. KOPERNICKI.

THE Calmucks primitively inhabited the countries northeast of the Chinese Empire. At the commencement of the seventeenth century, they arrived on the shores of the Caspian Sea; and they have camped there to the present day.

The first glance at a Calmuck suffices to recognize in him the model representative of the true Mongol type. They are of middle stature, robust, and broad in the shoulders. Their skin is swarthy, face flat, fissure of the eyelids narrow and oblique, nose depressed, nostrils wide, lips thick, teeth white and regular, ears long and prominent, hair black, and beard thin.

The principal trait in the character of the Calmucks, after their simplicity, want of cleanliness, and laziness, is that, after the manner of all nomad people, they are extremely superstitious. The Calmuck never undertakes any serious matter without having previously consulted a sorcerer. He never dares to kill a fly, for fear of assailing the soul of one of his ancestors, which may perhaps animate this insect. When, on a journey, a Calmuck perceives a certain bird which he esteems to be a good augury, he rejoices in this conjuncture, does not fail to manifest his satisfaction, and bows himself three times. As soon as he perceives a hare, on the contrary, he utters a cry, pursues it, and strikes a blow in the air with his stick, in order to exorcise the misfortune which might happen. For the world, he would not pick up a steel for striking a light found upon the way. To seat himself upon the threshold of the door, or warm his feet before the fire, he holds for a great impiety; and if it happens to any one to light his pipe with paper, it is certain that he will soon die.

Notwithstanding these superstitions of the Calmucks, they are said to possess a good deal of intelligence. Their imagination, especially, is much developed, and they are ingenious, as is proved by their tales and proverbs. Some of their tales are so long that they require many evenings to be recited to the end. The Calmucks recite them in a singing tone.

Being exclusively occupied in raising cattle, the life of the Calmuck is nomad. A *khoton*, which is a commune, more or less numerous, composed of many families united by bonds of relationship, never remains more than two or three weeks in the same place. Transmigration from one place to another is a real feast to the Calmucks. All their goods, including their tent, are loaded upon the back of a camel, and covered over with a piece of drapery if the family is in easy circumstances. The women and girls, in holiday dress, as well as the young boys, drive the flocks. The little infants are placed in panniers, which are attached to the sides of the loaded camels, and the mother who is suckling is mounted on the top with her infant. The men on horseback take the lead, and conduct the caravan. The march, which sometimes lasts many days, does not tire the Calmucks; and they often divert themselves with songs and stories.

Behold them at last arrived at a spot which affords more abundant pasturage. They make a halt, unload the camels, and set to work to erect the tents, which does not require much time. At the end of half an hour, the framework of the tent is put up. It has the form of a truncated tunnel reversed, resting by its base upon a cylindrical support, which has the same circumference. It is covered outside by a felt cloth, and inside with reed mats. At one side there is an opening, into which is fitted a wooden frame for the door. This door, being open all day, allows the air and light to enter into the interior of the tent, which also receives a little light from above by an opening in the centre of the roof. The floor is covered with a carpet and felts in summer, and with the skins of different animals in winter. The arrangement of the interior does not require much pains or time. Opposite the door they put up against the side of the tent a low couch. On the left of this is raised the grand *baran*, the most sacred place in the habitation of a Calmuck. It is upon this that the objects of his religious adoration are deposited, as well as all the treasures of his family. Upon the spot in which this great baran is to be raised, they first spread the coverings and caparisons of the horse-equipage and saddles; upon these are placed coffers with clothes: these being covered over with a drapery, they deposit last of all the trunks in which are kept the Calmuck's idols. These being withdrawn from the trunks and placed upon the draperies, a sort of altar is raised. It is a little wooden table, upon which they arrange many little dishes of silver and copper, intended to receive offerings, cheese, gruel, and different kinds of incense. Lastly, before this little table they plant in the soil a piece of wood surmounted with a small silver cup. It is in this that the head of the family deposits the first morsel of every dish that is eaten during the common repast.

Fig. 1.

Feodor Ivanovitsch, a Calmuck Painter of some Celebrity at Rome.

The entire arrangement of the tent, both outside and inside, is the affair of the woman. The husband only charges himself with the construction of the framework, and with some definite corrections which may be necessary. He passes his time in the chase, in pasturing his flocks, or simply doing nothing. All the charge and cares of the household belong to the woman.

In the family life of the Calmucks, the marriage of a son or daughter is a principal occasion of rejoicing and of feasts. The choice among the Calmucks belongs entirely to the parents. Still, there is no constraint upon this point, and, if the son declares that the selection of his parents displeases him, there is no further question about the matter. In considering marriage as the most serious and grave act of life, the Calmucks never undertake it without the benediction of their priest. As soon as he, after having consulted the constellations under which the affianced were born, declares that there are no obstacles to their marriage, one of the elder relatives, on the part of the boy, repairs to the parents of the girl, and, after having regaled them with *eau-de-vie*, announces the object of his visit. It is rare that a refusal takes place in these cases. The parents, having given their consent, may expect the formal demand in marriage. Some days afterward, the father of the affianced youth, having taken with him a provision of wine, a sheep, a block of tea in the form of a brick, and a roll of paper containing a strap and a piece of fish-glue, accompanied with many friends, who ought to be absolutely married, repairs to the khoton of the betrothed girl. Having arrived in the tent, he begins by serving out the wine to all present; then he brings up the sheep, which his friends kill, and immediately put it into the caldron to be boiled. The little packet, containing the tea, the strap, and the glue, is presented to the father of the affianced girl. The tea is consumed at once, and the two other objects, which represent the jewels of betrothal, are deposited on the little table before the idols.

The demand in marriage is shortly followed by betrothal, which consists in the youth repairing to the khoton of his intended bride, and offering her presents of dresses and stuffs. This, which takes place without any thing in particular being said, gives occasion to a fresh banquet. Between the betrothal and the marriage, there sometimes elapses a whole year, or even more. During this long interval, sometimes the youth, sometimes his parents, come from time to time to see the affianced. When she has completed her sixteenth year, the parents of the youth address the priest, beseeching him to fix the propitious and happy month and the day for the celebration of the marriage. Afterward, some days before the date fixed, the whole family of the young man go to the tent of the betrothed. The first day of their arrival passes in doing the honors of reception; the next day the parents of the youth declare to those of the affianced girl their desire that the ceremonies of the marriage should be accomplished, and at the same time they endeavor to learn, in an indirect manner, to what sum the expenses on the part of the young man would amount, and what feasts ought to be offered to the most notable guests, to the acquaintances and the parents of the girl. They never speak of dowry, since the woman ordinarily receives every thing necessary for housekeeping.

The day of the marriage, the young man, with his assistants, well provided with wine and viands, repairs to his future father-in-law's, where they make a great feast. When the feast is concluded, he is invited into the tent of his betrothed, where is exposed her entire dowry, which they shortly send to his khoton. Sometimes the entrance is guarded by the companions of the betrothed, armed with sticks, so that the youth often has great difficulty in gaining an entrance. In order to avoid the blows which threaten him, he offers sweetmeats to the guard. When this guard is satisfied, the young man carries away his betrothed, places her behind him upon his saddle, and repairs to the khoton of his parents.

Here there has been early prepared a tent to receive the newly-married people, and it is before this that the following marriage ceremony is performed: Before the entrance they spread a carpet, and upon this is put a quilt of white felt. Behind the carpet is found the table with the idols, before which is placed, in an offering-dish, a shoulder of mutton, as an emblem of riches. The affianced, surrounded with acquaintances and relatives, place themselves before the sacred table; the priest recites many prayers, after which he seats himself upon the carpet, takes the fold which veils the face of the girl, envelops in it the shoulder of mutton, and presents it to her. The young man takes it in his left hand and his betrothed in the right. Then the priest, after having pronounced many more prayers, raises the two affianced up, and recommends them to bow three times to the earth. They execute these motions without relinquishing the shoulder of mutton, which they continue to hold in their hands, and, in making each reverence, they pronounce the following words:

"I incline myself this first time to adore my Lord God, who is my father and my mother.

"I incline myself this second time to adore my Sun, which is the light of my beloved day; and my Moon, which is the light of my beloved night.

"We swear to love one another, to respect one another mutually, and to partake in common of all the trials and all the joys of our life."

After which, the priest having taken an idol from the table and touched the heads of the couple, the principal and essential portion of the ceremony is finished.

The rest is accomplished in the interior of the tent. Having entered, the affianced incline themselves three times before the idols, and seat themselves in their places, the youth on the bolster of the bed, and his affianced at the other end. After which, all the acquaintances enter and occupy their places. The priest takes the shoulder of mutton, cuts the flesh in pieces, and distributes them to the betrothed and their parents: the viand is consumed instantly; and the bone is preserved as a sacred thing, as a pledge of the future happiness of the new family.

Having accomplished all this, the priest retires, and the party devote themselves to the rejoicings they have been so long expecting, which are prolonged two or three days. Among these entertainments during the marriage-feast, an indispensable part is assigned to wrestling, which is an exercise much esteemed among the Calmucks.

The marriage ceremonies among notable Calmucks are conducted rather differently; yet the difference only consists in this: Ordinarily, it is not the youth in person, but one of his nearest relations, who is charged with conducting his betrothed. The young man meets her on the way, and it is at this place that the principal ceremony of the marriage is accomplished. Arrived at the tent of her husband, the girl does not descend from the horse until she is taken off in his arms. Afterward her horse is set free, and passes into the possession of him who first catches it.

In that which concerns the position of the woman in the Calmuck family, it is much superior in comparison with that which occurs among other people who are on the same level of civilization as the Calmucks. The law, consecrated by usage, in making the Calmuck woman full mistress of the household, determines strictly what ought to be the conduct of the man. The man has not only no right to raise his hand against a woman, but he is obliged, on the contrary, to treat her with respect. Thus, for example, in inviting a woman to dance, he ought to kneel, and carry his hand to his forehead, and afterward to the knee of his wife. She, on the other hand, in inviting one to dance, has only to incline herself gently, and to touch his shoulder. A man is not permitted to refuse a dish or a drink which is offered to him by a woman. Also, upon a journey, if he perceives that a woman intends to descend from her horse, he is expected to get off immediately to assist her to descend.

Such are the laws and usages of the Calmucks with respect to their women; but, at the same time, these laws are not observed very strictly. The Calmuck treats his wife with consideration only in the presence of other persons. When alone, it often happens that he beats her, not only for some omission or negligence on her part, but, for example, for having carelessly trodden upon the foot, the gun, or the stick of her husband.

Divorce is equally forbidden by law, but usage gives the husband the right to send his wife back as soon as she displeases him, and that without assuring her the means of subsistence. In case a Calmuck abandons his wife in an honorable manner, he gives an especial entertainment, to which all her relations are invited. When the repast is ended, he orders a horse out, ready saddled, to carry back his wife to the khoton of her parents.

Besides the cares of the household, the Calmuck woman is charged with the education of her children. The birth of a child among the Calmucks does not give occasion to any particular ceremonies. Scarcely has the new-born child come into the world, when it is carried out of the tent, and the first object which then presents itself to the eyes—dog, sheep, serpent, or other—yields its name to the infant. Sometimes the priest is invited to give it the name which he finds in his book. Besides which, each Calmuck bears a certain *sobriquet;* fo: example, *badma*, flower, *narbo*, jewel, etc.

The Calmucks do not reckon their age from the time of their birth, but by a peculiar calculation. Thus, the day of the new year (November 24th—December 6th) being the *general birthday*, they reckon that a child born, if only a few days before that day of the year, is two years old. The Calmucks trouble themselves very little with the education of their children. As soon as a child begins to walk, he is abandoned to himself, and he habituates himself gradually, by his own experience, to all the privations of a Calmuck existence. When arrived at the age of eight years, the boy is sent to some priest to commence his studies. These consist in learning to read and write and endure for two or three years. The master is paid by means of presents received from the parents at the commencement and at the termination of the course. The girls of the Calmucks, as well of the poor as of the rich, do not learn to read or to write. A girl having finished her thirteenth, and the boy his fifteenth year, they convoke the near relatives, and invite the priests. After a short prayer before the idols, the boy or girl having attained majority is introduced, and his or her hair clipped on the temples. From this moment they are considered marriageable, and they shortly become betrothed.

The *religion* of the Calmucks is Lamaic, or Buddhist. The doctrine of Buddha, undergoing corruption among the Calmucks from generation to generation, consists at the present day of a most absurd mixture of credences.

According to their ideas, before the creation of the universe, there existed an enormous abyss, which was 20,000,000 miles in depth, and 60,000,000 in breadth. From the bottom of this abyss there came out golden clouds, which afterward condensed into a cloud charged with lightning, and then melted into abundant rain, which formed the ocean. This ocean was nearly 6,000,000 miles in length and 7,000,000 in breadth. In time the winds gradually formed a great quantity of froth on the surface of the ocean, and of this froth the continent was formed. In the first place, there appeared the mountain Summer, which is more than 200,000 miles in height. Upon the top of this gigantic mountain, of which we only see the half, is found a vast plain. The mountain itself has the form of a rock with four flanks. Each side of the mountain has a different color: silvered on the side of the east, red on the west, blue on the side of the south, and golden on that of the north. Around the Summer are found four great islands, which form the four parts of the world. The isle of the south is that which we inhabit; that of the east is peopled with men who live 150 years; the isle of the west, which abounds with cattle, is inhabited by giants; lastly, the isle of the north is peopled by peculiar beings—they each live 1,000 years, and the end of their lives is announced to them by an unknown voice.

The first inhabitants of this world were divine beings. They primarily inhabited the seventh heaven, but at one time they lapsed into war one against the other. The good conquered; and the wicked were forced to quit heaven, and they installed themselves upon the summit of Summer. Nevertheless, the contest begun in heaven always continued, and the number of fugitives increased so that they occupied all the islands which surrounded the mountain Summer. At the commencement of their terrestrial life, they preserved their divine qualities. Thus, for instance, they each lived 80,000 years, their faces were luminous, they possessed wings wherewith to fly, they went without food, etc. But one day there appeared upon the earth a certain fruit named *shime*, which was as sweet and as white as sugar. As soon as men tasted it, they lost all their qualities of perfection; the brilliancy of their faces disappeared, their wings fell off, they felt the need of nourishment, and the duration of their lives sank to 10,000 years only.

As long as men had luminous faces, there was no reason or necessity for the existence of the sun and moon. But, as soon as the shining of their faces was extinguished, obscurity spread over all the earth. Then four benevolent persons having taken pity on the human race, and having seized the Mount Summer in their arms, shook it so violently that the ocean of the universe was agitated, in consequence of which there appeared the sun, the moon, and the stars.

The sun, according to the doctrine of the Buddhists, is a globe of crystal, being more than 700 miles in circumference. In its interior there is lodged a luminous being, whose radiant face spreads light and heat over all the earth. The sun is placed in an enormous plain, all covered with the most splendid flowers. Every twenty-four hours seven aërial horses draw it round Mount Summer. In the morning the rays of the sun fall upon the silver side of Summer, before noon upon the blue side, at noon upon the golden side, and lastly, in the evening, its red side is illumined. Afterward the sun hides himself entirely behind the mountain, in consequence of which darkness and night ensue.

The moon, according to the ideas of the Buddhists, is also a globe of crystal, but filled with water, and it also is inhabited by a luminous being. The phases of the moon depend on its more or less remoteness from the sun; and the spots which are perceived on its surface are the shadows of the different marine animals which live in the universal ocean. After having created the sun and the moon, the creative gods held a council, during which the wicked spirit glided in unperceived and drank up all the sacred water of the vase which stood before the gods. Indignant at this audacity, they decided to punish him; but for a long time they could not discover where he was. They then interrogated the sun, and the sun gave them an unsatisfactory reply. They then addressed themselves to the moon, and she indicated to them the place in which he was hidden. In revenge for this he had frequent quarrels both with the sun and the moon, and sometimes he fought with them. During these duels there was an eclipse upon the earth.

The stars, likewise, are equally great globes of crystal, inhabited by spirits. One only among all the stars—the pole-star, called the "pile of gold"—is fixed. All the others, to the number of 225,000,000, are transposed by aërial horses from one place to another. The fall of a star signifies the death of its inhabiting spirit, whose soul then descends into the abyss to animate another body.

The change of seasons is produced by a winged dragon. During the whole of winter it is in repose, lying upon the seven seas. In summer it rises up with the vapors, and ascends toward the upper strata of the atmosphere. The creature which rides this dragon excites it from time to time to thunder and to vomit flames. From time to time also he shoots from heaven fiery and deadly arrows.

As to the past destinies of the human race, the Buddhists teach thus. Men, having tasted the fruit shime, could not any longer do without nutriment; and, since the shime could not suffice for them all, they began to feed upon terrestrial honey and some vegetables. The fear of the want of food has forced every one to think only of himself, and to seek to provide for the future. Indigent people began to envy those who were richer. The discord which arose among men forced them to choose chiefs charged with their well-being. These chiefs abused the confidence placed in them, and, supporting themselves upon their power, changed into despots.

In proportion as iniquities multiplied among men, their longevity decreased more and more, and at length arrived at its present degree. During this period of continual calamities, many deities, clothed in human form, descended from time to time upon the earth, and preached penitence and correction. There were four of them; and the last is recognized as the founder of Buddhism. He taught his doctrine to sixty nations, each one of which understood it differently, which has occasioned the origin of so many different religions that prevail upon the earth.

As to what concerns the future destinies of the human race, they teach that the stature and the age of men will sink by degrees, and that there will come a time at which human stature will not exceed twenty-eight inches and a half. Then each child will speak immediately after its birth, and the next day it will be capable of undertaking its own management. They will marry at five years of age, and will not live longer than ten years. The human race having arrived at such a state will be the sign that the moment of universal destruction is at hand. Seven years before this cataclysm, the earth will become completely sterile, and the greater part of mankind will die. Afterward a great number of swords will be cast down from heaven, which will put to death the rest of the survivors, excepting a single just family, which will be hidden in a ravine. After which the earth will be covered with dead bodies and gorged with blood. It will rain a purifying rain, afterward a fecundating rain; lastly, a third rain will bring all that is indispensable to man. The family which was hidden will then come out from its refuge, and many other virtuous men will be resuscitated to recommence their new life, which will endure 80,000 years, and to enjoy all the blessings of the earth.

But shortly men, forgetting past misfortunes, will begin again to do evil, and consequently their longevity will be gradually decreased. When human life will not endure more than 2,000 years, there will appear upon the earth the being Maïdari. He will be of high stature, and of dazzling beauty. Men, surprised with his exterior, will ask him by what means he had arrived at such perfection. To which Maïdari will reply that all this came to him in consequence of his good works, by which they also are capable of gaining the same perfection. The example and the instruction of God reacting upon men, they will be corrected, and they will live anew 80,000 years. This second change will be followed by fifty-four new ones; and each eighth change will be accompanied by a deluge, all the others by a fire.

The Buddhist doctrines of the soul, of punishments and rewards which are prepared for every one after death, are equally very strange. The souls of all creatures pass after death into new beings. Each soul prepares itself for this transmigration during its terrestrial life. Dwelling in the human body, the soul never seats itself in one single definite place, but every day changes its seat. Thus, on the first of each month the soul finds itself in the forefinger; the second day it resides in the foot; the third day in the calf of the leg; the fourth in the knee. In this way it ascends every day higher; at the eighth day it finds itself in the loins; the twelfth it passes into the palm of the hand; the fifteenth it spreads through the whole body; the sixteenth it seats itself in the nose; and on the last day of the month it appears in the thumb. Afterward its migration recommences in the same order. The injury of a part, when the soul is seated in it, is always followed by an inevitable death. After death the soul passes into one of the six reigns, and animates some other body.

The choice of a reign does not depend upon the soul itself, but it is fixed by the judge of the lower regions, who takes into consideration the good works accomplished upon earth. The habitation of the judge of the infernal regions is situated in a subterranean palace, surrounded with sixteen walls of iron. It is there that all the souls of dead men present themselves before him, except those of lamas, which ascend at once toward the happier dwelling-place. Each soul is escorted by two spirits, the good and the wicked, who, presenting it to Erlik-Khan, place before him white and black stones. If the white stones, which signify good works, exceed the black, then the soul, placed upon a golden throne, ascends to the kingdom of the good. In a contrary case, it descends to be purified in another kingdom, which is divided into thirty-six sections. The inhabitants of this kingdom remain there five hundred years at least, and every day of these years is equal to one of our months. The souls here undergo pains more or less severe, according to the nature and the degree of their crimes. Thus, cruel chiefs and homicides are condemned to swim without rest in a sea of blood; misers, transfigured into monsters, having a mouth as small as the eye of a needle and a throat as fine as a thread, have nothing but flames upon which to feed and blood to drink. These poor damned continually rove over a desert plain, seeking in vain some nourishment. They sometimes perceive trees full of delicious fruits, but scarcely do they happen to approach them than the trees disappear, and the unfortunates behold themselves again abandoned to their punishment in the midst of the desert.

The punishments practised in the kingdom of eternal pains are still more terrible. Situated at 200,000 miles below the earth, it is divided into sixteen sections. In the first, the damned, half dead, are continually cast from knives to knives; and this punishment endures for 500 years, of which each day further equals 9,000,000 years. In the second section, the condemned are continually sawn. In the third, they break them in an iron press, and every time they revive they are bruised again. In the fourth and fifth sections, the condemned are roasted by the fire. In the sixth, they are boiled. In the following, they are frozen to the degree that their skin is covered with blisters, their lips split into shreds, etc. Not only men, but animals also, are condemned to undergo different pains. Thus, some are condemned to bear different burdens; others to run without rest, and to be torn in pieces by ferocious animals.

Just as the punishments of hell are terrible, so also the enjoyments of paradise, prepared for the just, are delicious. The paradise of the Buddhists is divided into five regions, each of which bears the name of one of the principal idols. The first kingdom is full of trees of silver, with branches of gold, which bear, in the place of fruit, stones the most precious. Streams of living water irrigate this miraculous country, in the midst of which is found a delightful forest, in which the spirit, surrounded by the just, reposes upon a throne, which is supported by a peacock and a lion.

The chiefs of the Buddhist clergy are the *Dalai-Lama* and the *Bogdobatsin.* They both reside in Thibet. Formerly Dalai-Lama exercised the civil and spiritual power in the whole of Thibet. But since 1703, that is, since that country has passed under the power of China, Dalai-Lama has not only lost his civil power, but he has been obliged to divide with Bogdobatsin his spiritual power also. Notwithstanding, Dalai-Lama always exercises an enormous authority. He inhabits the palace which is constructed of stones proceeding from a sacred mountain of Thibet, and contains 999 chambers. At a mile from this palace stands the celebrated temple Dshu. Every new year there assembles in this temple the clergy of the whole of Thibet, to the number of 17,000 men. They celebrate there day and night divine service for twenty-one days.

All the rest of the clergy is composed of lamas. To become a lama is not an easy thing. For this, besides the three principal books, it is necessary to read a multitude of others, which embrace many hundred volumes. It is also necessary to be instructed in astronomy, in medicine, and in other sciences; and lastly, which is the most difficult, it is necessary to perform the *vote* to think upon God every moment, and strictly to execute all the commandments, the number of which surpasses two hundred.

The social organization of the Calmucks at the commencement of the seventeenth century, that is to say, at the epoch of their arrival in Russia, was purely patriarchal. Many families united by the bonds of relationship formed a khoton, of which the most aged was the head. Many khotons composed an *aïmak*, governed by the *zaïsangh* the power of whom was hereditary from father to son. Afterward many aïmaks in their turn formed a commune, and many communes composed an *oulouss*, governed by a *nohyon*, or chief. Lastly, a certain number of oulouss, united under the command of a *taïsha*, formed a tribe. The taïsha, who had the rank of a prince, governed personally in the principal oulouss; and all the others he ceded to his sons and brothers, who governed there by turns. All the tribes united constituted the entire people, commanded by the *khan*.

The actual rule over the Calmucks belongs to the *Court of Domains*, at Astrakhan. Formerly there were three kinds of punishment —corporal punishment, fine, and the degradation of the criminal in the face of the entire tribe. Thus, for example, for disobedience to parents, as well as for rudeness or insolence to elders or chiefs, they applied to the offender, first, a certain number of blows with a stick, and then, after having daubed his face with soot, and tied a pan round his neck, they promenaded him through the whole khoton. This chastisement is called *degradation by means of the hand*, because, to apply it, he who is charged with its execution takes a handful of soot from the bottom of the pan, and spreads the whole handful over the face of the offender. For a theft they punished the thief by promenading him equally through the khoton by a cord round his neck. Those who met him gave him blows with a rod on his naked body, and some deride him.

The exercise of justice has three degrees: The first, which was practised in the khoton, had a family character. The second consisted in a veritable tribunal, named *zargo*, and was composed of the zaïsanghs under the presidency of a nohyon. Lastly, the supreme tribunal, after the number of its members, called *Judgment of the*

Eight, was composed of the nohyons, under the presidency of the Khan. In this supreme tribunal were judged all criminal affairs of every nature. Murder was considered as the gravest of crimes. In the eyes of the Calmucks it was a frightful sin, and absolutely unpardonable. For murder committed for the first time, the offender paid a fine, judicially decreed to the parents of the person killed, in the manner of a retribution. Besides which, he was obliged to renounce every kind of enjoyment during a certain time, to carry a red scarf round his shoulders, and to do penance during some time near a temple. For a second murder, the fine and the penitence were heavier, and, further, the criminal was marked on the face. Lastly, he who had committed a homicide for the third time was marked on both sides of the face, and expelled forever from the midst of the people. In case the condemned had not the means of paying the fine, he was surrendered in person to the disposal of the relations of his victim, who had the full power to employ him in any kind of labor, as well as to sell him, or to exchange him for a flock of sheep.

In the case in which there was no confession on the part of the accused, or of failure of sufficient proof to establish the crime, the tribunal had recourse to *the oath of justification.* To accomplish this appeal, the accused might choose an adversary, who was generally reckoned an honest man. For the accomplishment of this act, they prepared a tent, in which, upon an elevation, an idol was exposed, before which they lit a perfumed taper. On the two sides of the idol they raised the images of punishing beings, under which were arranged the priests with their musical instruments, employed in divine service. Upon the floor of the tent they spread the skin of a cow, quite black, recently skinned, and moistened with the blood of the immolated beast. Above, and to the right of the door, inside the tent, they suspended the head of the same cow. Its eyes were opened wide, the tongue drawn out and turned to one side. On the left of the door they suspended a human skull, and below this last they placed a loaded gun with its lock tied up. Outside the tent, on the two sides of the door, were placed the judges, the accusers, and the accused.

All these preparations being made, the person chosen by the accused for an adversary was first obliged to persuade the parties to be reconciled, in order to avoid the necessity of so great and solemn an oath. If this exhortation had no success, then they proceeded to accomplish the *shakhan*, which took place in the following manner: The accused who has to swear, being undressed to his shirt, placing himself upon the bloody skin of the cow, after making three profound bows, ought to jump over the threshold of the tent. Scarcely has he made the first movement to advance, than the priests begin to sound their trumpets, little bells, and metallic plates, to blow into shells, etc. These solemn sounds accompany the oath at the table upon which the idol rests, and this music is only interrupted by the slow recitation of prayers. Naturally, all this ceremony must react strongly upon the imagination of the accused; but when the accusation is unjust he is not in the least confused, and comes without fear to the idol; he extinguishes the lighted taper before the idol, after which, inclining himself toward the table, he seizes the heart of the cow with his teeth, which was exposed there upon a dish, and carries it out of the tent. Here one of the priests receives this revealing object from him, and passes it to the judges to be inspected. If, on inspection, there are no injuries observed upon the heart, then the accused is acquitted, and the accuser is condemned to a fine fixed upon beforehand.

All this mysterious ceremony would impress the Calmucks deeply by its solemnity, and inspire them with sentiments of terror. And this so much the more easily, as each detail of this shakhan had a certain symbolical signification. Thus, the black cow was the symbol of death, which ought to recall to the person taking the oath the enormous responsibility to which he exposed himself, if he had taken a false oath. The charged gun, with the lock bound up, signified that the perjured ran the risk of being immediately struck by divine justice. And the head of the cow, monstrously disfigured, ought to recall to him that his soul would be excommunicated from the midst of men, and driven into some frightful and monstrous being. The idol spoke to him of the presence of the supreme judge, who listened to his oath. The illuminated taper signified the divine light spread abroad by the Creator, and its perfume signified the grace of God, both of which the perjured renounced and deprived himself of voluntarily in extinguishing the taper. Lastly, the heart of the immolated cow signified the innocence of the person swearing, and the purity of his intentions.

Of all this terrible oath there remains at the present day but a very small portion in use. In doubtful and very grave cases, the Calmuck, who has to justify himself by means of the oath, only approaches to the table of the idol, before which he prostrates himself three times to the earth, and, after pronouncing with a loud voice, "I am innocent!" he extinguishes the taper, to express that he renounces the favors of the Creator if he has lied. Such an oath is very serious, and appears to be the only relic which testifies to the ancient *régime* proper to the Calmucks. At the present day their ancient judgment, as well as the punishments of former times, is abolished, and the Calmucks are judged according to the common laws of the empire.

As to their actual chiefs, these have preserved to the present day the same authority in the eyes of the Calmucks which they formerly possessed. A chief is respected not only by his subordinates, but by all the other Calmucks. They dare not enter into his tent without having first made a sign of reverence, which consists in him who is entering touching with the palm of his hand the door of entrance, and afterward his own forehead. In withdrawing from the tent they march backward, in order not to turn the back upon the chief. If he permits his subordinate to sit in his presence, this person thanks him by carrying his hand to his forehead; afterward he places himself upon his knees, and, resting his two hands there, seats himself lastly upon the soles of his feet.

The clergy enjoy among the Calmucks a respect equal, if not superior, to that which they manifest to their chiefs. The supreme chief of their clergy is a lama. Up to the year 1800 he was always instituted by the Dalai-Lama of Thibet, but now it is the Russian Government which names him. The fixed residence of the lama is at the distance of a league from Astrakhan, at Bazar Kalmouke, by the shore of the Volga. Every summer the lama quits his residence to make the tour of the steppes.

All the priests are exempt from taxes, and subsist upon offerings, which consist of cattle, different objects, and money. They exercise medicine among the Calmucks, and, notwithstanding their ignorance in this science, they nevertheless enjoy a much greater confidence among the population than any physician appointed by government.

A priest being called to a sick person, begins by giving him soup to drink, pure water, or he prepares the most ordinary medicaments for him; and for nothing but this he frequently deprives the poor Calmuck of all that he has, under the pretext of the offerings demanded for the idols, the intervention of which is indispensable to procure the cure of the sick. If it is a rich man who becomes ill, then there are many who take charge of his treatment. They do not fail to take away all that their client possesses—his treasures, flocks, and, last of all, his tent—and all this under the pretext of offerings for the deities. Notwithstanding all these sacrifices, it ordinarily happens that the sick man dies, leaving all his family in complete poverty.

The principal duty of the priests is limited to the religious practices of their idolatry. Their divine service, held in the tents, consists in the united priests reciting—to the sounds of little bells, metallic plates, tambours, and gigantic trumpets—fragments of prayers, which they read from their sacred books, for the most part incomprehensible to themselves. A priest never voluntarily speaks upon matters relating to his religion, and, if any one of his people questions him upon this subject, he never replies, giving for his reason that it is a sin to speak about religion.

The chronology of the Calmucks does not consist in reckoning the years setting out from a certain memorable date; but they count by cycles each of twelve years, to which they give a particular name of such and such an animal. The year is composed of 13 months, each of which also bears the name of an animal. Thus the first month in the year, which corresponds to our December, is called the *tiger* month; the months which follow are those of the *hare*, the *dragon*, the *serpent*, the *horse*, the *goat*, the *ape*, the *fowl*, the *dog*, the *pig*, the *mouse*, and the *cow*. One of the months returns twice, and that is the thirteenth of the year. Each month has thirty days, and the week has seven.

The priests are greatly respected on account of their spiritual functions, and they exercise a great influence upon the whole population. It is these who are specially addressed to fix the day propitious to celebrate marriage, or to point out the kind of funeral proper for a person dead. In this last circumstance they conform to the rank, more or less important, of the deceased, or, to speak more correctly, to the greater or smaller number of sheep which the relations offer for the *khouroul.* The more liberal the offering, the more distinguished is the sepulture. But, since the rich have more means for making offerings, their bodies are ordinarily destined to be burned, while the corpse of a poor man is simply interred, or even abandoned in the midst of the steppe, to become the prey of wild animals.

The principal evil arising from this great influence of the priests over the Calmuck population is, that it is opposed to every civilizing effort; this is why all the attempts of the government to convert the Calmucks to Christianity, and to induce them to abandon their nomad life, have hitherto almost entirely failed. Moreover, the nature of the country occupied by the Calmucks is greatly opposed to their being able to establish themselves in colonies.—*Anthropological Review.*

THE BALANCE OF LIFE IN THE AQUARIUM.

By SHIRLEY HIBBARD.

When man looks upon Nature, he sees everywhere the records of death's work among the representatives of creative energy. The stratified rocks are but the tombstones in the great graveyard of the world; they cover the bones of a million generations, and their inscription is, "The dust we tread upon was once alive." If the infusion of life into countless forms, each in itself perfect, needed nothing less than Almighty power, it needed Almighty power too to complete the scheme in the institution of dissolution; and the grim king of terrors, before whom the bee and the sparrow tremble, perhaps, not less than man, became co-worker with God by a wise and beneficent appointment; and so the orders of being began, and have to this hour continued, as a series of dissolving views, in which there is no hiatus, but only *change;* no shifting of the focus or the screen, no aberration or intermission of the source of light, but an unending variety in the pictures. We know not how other worlds may fare, but this we know, that *here* death supplies from every extinguished picture the colors with which the next are painted, and we live—man and brute—on the *débris* of the past.

I see all this and more in the aquarium; it teaches me lessons in physics, and, I trust, also teaches me that the moral and spiritual truths of the universe may be illustrated, sometimes explained, by a patient study of the commonest things. The aquarium is a world in little; it sustains itself. For the moment, I put aside the law of gravity as a universal law, and the presence of the atmosphere as a universal thing, and I call it a world, needing no aid, for its continuance and the perfect adjustment of its balance of power, from external things. I take a vessel of glass, a few pebbles, a few pieces of sandstone-rock, and a sufficiency of water, and to that I commit my fishes and insects, and say, "There is your world; the order of Nature is such that you may henceforth live and die without human interference." I say nothing here of the details of management; I am looking for instruction in the laws of life and death.

The two requisites of animal life, food and air, must be generated in this world, or it ceases to instruct me; yet the water contains but little of each, and whence is its supply to come? God has ordained such a wealth of organic forms that, wherever the conditions of life are found, life takes possession of the spot, whether it be the bottom of the ocean, the dripping roof of a cave, the expanse of the viewless air, or the mimic lake I call an aquarium. Forthwith the dead stones become alive with greenness, the glass walls assume the semblance of a meadow, the milky hue of the water disappears as the earthy particles it held in solution subside, and the light that streams through it takes a tint of greenness. There is an order of vegetation appointed to occupy such sites, and almost every non-metallic, and some metallic substances too, become speedily coated with confervæ, when their surfaces are kept moist a sufficient length of time. Were it not so, the inhabitants of my world must perish; and to prove the fact I try an experiment. I place some fishes in a clean vessel of water, without pebbles and without rock; the moment the first dim bronzy speck appears, I rub it off the glass, and so thwart the course of Nature. The fishes soon exhaust the water of its oxygen, and though the water attempts to renew its supplies by absorption from the atmosphere, the compensation is too slow, the fishes come gasping to the surface, and in a short while perish.

Even then I learn something from their death if I leave the vessel in the hands of Nature. Death has no sooner spread his black banner over my household gods than life of another kind arises to confound him, and the microscope reveals to me myriads of animals and plants, and organisms that seemingly occupy an intermediate place between the two great kingdoms, rioting upon the wreck that death has made. My half-dozen dead fishes have given birth to existences numerous as the stars in heaven, or as the sand upon the sea-shore, innumerable.

While these devour the banquet death has spread for them, while forests of confervoid threads rise in silken tufts like microscopic savannas, Nature is passing portions of the ichthyic *débris* through her laboratory, and the very source of life for which they pined and perished—oxygen—is poured in in large measure, and the corruption is quickly changed to sweetness. Of the once sportive fishes some portions have become air, other portions have become water, but the chief of their bulk lives already in the vegetation which hides their grave, and the moving throng with which that vegetation is peopled. God's purpose, in the working of the laws in obedience to which these changes have taken place, is manifestly to keep ever true that balance of life and death of which He holds the beam in His own hands.

But my aquarium which has not thus been interfered with presents already a similar scene of life and bustle. When first supplied, the milky-looking water was abundantly full of gaseous matters, and every part of the rough rockwork was, for a time studded with silvery globules. The fishes consumed all that in the process of breathing. As the water passed through their gills, the oxygen was absorbed; that oxygen, by a process of refined chemistry, and perhaps by the help of iron also, gave their gills a bright-red color, gave their blood its red color too, and, by other processes not less refined, sustained he balance of life's functions within them, for without it they must perish. We believe that not the airiest particle of earth, atmosphere, or water, nor the most minute globule of condensed moisture, nor the most infinitesimal point of meteoric dust, can ever be lost, at least during Time, from the fabric of the universe. My fishes tell me that the oxygen they absorb from the water they again return to it, but *in another form.* They *in*spire oxygen and *ex*pire carbonic acid, just as a man does, and every other living creature that moveth upon the face of all the earth. Is it within the reach of human power, even when reason, imagination, and fancy combine together as a bold triad to look direct upon a fact, to appreciate that principle of terrestrial life by which animal and vegetable organisms reciprocally labor to maintain the balance of atmospheric purity? The carbonic acid given off by the animal is poison to it, if it accumulate while the supply of oxygen is cut short. It was carbonic acid as much as absence of oxygen that killed our fishes just now, for, though inhabitants of water, they were not the less suffocated. Therefore I see *why*, in the tank that has been left alone, plants have cast anchor on the glass walls, the brown pebbles, and the gray blocks of sandstone-rock. My fishes breathe and breathe. If their numbers are properly proportioned to the area they occupy, they will never exhaust the water of oxygen, never render it fetid with carbonic acid, so long as one necessity of vegetable life—light—is allowed to use its active influence to paint the plants green, even as oxygen gives a sanguine hue to the gills or lungs of the fishes. To those plants, the carbonic acid, which the fishes expire day and night, is as essential as oxygen is to the animal economy, and thus, without introducing a single scrap of any living plant, the balance is sustained, and death seems to be kept at a distance. If at first I threw in a tuft of callitriche or anacharis, or any other true aquatic vegetable, oxygen would be supplied abundantly; and in practice it might be well to begin so, because some little time elapses ere the seeds of the microscopic forest, the tops of whose trees present to the eye but a felt-like coating of superficial greenness, are developed into true plants; though with a fair amount of indirect daylight, and at certain seasons of the year, a few hours suffice to set the vegetative process, with all its proper consequences, in full action. Many of the readers of this paper will call to mind the aquarium that stands in my entrance-hall. It contains twenty fishes, large and small, and not a single scrap of vegetation except what has been developed *in situ* by spontaneous generation. It is three years since that was fitted and stocked, and committed to the management of Nature, with the sole exception of the external aid afforded by regular supplies of food for its inmates, which need not be taken account of, now that we are considering it as a world in which the balance of life and death is sustained by the operation of principles ordained by the Creator.

It is when we leave the principles and attempt to classify the details of the scheme that we become bewildered. The smooth revolution of the fly-wheel and the noiseless oscillation of the piston convince the unprofessional observer of a great engine that mechanical motions are possessed of poetry; but, if he would analyze the relations of the cog-wheels, the indications of the "governor," the "gauge," and the pressure-valve, he must descend to hard facts, and forget for a while the sublime suggestions of a system of mechanism that throbs like a living creature. Admit a full glare of summer sun to the aquarium, and forthwith the water loses its pellucid fluidity, and becomes deeply tinged throughout of a dull green, as if some pigment had been dissolved in it. Instead of plants attached to stones and glass only, and animals that float unseen, the whole of the water is occupied by visible masses of animal and vegetable life; and, if the fishes suffer, it will be from undue heat, not from the addition to the element in which they live of this new mass of being. Shut out the sunshine, let the fresh air play over the surface of the water, let moderate daylight stream through it as before, and speedily the green fog clears away, the water again becomes transparent, and the balance is restored. Monas, euglena, uvella, cryptomonas, gonium, and other wondrous infusoria, may be detected as constituents of the cloudy mass while it lasts, called into being because the conditions of the tank were such as they required, as if life in embryo were everywhere locked up until the moment came for its liberation, and some particular circumstance was the talisman to set it free· or, if we consider created forms to be marshalled in grand procession, may we not expect that every tribe will hurry to its appointed place the instant that a door is opened?

Microscopists have long been at war, but without bloodshed, as to the place to be assigned to certain organic forms which are hidden from our common eyesight. While the war goes on as to whether desmidiaceæ and diatomaceæ be animal or vegetable, or both, let facts suffice us here in the study of the aquarium. Does an animal exhale carbonic acid? Yes. Well, here are plants or animals, concerned in keeping up the balance, which exhale oxygen, and their name is legion. Volvox globator and the bacillariæ labor as hard to supply the fishes with the life-sustaining gas as do the silken threads of verdure that line the glass like a carpet. Is the possession of starch a distinctive feature of the vegetable? Perhaps so. Truly here are desmidiaceæ that contain starch, and, if I make the possession of cilia the test for assigning certain forms to the animal kingdom, I find in the aquarium spores of algæ furnished with them. Motion I know to be no test, because algæ-spores dance through the water gayly till they find a resting-place, and, when the aquarium was first filled, it was by dancing they at last found where to pitch their tents, and cease their nomad wanderings. But they all work together to sustain the balance, and the law of "give and take" prevails among them—the stentor devours the oscillatoriæ, rotatoria, and monads, and the hydras swallow all; every darting speck is a tomb wherein some smaller speck of life is to be buried, and life thus prospers on the decay it is itself undergoing.

But all this while a fine deposit slowly settles among the pebbles, which form the lower stratum of this watery world. Between the stones a fine alluvial silt collects and thickens. The first frost, sufficiently severe to touch the tank, causes the whole green coating to peel off from the glass and rock, and, while this subsides, to add to the thickness of the alluvium—how slightly, and yet how sufficiently for an example of Nature's working!—a new growth commences, and *that* balance is restored. Do you not see that the chief teaching of geology—the piling of stratum upon stratum, the conversion of disrupted rock and decayed plant and animal into rock again—is here exemplified in the history of a domestic toy, which contains already one example of stratification in the silence of watery submergence? A tank which has been fitted with loam, pebbles, and plants of the brook and river, will, if left undisturbed for three years, be in this state. Those plants will all have decayed, but there will be an abundant spontaneous vegetation. The accumulations of that short period will have settled into a close mass, almost as hard as stone; and if fishes have died in the mean time, and have not been removed, their bones will be found overlaid with hardened mud, just as we find them in the old red sandstone, or the chalk, or the carboniferous rocks, and shall we not call them *our own* fossils? See again in this case in which death has been very busy (for plants of large growth soon perish in the absence of sunshine, and occasional attendant accidents will carry off some of the finny pets), how life has been equally active on the other side, for such an aquarium will be a hundred times richer in those spontaneous growths we have already spoken of, and visible forms of infusoria and true zoophytes will abound, and every class will be more fully represented, down even to the twilight monad.

Though this paper must have an end, there is no end to the teaching of the aquarium. It is a watery microcosm of living and dead wonders, and we need not marvel that the balance of life and death may be observed in its succession of changes, because all the physical forces of the universe are locked up within a single bead of dew, and all the functions of organic creation are comprised in the economy of a monas termo. If God so ordains that life shall be constantly soaring from the tomb, if the story of the Phœnix ceases to be a fable, need man, the victim of doubts and fears, ever fail in his trust of that blessed promise, that "this mortal shall put on immortality, and this corruptible shall put on incorruption?" Science may fix his mind on the appreciation of God's wisdom and power as he reads the handwriting of the Almighty in Nature, but through faith in another revelation must we hope to exclaim, triumphantly, "O death, where is thy sting? O grave, where is thy victory?" Or, to pass from divine to human consolations, we may take up the apostrophe of the great Raleigh, and say: "O eloquent, just, and mighty Death! what none have dared, thou hast done; what none have attempted, thou hast accomplished; thou hast gathered all the might, majesty, and meanness of mankind, and hast covered them with these two words, '*hic jacet.*'" Nature's children have a dread of death, but Nature herself is in friendly compact with the master of silence. If the *types* which are the ideas of God have survived from the oldest rocks to this present hour, will not the spirit which lives on ideas, and evolves them as the aquarium evolves its throng of animalcules, live forever? It is not hard to believe with Tennyson—

> "That nothing walks with aimless feet,
> That not one life shall be destroyed,
> Or cast as rubbish to the void,
> When God hath made the pile complete."

"The pile" will be complete when God's purpose is fulfilled in man, to whom it is given to hope after eternal life, and with eyes of faith to pierce through the veil, and behold the wondrous things of eternity.—*Recreative Science.*

JURIES, JUDGES, AND INSANITY.

By Dr. HENRY MAUDSLEY.

THE recent trials for murder, in which insanity has been alleged for the defence, whatever differences of opinion they may have given rise to, have clearly shown how entirely unfitted a common jury is to decide the delicate and difficult question of a prisoner's mental state. Had the wit of man been employed to devise a tribunal more unfitted for such a purpose, it might have exhausted itself in the vain attempt. It is one of the anomalies of British jurisprudence that while in an action for libel or any civil injury a special jury may be claimed, and the services of men who are above the lowest levels of ignorance and prejudice be thus obtained, it is quite otherwise when a person is on trial for his life. In this most momentous issue, however complicated the circumstances, however obscure the facts, he must stand the verdict of twelve common jurymen. In ordinary cases of murder, when the facts are such as any person of average sense and experience may judge of, the system works sufficiently well, or at any rate no great harm ensues; but, in any case in which it is necessary to form a judgment upon scientific data, a common jury is assuredly a singulary incompetent tribunal. The very terms of science they are ignorant of, and they either accept the data blindly on the authority of a skilled witness, or reject them blindly from the prejudice of ignorance. The former result is commonly what happens in regard to scientific evidence of poisoning; the latter is commonly what happens in regard to scientific evidence of insanity. There are few persons who, without having had a special chemical training, would venture to give an opinion on the value of the chemical evidence given in a case of poisoning, but everybody thinks himself competent to say when a man is mad; and, as the common opinion as to an insane person is that he is either a raging maniac or an idiot, it is no wonder that juries are prone to reject the theory of insanity which is propounded to them by medical men acquainted with its manifold varieties. It would seem to be an elementary principle of justice that a prisoner on trial for his life should have the right to claim a jury of men specially competent, or at any rate not absolutely incompetent, to judge of the facts on which his defence is to be based.

It is an additional evil of the present system that judges too often share the ignorance of juries, and surpass them in the arrogant presumption which springs from ignorance. Instead of urging them to throw off all prejudice, and aiding them with right information, they sometimes strengthen their prejudices by sneers at the medical evidence, and directly mislead them by laying down false doctrines. They may even go so far as to flatter them in the opinion that they, as men of common-sense, are quite as well able as medical men to say whether a person is insane or not. In the last number of this Journal we gave a report of a trial which took place in Scotland for the reduction of a will, in which the judge directed the jury, with the greatest assurance, that the symptoms which preceded insanity and indicated its approach, in an ordinary case, went on increasing as the disease advanced, and implied that, as they had not done so in the case in question, it was preposterous to allege insanity.

To our mind, the evidence of insanity in that case was conclusive, but at any rate the statement of the judge was utterly untrue, as a very little knowledge of insanity would have taught him; and we cannot help thinking that the authoritative enunciation of such false doctrine to a jury is nothing less than a judicial misdemeanor. One cannot justly complain that judges should be ignorant of insanity, seeing that only by long experience and study is a true knowledge of it to be acquired; but it is a fair ground of complaint that, being ignorant, they should speak as confidently and as foolishly as they sometimes do. Here, as in other scientific matters, it is not intuition, but experience, which giveth understanding.

Not only is it the fact that judges are ignorant, but they are too often hostile. Governed by the old and barbarous dictum that knowledge of right and wrong is the proper criterion of responsibility when insanity is alleged, they resent angrily the allegation of insanity in any case in which the person has not lost all knowledge of right and wrong. Believing that medical men are striving to snatch the accused person from their jurisdiction, they are jealous of interference, are eager to secure a conviction, and sometimes lose the impartiality becoming the judge in the zeal proper to the partisan. The reporters are happily good to them, in forbearing to report all they say and do, or we fear that the dignity of the bench would have suffered more in public estimation even than it has done of late years.

It is useless to say smooth things when things are not smooth. There is a direct conflict between medical knowledge and judge-made law,[1] which must go on until bad law is superseded by just principles

[1] Dr. Landor says: "If the principle that it is essential to institute a thorough examination of the individual's past and present condition before determining his state of mind is the right one, then the proceedings of lawyers are in complete antagonism to truth. There can be no conflict between propositions more complete. Medicine declares that insanity is a physical and corporeal disease; Law, that it is not. Medicine says that imbecility and insanity are different conditions; Law, that they are identical. Medicine asserts that a theoretical study of mental diseases and defects is necessary to a proper understanding of such diseases and defects; Law denies this, and says that insanity is a fact to be determined by any dozen of ordinary men, in consultation, on the case, selected at random from any class of the population. Medicine says that a man may be insane and irresponsible, and yet know right from wrong; Law says that a knowledge of right and wrong is the test both of soundness of mind and responsibility to the law. Medicine says restrain and cure the insane and imbecile sufferer. The object of the ac-

in harmony with the teachings of science. For many years, by all authorities on insanity, in season and out of season, the truth has been in vain proclaimed: many times have futile attempts been made to arouse attention to the iniquity of the law as laid down by the judges; but it is still necessary for us to go on protesting, as our forefathers did, and as our children's children may have to do. We may, at any rate, take leave to characterize the administration of the law on every occasion in the plain terms which it deserves. Under the name of justice, grievous injustice has sometimes been done, and it would be easy to point to more than one instance in which murder has been avenged by the judicial murder of an insane and irresponsible person. The saddest and most humiliating disease with which mankind is afflicted, and which should rightly make the sufferer an object of the deepest compassion, only avails in England in the nineteenth century to bring him, in the event of his doing violence, to the edge of the scaffold or over it. To this point have eighteen hundred and seventy-two years of Christianity brought us! And Science protests in vain! Without laying claim to much gift of prophecy, one may, perhaps, venture to predict that the time will come when the inhabitants of the earth will look back upon us with astonishment and horror, not otherwise than as we now look back upon the execution of old women for witchcraft in past times—a barbarity which the judges were the last to be willing to abandon, which they clung to long after it had been condemned by enlightened opinion. Indeed, there has not been, as Mr. Bright once said in the House of Commons, a single modification of the law in the direction of mercy and justice which has not been opposed by the judges!

The ground which medical men should firmly and consistently take in regard to insanity is, that it is a physical disease; that they alone are competent to decide upon its presence or absence; and that it is quite as absurd for lawyers or the general public to give their opinion on the subject in a doubtful case, as it would be for them to do so in a case of fever. For what can they know of its predisposing and exciting

tion of the law is punishment, and, if its severity is mitigated, it is not by the law, but by the suspension of the law, by authority above the law. The Law is thus entirely antagonistic to Medicine on all those questions of mental science which involve the freedom and well-being of the imbecile and the insane, and which often determine whether they shall be put to an ignominious death or not, whether they shall be deprived of their property or suffered to retain it. This antagonism is, therefore, a most serious matter to the insane, their friends and families, not less serious to judges and legislators, and of the deepest interest to both medical and legal professions. For with such opinions inculcated by the law, existing ignorances are more deeply rooted in the public mind, so that the difficulty in treating the insane by medical men, and in giving testimony in courts, is greatly increased, especially when great judges remark (influenced, no doubt, by the degrading exhibition of opposing bitterness of medical men in courts), that 'the introduction of medical opinions and theories on this subject has proceeded from the vicious principle of considering insanity a disease, whereas it is a fact to be ascertained by evidence, in like manner as any other fact, and no more is necessary than to try the question by proof of the habits, the demeanor, conversation, and acts of the alleged lunatic.'"

causes, its premonitory symptoms, its occasional sudden accession, its remissions and intermissions, its various phases of depression, excitement, or violence, its different symptoms and its probable termination? Only by careful observation of the disease can its real character be known, and its symptoms be rightly interpreted: from this firm base Medicine should refuse to be moved.

It is said sometimes, however, in vindication of the law, that it does not and cannot attempt to apportion exactly the individual responsibility, but that it looks to the great interests of society, and inflicts punishment in order to deter others from crime. The well-known writer, W. R. G., in a letter to the *Pall Mall Gazette*, has recently given forcible expression to this principle, and maintains that, if men would get a firm grasp of it, the conflicts which now occur would cease. He quotes with approbation the saying of the judge who, in sentencing a prisoner to death for sheep-stealing, said: "I do not sentence you to be hanged for stealing sheep, but I sentence you to be hanged in order that sheep may not be stolen." Here we see how entirely the writer has failed to grasp the real nature of insanity *as a disease*, for which the sufferer is not responsible, and which renders him irresponsible for what he does. Were one-half the lunatic population of the country hanged, the spectacle would have no effect upon the insane person who cannot help doing what he does. If a boy in school were wilfully to pull faces and make strange antics, the master might justly punish him, and the punishment would probably deter other boys from following his example, but it would have no deterrent effect upon the unfortunate boy whose grimaces and antics were produced against his will by chorea. The one is a proper object of punishment; the other is a sad object of compassion, whom it would be a barbarous and cruel thing to punish. To execute a madman is no punishment to him, and no warning to other madmen, but a punishment to those who see in it, to use the words of Sir E. Coke, "a miserable spectacle, both against law, and of extreme inhumanity and cruelty, and which can be no example to others."

Moreover, it is not necessary to hang a lunatic in order to protect society, or in order to punish him, for it can protect itself sufficiently well by shutting him up in an asylum; and the prospect of being confined in a lunatic asylum is not one which is likely to encourage a man to do a murder; on the contrary, it is one which excites as much horror and antipathy in the minds of both sane and insane persons as can well be imagined.

And, finally, as the law did not prevent sheep-stealing by hanging sheep-stealers, but brought itself into discredit by offending the moral sense of mankind; so, likewise, it will not, by hanging madmen, prevent insane persons from doing murder, but must inevitably bring itself into contempt by offending the moral sense of mankind. Is not this result happening now? Has Mr. Baron Martin added any thing to the strength and dignity of the Bench by his conduct in the recent trial of Christiana Edmunds? That conduct has elicited such comments from all quarters as it has not often before happened in this country to find made on the administration of justice; and, if the law has not been brought into contempt, it has received a rude shock among a law-abiding people. The uncertainty which now exists, whether a person shall be convicted as a criminal or acquitted as insane, and the accidental character of the result, cannot fail to be injurious to the welfare of society. And if the present agitation subsides, as former agitations have subsided, without any step in advance being made, the bad law is none the less certainly doomed. As we have said on a former occasion, "men will go mad, and madmen will commit crimes, and in spite of prejudice, and in spite of clamor, Science will declare the truth. Juries, too, will now and then be found enlightened enough to appreciate it: and if the voice of Justice be unsuccessfully raised, it will be but a doubtful triumph for prejudice when Science shall say, 'You have hanged a madman.'"

It will not be of much use to point out once more, what has been pointed out over and over again, that the manner in which scientific evidence is procured and taken in courts of justice is very ill-fitted to elicit the truth and to further the ends of justice. One side procures its scientific witness, and the other side procures its scientific witness, each of whom is necessarily, though it may be involuntarily, biassed in favor of the side on which he is called to give evidence—biassed by his wishes, or interests, or passions, or pretensions. It is not in human nature entirely to escape some bias under such circumstances. In due course he is called into the witness-box and examined by those who only wish to elicit just as much as will serve their purpose; he is then cross-examined by those whose aim is to elicit something that will serve their purpose; and the end of the matter seldom is "the truth, the whole truth, and nothing but the truth." Having regard to the entire ignorance of scientific matters which counsel, jury, and judge show, it may be truly said that the present system of taking scientific evidence is as bad as it well can be, and that it completely fails in what should be its object—to elicit truth and to administer justice. "The incompetency of a court, as ordinarily constituted, is," as we have formerly said, "practically recognized in a class of cases known as Admiralty cases, where the judge is assisted by assessors of competent skill and knowledge in the technical matters under consideration. Moreover, by the 15th and 16th Vict., c. 80, s. 42, the Court of Chancery, or any judge thereof, is empowered, in such way as he may think fit, to obtain the assistance of accountants, merchants, engineers, actuaries, or other scientific persons, the better to enable such court or judge to determine any matter at issue in any cause or proceeding, and to act upon the certificate of such persons." The Lords Justices seldom, if ever, decide on a question of insanity without calling for a report upon the case from one of the Medical Visitors in Lunacy. If the English law were not more careful about property than about life, it would long ago have acted upon this principle in criminal trials.

However, he who advocates a reform in the legal proceedings of this country is assuredly a voice crying in the wilderness, and with less result than the Baptist had when he cried aloud there. It is not likely that any thing we can say will induce those who have the privilege or pain of constituting our government to leave for a time the ambitious struggles of politics, and to devote their energies to a reform of the law. And yet a government could not be better employed than in laboring to effect such a reform. A system of just laws and a simple and expeditious administration of justice would assuredly conduce more to the welfare of the community than years of parliamentary squabbles about politics. Many parliamentary questions which have occupied much time and made a great show in their day will look very small, if they are ever heard of at all, in history, while the reputations that grew out of them will have been lost in oblivion; but an effectual reform of the jurisprudence of the country, which is now an urgent need, would be a lasting benefit to the community, and an eternal honor to the statesman who initiated and carried it through.—*Abstract from the Journal of Mental Science.*

CONCERNING CORPULENCE.

By W. J. YOUMANS, M. D.

MR. BANTING had defective hearing, and consulted a physician for his deafness. The doctor was William Harvey, aural surgeon to the Royal Dispensary for Diseases of the Ear, and also for the great Northern Hospital of London. Dr. Harvey told the patient that his deafness was complicated with his corpulence, for Mr. Banting was very fat. He told him that, to improve his hearing, it would be necessary to reduce his obesity, and he prescribed a diet for the purpose. This was good news for Mr. Banting; he had come to get his ears syringed for deafness, and a way was pointed out by which he could get back his hearing and get rid of his burden of adipose at the same time. He commenced the dietetic treatment, and so successful did it prove in relieving his corpulence, that he rushed into print to convey the glad tidings to all over-unctuous people. He thus became immortal as a philanthropist, and enriched our speech with a new term —*Bantingism*—which will last as long as the literature of fatness endures. Banting was, however, only a layman, after all, and his ambition was satisfied to produce a pamphlet; but now comes the doctor himself, with his regular treatise "On Corpulence in Relation to Disease." Dr. Harvey's book is an excellent summary of the subject, and has the weight of professional and scientific authority; the present article is mainly condensed from his pages:

The manner in which fat is distributed over the body is now generally understood to be by the texture of the cellular membrane. Formerly it was thought to adhere in clusters to the parts where it was found—a mistake that has been corrected by the study of minute anatomy. The cellular tissue, as its name implies, is made up of great numbers of minute cells, which communicate with each other, and which are formed by the interlacings of fine, soft, colorless, elastic threads, intermixed with delicate films or laminæ, the tissue presenting, when free from fat, a white, fleecy aspect. This tissue is found everywhere underneath the skin; the serous and mucous membranes are attached by it to subjacent parts; it lies between the muscles, and also among their fibres, surrounds the blood-vessels, and is generally distributed throughout the body. In certain situations, as around the large blood-vessels and nerves, in the omentum and mesentery, about the joints, and especially under the skin, the cells enclose what are known as *adipose vesicles*, minute spherical pouches, filled with fat or oil; and, when these are present in notable quantity, the structure takes the name of adipose tissue. As thus deposited, the fat appears merely to be held in store, as it remains quite distinct in form and situation from other parts of the animal frame. It, however, enters largely into the composition of nerve-substance, where it becomes an essential part of a highly-organized tissue.

The development of fatty tissue varies considerably at different ages, and in the two sexes. In children and in females, especially in early age, the principal seat of the fatty deposit is in the cellular tissue, immediately under the skin. During adolescence, the fat has a tendency to disappear from this situation; but, about middle age, frequently becomes again deposited, not only in the subcutaneous tissues, but also in the neighborhood of certain internal viscera. The quality of the fat also varies, both with the age and with the part in which it is deposited. It is firmer and higher colored in old persons than in young ones; and is more condensed and solid in parts liable to compression, than in the omentum, or about the heart, stomach, and intestines.

A moderate amount of fat is a sign of good health, and physiologists generally allow that it ought to form about the twentieth part of the weight of a man, and the sixteenth of a woman. Independently of its importance as a non-conducting substance in impeding the too rapid escape of animal heat, fat may also be regarded as a store of material to compensate for waste of tissue, under sickness, or other circumstances, entailing temporary abstinence from food. But when fat accumulates to the extent of interfering with important functions, and becomes a load and a drag, impeding the respiratory movements, making exercise painful, and dulling the sensibilities, it is then not only a source of great discomfort, but the precursor of positive disease.

In a perfectly healthy individual, no abnormal deposition of fat can be supposed to take place, at any age or in any locality, provided the natural appetites and muscular powers be regulated as they ought. Whenever, therefore, we see an individual unnaturally fat or lean, we may safely conclude that an error exists somewhere, and that such an individual either inherits a morbid propensity, or is producing for himself such a propensity.

The conditions which appear to favor an excessive deposit of fat are the following: First, an inherited tendency which predisposes to corpulence, yet always requiring the influence of some exciting cause to bring it into activity. No one can doubt that certain families have a natural tendency to corpulence, which can be often traced through successive generations. It is curious, also, to observe how this tendency is varied in different families, and even in different individuals of the same family. Thus, in one family, we see that the children and females possess a striking tendency to *embonpoint*, while the male adults, particularly in advanced age, are remarkable for their leanness. In another family, directly the reverse may be observed, the children and females are lean and squalid, while the middle-aged male adults are conspicuous for their corpulence.

Climate and locality seem also to exert considerable influence on the deposition of fat. The inhabitants of low, swampy situations, in temperate climates, are usually remarkable for their bulky flabbiness, and propensity to corpulence; while the inhabitants of very hot and of very cold climates, as well as the inhabitants of mountainous regions, have, perhaps, less tendency to obesity. There is this remarkable difference, however, between the dwellers in hot, and in cold climates: those living in hot climates rarely become fat, without becoming otherwise diseased; while the people of cold climates seem not only to derive protection against the influence of external cold by the layer of fat with which their bodies may be enveloped, but the carbon of the fat, combining with oxygen during the process of secondary assimilation, has with some reason been supposed to contribute to the production of animal heat.

But, of all the agencies which influence the deposition of fat, probably diet and exercise are the most important. Foods have been divided, according to their composition, into nitrogenous and non-nitrogenous. The former, including albumen, fibrine, and casein, consist of only carbon, hydrogen, oxygen, and nitrogen, with some minor ingredients; the latter, embracing starch, sugar, and the fats, are made up of only carbon, hydrogen, and oxygen. It has been thought that the nitrogenous foods are consumed chiefly in the formation of the tissues, while the non-nitrogenous are devoted mainly to the function of respiration, going principally to the maintenance of the animal temperature. Whatever basis in fact this view may have, it is pretty well established that the substances belonging to the latter class of foods are especially favorable to the production of fat, when taken into the system. This fat may exist ready formed in the food, as it is furnished abundantly by both the animal and vegetable kingdoms; or, as is held by many physiologists, it may be formed in the system by the chemical transformation of starch and sugar. Numerous experiments have been made on geese, ducks, pigs, bees, etc., which go to prove that these animals accumulate much more fat than can be accounted for by the quantity present in the food. M. Flourens had the bears in the Jardin des Plantes fed exclusively on bread, and they became excessively fat. Bees confined to a diet of purified sugar continue to produce wax, which strictly belongs to the group of fats. But, whatever its source, the excessive use of non-nitrogenous food, conjoined with inactivity, frequently leads to the deposit of an inordinate amount of oleaginous matter. This fact is illustrated by numerous instances both among the lower animals and among men. At Strasbourg, the geese are fattened by shutting them up in darkened coops within a heated room, and stuffing them constantly with food. The high temperature lessens the escape of heat, and thus favors the process. Here all the conditions for insuring obesity are resorted to—viz., external heat, obscurity, inactivity, and the cramming of the animals with fattening food. A still greater refinement for pandering to the appetite is resorted to by the Italians who relish the fat of the ortolan. To procure this in perfection the natural habits of the bird were watched, and, it having been found that it only takes food at the rising of the sun, they cheat the birds by producing an artificial sunrise. To effect this, the ortolans are placed in a dark, warm chamber which has but one aperture in the wall. Food being scattered over the floor, a lantern is placed at a certain hour in the opening, when the birds, misled by the dim light, at once commence feeding. The meal finished, the lantern is withdrawn, and more food scattered about, when the ortolans sleep. Two or three hours having elapsed, and digestion being completed, the lantern is again made to throw its light into the apartment. The rising sun recalls the birds to the habit of again feeding; and they again sleep with returning darkness. This process is repeated several times in the twenty-four hours, and in a very short time the ortolan becomes literally a ball of fat, which, strung on a wick, is said to make an excellent lamp.

It is known that farinaceous and vegetable foods are fattening, and saccharine matters are especially so. The instance of laborers in Italy, who get fat during the grape and fig season, has been frequently quoted. In sugar-growing countries, the negroes and cattle employed on the plantations grow remarkably stout while the cane is being gathered and the sugar extracted. During this harvest the saccharine juices are freely consumed, but, when the season is over, the superabundant adipose tissue is gradually lost. It is said that, among the Asiatics, there are Bramins who pride themselves on their extreme corpulency. Their diet consists of farinaceous vegetables, milk, sugar, sweetmeats, and ghee, a species of Indian butter. Dr. Fothergill remarks, that a strictly vegetable diet produces excess of fat more certainly than other means.

The use of a large amount of liquid in the diet also favors the deposit of fat. Alcoholic drinks are especially objectionable in this respect, for, according to Dr. Harvey, the elements which are chemically convertible into fat are rendered more fattening if alcoholic liquids be added to them in the stomach; perhaps, because of the power which alcoholic liquids possess of lessening or delaying destructive metamorphosis.

Inactivity, by decreasing waste in the system, acts in a negative way toward the production of obesity. In order to fatten animals, they are habitually confined, and, if the process is to be a rapid one, they are kept in the dark as a means of securing the utmost quiet. Now, indolence on the part of the human animal, associated, as it generally is, with excessive eating and drinking, and much sleep, constitutes a similar set of conditions, and is likely to lead to a similar result.

The consequences of obesity are often more serious than is generally believed. To put aside the many minor inconveniences, which, however, may be sufficiently annoying to make the sufferer desirous of reducing his weight, it may be taken as a general rule that obesity does not conduce to longevity. Usually it is accompanied with diminished vital power; there are disturbances of the organs of respiration, circulation, and digestion. The blood is proportionately deficient in quantity or quality, and the muscles are weak and have but little firmness. And, although the disposition is often sanguine, so that the sufferer continues lively and cheerful, and has the happy habit of looking at the best side of every thing, yet physical and mental occupations are generally uncongenial. There are several notable exceptions to this, however, and many can call to mind cases where both the bodily and mental habits are quite as active in the obese as in others. Maccaz gives the case of an enormously fat man, whom he met at Pavia, that was celebrated as a dancer, and whose movements were exceedingly agile and graceful. David Hume and Napoleon may be instanced as examples where corpulence was associated with great mental powers; and Raggi, an Italian physician, who was an eminent authority on corpulence, relates numerous cases of extreme obesity in which the intellect remained quite alert to the last. Nevertheless, the rule holds good that extreme fatness is very much in the way of either bodily or mental work.

By an over-development of adipose tissue the capillary system of blood-vessels is vastly increased in aggregate bulk, while at the same time no corresponding increase takes place in the forces which supply the means of action to those capillaries. Hence there is a comparative weakness in the conservative vital processes, and any injury to a part, especially if remotely situated, is less easily repaired.

The senses of hearing, taste, and smell, are frequently much impaired in corpulent people, a condition due in the majority of cases, according to Dr. Harvey, to deposits of fat in the organs concerned. The nasal passages, mouth, and throat, are, as all know, lined with mucous membrane, which continues through the Eustachian tubes into the middle ear. This mucous membrane may become the seat of a fatty deposit, and thus impair the function of the part. The sense of smell depends upon the contact of odorous emanations with the sensitive olfactory membrane, and such contact can only take place when there is a free passage for them through the nose. If the nasal membranes become thickened from any cause, thus partially or wholly preventing the passage of air, the capacity of smell is correspondingly affected. The sense of taste, which, to according many physiologists, is properly limited to the perception of the acid, bitter, sweet, or saline properties of food, does not appear to suffer; but the power to recognize and enjoy flavors, which is commonly associated with taste, but which in reality belongs to the nose, is sometimes lost along with the sense of smell. Access of air to the middle ear through the Eustachian tubes is an essential to the sense of hearing, and this, too, is greatly interfered with oftentimes by the fatty thickening of the mucous membrane of the nose and throat. At all events, whatever the nature of the cause, it has resulted, in great numbers of cases where corpulence was attended by these defects of sense, that removal of the deposit by a proper dietary has been immediately followed by recovery, after all sorts of local remedies had failed to afford relief.

Dr. Harvey thinks that both gout and rheumatism are aggravated by corpulence. Another troublesome attendant is a tendency to the formation of gravel and calculus. In regard to this, Dr. Harvey states that, after the usual remedies prescribed for its relief have completely failed, he has seen a well-directed dietary, designed with a view to restraining the formation of adipose, completely successful in finally preventing these distressing formations.

Although obesity may be ranked among the diseases arising from original imperfection in the functions of some of the organs, it is also, without doubt, most intimately connected with our habits of life. The inconveniences arising from it are, therefore, to be removed by correcting those habits, especially such as relate to diet and regimen. Drugs without number have been tried, both for the removal of corpulence itself, and for the many troubles to which it gives rise; but they have almost uniformly failed when diet and exercise have been neglected. On the other hand, attention to these points, persistently carried out, has been as uniformly followed by improvement without the aid of medicine. It is a true maxim in physic that diseases which are long in their advancement are, as a rule, only to be remedied by long-continued curative attention. Common-sense proves the fallacy of expecting to eradicate old-established errors of the body by any sudden remedies; the diet and medical regimen of such persons should therefore be undeviatingly suited to their disordered tendencies, and resolutely maintained as long as they afford any hope of relief.

We have seen that certain foods, such as the fats themselves, and others that consist principally of starch or sugar, favor the development of corpulence; and it will be observed that in the following dietary designed by Dr. Harvey, and prescribed by him in the famous case of Banting, foods of this class are reduced to a minimum, though not altogether interdicted, the nitrogenous foods being correspondingly increased.

Breakfast.—Four to six ounces of meat, two ounces of biscuit or toast, and a large cup of tea, but without milk or sugar.

Dinner.—Ten to twelve ounces of any fish except salmon; any vegetable except potatoes and vegetable roots; any kind of poultry or venison, and two ounces of toasted bread. With it drink two or three glasses of good red wine, sherry or madeira, avoiding champagne, port, or beer.

In the afternoon, four to six ounces of fruit, one or two biscuits, and again a large cup of tea without milk or sugar.

Supper.—Six to eight ounces of meat or fish, and one or two glasses of red wine.

Dr. Harvey remarks: "When once the body has reached its full development in manhood, the quantity and quality of the food should be regulated by the demand made by the wear and tear of the system. If, for instance, a person, already sufficiently stout, is growing fatter and fatter, he is taking more fattening food than is necessary or safe, and must restrict himself if he would restore the balance of the functions."

THE STUDY OF PHYSICAL SCIENCE.

A LECTURE TO YOUNG MEN.

By Rev. CHARLES KINGSLEY.

SOME of you may ask, and you have a perfect right to ask, why I, a clergyman, have chosen this subject for my lecture? Why do I wish to teach young men physical science? What good will the right understanding of astronomy or of chemistry, or of the stones under their feet, or of the plants or animals which they meet—What good, I say, will that do them?

In the first place, they need, I presume, occupation after their hours of work; and to give that this class was established. If any of them answer, "We do not want occupation, we want amusement. Work is very dull, and we want something which will excite our fancy, imagination, sense of humor. We want poetry, fiction, even a good laugh or a game of play"—I shall most fully agree with them. There is often no better medicine for a hard-worked body and mind than a good laugh; and the man that can play most heartily when he has a chance is generally the man who can work most heartily when he must work. But there is certainly nothing in the study of physical science to interfere with genial hilarity. Indeed, some solemn persons have been wont to reprove the members of the British Association, and specially that Red Lion Club, where all the philosophers are expected to lash their tails and roar, of being somewhat too fond of mere and sheer fun, after the abstruse papers of the day are read and discussed. And as for harmless amusement, and still more for the free exercise of the fancy and the imagination, I know few studies to compare with Natural History; with the search for the most beautiful and curious productions of Nature amid her loveliest scenery, and in her freshest atmosphere. I have known again and again working-men who in the midst of smoky cities have kept their bodies, their minds, and their hearts healthy and pure by going out into the country at odd hours, and making collections of plants, insects, birds, or some other objects of natural history; and I doubt not that such will be the case with some of you.

Another argument, and a very strong one, in favor of studying some branch of physical science just now is this—that without it you can hardly keep pace with the thought of the world around you.

Over and above the solid gain of a scientific habit of mind, of which I shall speak presently, the gain of mere facts, the increased knowledge of this planet on which we live, is very valuable just now; valuable certainly to all who do not wish their children and their younger brothers to know more about the universe than they do.

Natural science is now occupying a more and more important place in education. Oxford, Cambridge, the London University, the public schools one after another, are taking up the subject in earnest; so are the middle-class schools; so, I trust, will all primary schools throughout the country; and I hope that my children, at least, if not I myself, will see the day, when ignorance of the primary laws and facts of science will be looked on as a defect, only second to ignorance of the primary laws of religion and morality.

I speak strongly, but deliberately. It does seem to me strange, to use the mildest word, that people whose destiny it is to live, even for a few short years, on this planet which we call the earth, and who do not at all intend to live on it as hermits, shutting themseves up in cells, and looking on death as an escape and a deliverance, but intend to live as comfortably and wholesomely as they can, they and their children after them—it seems strange, I say, that such people should in general be so careless about the constitution of this same planet, and of the laws and facts on which depend, not merely their comfort and their wealth, but their health and their very lives, and the health and the lives of their children and descendants.

I know some will say, at least to themselves, "What need for us to study science? There are plenty to do that already; and we shall be sure sooner or later to profit by their discoveries; and meanwhile it is not science which is needed to make mankind thrive, but simple common-sense."

I should reply that, to expect to profit by other men's discoveries when you do not pay for them—to let others labor in the hope of entering into their labors, is not a very noble or generous state of mind—comparable somewhat, I should say, to that of the fatting ox, who willingly allows the farmer to house him, till for him, feed for him, provided only he himself may lounge in his stall, and eat, and *not* be thankful. There is one difference in the two cases, but only one—that while the farmer can repay himself by eating the ox, the scientific man cannot repay himself by eating you; and so never gets paid, in most cases, at all.

But as for mankind thriving by common-sense: they have not thriven by common-sense, because they have not used their common-sense according to that regulated method which is called science. In no age, in no country, as yet, have the majority of mankind been guided, I will not say by the love of God, and by the fear of God, but not even by sense and reason. Not sense and reason, but nonsense and unreason—prejudice and fancy—greed and haste—have led them to such results as were to be expected—to superstitions, persecutions, wars, famines, pestilence, hereditary disease, poverty, waste—waste incalculable, and now too often irremediable—waste of life, of labor, of capital, of raw material, of soil, of manure, of every bounty which God has bestowed on man, till, as in the eastern Mediterranean, whole countries, some of the finest in the world, seem ruined forever: and all because men will not learn nor obey those physical laws of the universe which (whether we be conscious of them or not) are all around us, like walls of iron and of adamant—say rather, like some vast machine, ruthless though beneficent, among the wheels of which, if we entangle ourselves in our rash ignorance, they will not stop to set us free, but crush us, as they have crushed whole nations and whole races ere now to powder. Very terrible, though very calm, is outraged Nature:

> "Though the mills of God grind
> Slowly, yet they grind exceeding small.
> Though He sit, and wait with patience,
> With exactness grinds He all."

It is, I believe, one of the most hopeful among the many hopeful signs of the times, that the civilized nations of Europe and America are awakening, slowly but surely, to this truth. The civilized world is learning, thank God, more and more of the importance of physical science; year by year, thank God, it is learning to live more and more according to the laws of physical science, which are, as the great Lord Bacon said of old, none other than "Vox Dei in rebus revelata"—the voice of God vevealed in facts; and it is gaining, by so doing, year by year, more and more of health and wealth; of peaceful and comfortable, even of graceful and elevating, means of life for fresh millions.

If you want to know what the study of physical science has done for man, look, as a single instance, at the science of sanitary reform; the science which does not merely go to cure disease, and shut the stable-door after the horse is stolen, but tries to prevent disease; and, thank God, is succeeding beyond our highest expectations. Or look at the actual fresh amount of employment, of subsistence, which science has, during the last century, given to men, and judge for yourselves whether the study of it be not one worthy of those who wish to help themselves, and, in so doing, to help their fellow-men. Let me quote to you a passage from an essay urging the institution of schools of physical science for artisans, which says all which I wish to say and more:

"The discoveries of voltaic electricity, electro-magnetism, and magnetic electricity, by Volta, Oersted, and Faraday, led to the invention of electric telegraphy by Wheatstone and others, and to the great manufacturers of telegraph-cables and telegraph-wire, and of the materials required for them. The value of the cargo of the Great Eastern alone in the present Bombay telegraph expedition is calculated at three million pounds sterling. It also led to the employment of thousands of operators to transmit the telegraphic messages, and to a great increase of our commerce in nearly all its branches by the more rapid means of communication. The discovery of voltaic electricity further led to the invention of electro-plating, and to the employment of a large number of persons in that business. The numerous experimental researches on specific heat, latent heat, the tension of vapors, the properties of water, the mechanical effect of heat, etc., resulted in the development of steam-engines and railways, and the almost endless employments depending upon their construction and use. About a quarter of a million of persons are employed on railways alone in Great Britain. The various original investigations on the chemical effects of light led to the invention of photography, and have given employment to thousands of persons who practise that process, or manufacture and prepare the various material and articles required in it. The discovery of chlorine by Scheele led to the invention of the modern processes of bleaching, and to various improvements in the dyeing of the textile fabrics, and has given employment to a very large number of our Lancashire operatives. The discovery of chlorine has also contributed to the employment of thousands of printers, by enabling Esparto grass to be bleached and formed into paper for the use of our daily press. The numerous experimental investigations in relation to coal-gas have been the means of extending the use of that substance, and of increasing the employment of workmen and others connected with its manufacture. The discovery of the alkaline metals by Davy, of cyanide of potassium, of nickel, phosphorus, the common acids, and a multitude of other substances, has led to the employment of a whole army of workmen in the conversion of those substances into articles of utility. The foregoing examples might be greatly enlarged upon, and a great many others might be selected from the sciences of physics and chemistry: but those mentioned will suffice. There is not a force of Nature, nor scarcely a material substance that we employ, which has not been the subject of several, and in some cases of numerous, original experimental researches, many of which have resulted, in a greater or less degree, in increasing the employment for workmen and others."—(*Nature*, No. 25.)

Suppose that any one of you, learning a little sound natural history, should observe nothing but the hedgerow-plants, he would find that there is much more to be seen in those mere hedgerow-plants than he fancies now. The microscope will reveal to him in the tissues of any wood, of any seed, wonders which will first amuse him, then puzzle him, and at last (I hope) awe him, as he perceives that smallness of size interferes in no way with perfection of development, and that "Nature," as has been well said, "is greatest in that which is least." And more. Suppose that he went further still. Suppose that he extended his researches somewhat to those minuter vegetable forms, the mosses, fungi, lichens. Suppose that he went a little further still, and tried what the microscope would show him in any stagnant pool, whether fresh water or salt, of Desmidiæ, Diatoms, and all those wondrous atomies which seem as yet to defy our classification into plants or animals. Suppose he learned something of this, but nothing of aught else. Would he have gained no solid wisdom? He would be a stupider man than I have a right to believe any of you to be, if he had not gained thereby somewhat of the most valuable of treasures, namely, that scientific habit of mind which (as has been well said) is only common-sense well regulated, the art of seeing; the art of knowing what he sees; the art of comparing, of perceiving true likenesses and true differences, and so of classifying and arranging what he sees; the art of connecting facts together in his own mind, in chains of cause and effect; and that accurately, patiently, calmly, without prejudice, vanity, or temper. Accuracy, patience, freedom from prejudice, carelessness for all except the truth, whatever the truth may be—are not these virtues which it is worth any trouble to gain? Virtues, not merely of the intellect, but of the character; which, once gained, a man can apply to all subjects, and employ for the acquisition of all solid knowledge. And I know no study whatsoever more able to help a man to acquire that inductive habit of mind than natural history.

True, it may be acquired otherwise. The study of languages, for instance, when properly pursued, helps specially to form it, because words are facts, and the modern science of philology, which deals with them, has become now a thoroughly inductive, and therefore a trustworthy and a teaching science. But without that scientific temper of mind which judges calmly of facts, no good or lasting work will be done, whether in physical science, in social science, in politics, in philosophy, in philology, or in history.

Now, if this scientific habit of mind can be gained by other studies, why should I, as a clergyman, interest myself specially in the spread of physical science? Am I not going out of my proper sphere to meddle with secular matters? Am I not, indeed, going into a sphere out of which I had better keep myself, and all over whom I may have influence? For is not science antagonistic to religion? and, if so, what has a clergyman to do, save to warn the young against it, instead of attracting them toward it?

First, as to meddling with secular matters. I grudge that epithet of secular to any matter whatsoever. But I do more; I deny it to any thing which God has made, even to the tiniest of insects, the most insignificant atom of dust. To those who believe in God, and try to see all things in God, the most minute natural phenomenon cannot be secular. It must be divine; I say, deliberately, divine; and I can use no less lofty word. The grain of dust is a thought of God; God's power made it; God's wisdom gave it whatsoever properties or qualities it may possess. God's providence has put it in the place where it is now, and has ordained that it should be in that place at that moment, by a train of causes and effects which reaches back to the very creation of the universe. The grain of dust can no more go from God's presence, or flee from God's Spirit, than you or I can do. If it go up to the physical heaven, and float (as it actually often does) far above the clouds, in those higher strata of the atmosphere which the aëronaut has never visited, whither the Alpine snow-peaks do not rise, even there it will be obeying physical laws which we hastily term laws of Nature, but which are really the laws of God; and if it go down into the physical abyss; if it be buried fathoms, miles, below the surface, and become an atom of some rock still in the process of consolidation, has it escaped from God, even in the bowels of the earth? Is it not there still obeying physical laws, of pressure, heat, crystallization, and so forth, which are laws of God—the will and mind of God concerning particles of matter? Only look at all created things in this light—look at them as what they are, the expressions of God's mind and will concerning this universe in which we live—"the voice of God," as Bacon says, "revealed in facts"—and then you will not fear physical science, for you will be sure that, the more you know of physical science, the more you will know of the works and of the will of God. At least, you will be in harmony with the teaching of the Psalmist. "The heavens," says he, "declare the glory of God; and the firmament showeth his handiwork. There is neither speech nor language where their voices are not heard among them." So held the Psalmist concerning astronomy, the knowledge of the heavenly bodies; and what he says of sun and stars is true likewise of the flowers around our feet, of which the greatest Christian poet of modern times has said—

> "To me the meanest flower that grows may give
> Thoughts that do lie too deep for tears."

Abstract from Good Words.

SIGHT AND THE VISUAL ORGAN,

By Dr. A. VON GRAEFE,

LATE PROFESSOR OF THE UNIVERSITY OF BERLIN.

BE the idea what it may, that we form to ourselves of the mysterious tie that links our *perception to the life of the soul*, so much is undoubted, that the material supplied by the impressions of the senses constitutes the basis on which the soul unfolds; further, that they furnish the nutriment on which our thoughts and conceptions live and grow, and that through them alone is preserved the connection between the invisible "I" and the external world—the soil in which all conscious intellectual activity strikes root.

The child does not come into the world *fitted out* with elementary notions, as the idealists have taught, but endowed with the capacity for *acquiring* these ideas. These impressions, coming to it through the senses, furnish the "intellectual fuel" for the first psychical processes. And, obviously for this embryo stage of mental life, the association of the senses of seeing and feeling is of peculiar importance. The richer the world of sensuous impressions is, and the more manifold the relations of sense to sense are, so all the more numerous and varied are our inductions from them. By means of a process of collecting and comparing, compound ideas are evolved out of simple ones, and the normal, logically organized mental life attains an ever-higher development, while, by the inexhaustible activity of the senses, it receives a never-failing supply of fresh material for the perfecting of its psychical structure.

The senses are indeed the gates to the mind, through which aliment passes for its sustenance; but equally, they are the portals through which science must endeavor to penetrate into the mental world. This has often been attempted, though in another manner, as by laying down postulates on the nature of the soul. But, since the beginning of the world, this manner of committing our thoughts to the guidance of metaphysical hypotheses has never increased our knowledge even by a hair's breadth.

Fortunately, the majority of thinkers have now struck into the more promising paths of observation and analysis. Essential and most important progress has been made in the knowledge of the human body, since men have ceased to indulge in subtle speculation into the nature of the principle of life, and turned with an undivided spirit of inquiry into the laws of organic appearances. And since men have applied themselves to trace with care the psychical manifestations of perception into the world of ideas, and to do the utmost in their power to discover the laws which there govern, there has arisen another science, forcing itself more and more on our notice as it daily proves itself to be possessed of an inherent vitality. I refer to the science of *psychology*.

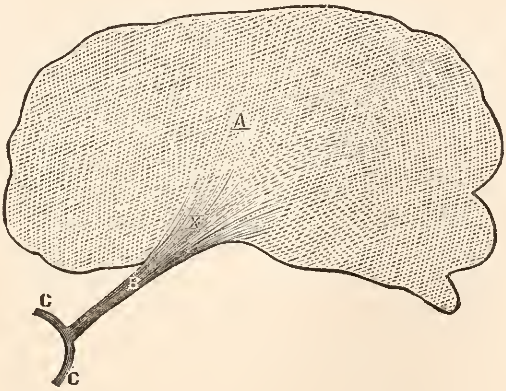
Such being our starting-point, the operations of the perceptions acquire a wider significance. Resting on this increased significance, I now venture to bring before you the structure and functions of that organ which, from the enormous amount of material it is the means of bringing to the mind, takes a prominent place in the part assigned to the operation of the senses. If I succeed in heightening a little your interest in this organ, or even only in reanimating in some of you the sentiment of happiness which must fill every grateful child of the Creator, when, on awaking in the morning, he joyfully greets the light of day, I shall have earned a rich reward for a trifling exertion.

Suppose, as shown in Fig. 1, that the brain which reposes in the cavity of the cranium, and is the bodily organ of consciousness, runs off, at one spot of its complicated structure, into a *cord-like process*, which lengthens till it reaches the surface of our body, when it then spreads out again in an umbellar form. Imagine, further, this whole process, including its roots, endowed with a specific sensitiveness, by virtue of which it responds with a *luminous sensation* to every irritation applied, and you have a fundamental idea of the *nervous* part of the visual organ.

Before proceeding further, let us first become better acquainted with these parts. A, indicates the brain; B, the aforesaid process, or in other words the *optic nerve*, which, passing through an aperture in the cranium, stretches on till it reaches into the orbit, where it spreads out into that expanse C, which, under the well-known term of *retina*, turns its surface to the outer world. Lastly, X is the point where the process is inserted in the brain, the letter X meaning to indicate the still unknown extent of its connections.

When I said, above, that every point of the whole mechanism, on being irritated, produced a luminous sensation, I meant that the irritation was conducted to the brain, and called forth this sensation in that sole source of conscious impressions. It is the same irritation coming in contact with the organ of consciousness, which we observe in the nerves of touch, with this difference that, in the above case, the *quality* of feeling differs; it is *luminous* or *colored.* The mere producing of this sensation of the luminous does not in any way depend on the *nature of the irritation.* Squeezing, pinching, pulling, chemical or electric irritations which give rise to the sensations of warmth or pain in a nerve of touch, call forth in the optic apparatus, by virtue of its specific sensitiveness, only a feeling of light, accompanied by neither pain nor heat.

FIG. 1.



A, Brain; B, Visual Nerve; C, Retina; X, Root of the Optic or Visual Nerve.

You ask how men have arrived at the knowledge of these things, seeing the mechanism in question is almost entirely removed from any direct investigation. First, then, the umbellar expansion of the optic nerve, the retina, enables us to make experiments; this retina being in such close contact with the eye, the optical part of the visual organ, that it is accessible to every sort of mechanical irritation. You have yourselves, consciously or unconsciously, often made such experiments, when you watched the circles and sparks of fire and light, which become visible on rubbing or pressing your eyes through their lids, or striking them with a hard substance. Here the eye, as an optical apparatus, remains passive. Just as a man, who sees, is aware of the phenomena even in the deepest darkness, so is also a blind man, as long as the retina is endowed with its specific sensitiveness or sensory power, by which it responds to every irritation with a luminous sensation. Even after blindness, this dancing of sparks of fire and light may be kept up by continual irritation in the eye to such a tormenting extent, that, in order to prevent it, we usually cut the optic nerve just behind the eye, when the sparkling and scintillating cease.

Although less directly, the optic nerve, as well as the retina, is accessible to our observation. Hence we ascribe certain scintillations, visible to us in a rapid motion of the eye, to a twist of the nerve: surgical operations, dating from a period when narcotics were not employed, have likewise shown that contact with this nervous cord produces only sensations of light, not those of pain.

Lastly, we can point out the seat of the root, or the central termination of the optic nerve, by anatomically tracing the fibrils of the visual nerve into this tract; and partly, too, by an analysis of the phenomena observable in healthy and diseased states. When the brain has been excited by a narcotic, and the irritation is transmitted to the aforesaid tract, there arise sensations of light, which, combining with ideas of luminous objects, simultaneously excited, are transformed into what we call phantasms. The same thing takes place when the blood, as in fever, heats the brain; or when that part of the organ is excited from other causes. And thus it is with our visual impressions during dreams, or even in a half-waking condition.

But all this does not constitute any relation between sensation and the objects of the external world; that is, proper *sensory action*, whether it be the gay visions that surround us in the intoxication caused by opium; the comic phantasmagoria that hashish conjures up; the compact shapes that belladonna brings so near us; the airy forms seen in our dreams, or the scintillations produced by pressure, they all proceed from irritation of the special sensory power, and it is indifferent to the brain whether it receives its impressions from direct vision, or only from internal influences. All those operations, therefore, which proceed from direct irritation of the nervous part of the visual organ, *without the medium of the eye and of light*, under the term *subjective vision*, are opposed to those phenomena produced by the media of eye and light, and known as *objective vision*.

Great as are the influences of this subjective sight for the refreshment of our brain during sleep, and powerfully as they affect the temperament of the blind, they cannot connect us with the outer world. The yellow light which floods our field of vision, on rubbing the retina, is of no use to light up external objects. Hence, when, some years ago, a man pretended to recognize a delinquent who had attacked him in the night, by the sparks of fire produced by a blow on his eye, and founded an accusation thereon, it was, of course, unjustifiable, although the authorities consulted did not declare against the impossibility of the fact.—Baron Münchausen went still further in the use to which he put those visual sparks; for, when attacked by bears in the night, he not only struck out light enough by which to prosecute the chase, but fire, too, for his guns with the same blow.

We cannot entirely overlook the question whether sensations of light can be produced with the assistance of any other mechanism in the body but that of the visual nerve. As only the part where sensa tion originates is endowed with specific sensory action, so the irritation of that part can alone produce impressions of vision; but this irritation may be imparted to it by other parts of the brain, or by other nerves. It has been already stated that irritations of the brain produced by narcotics are transmitted only by proximity to the terminal extremity of the optic nerve. At the same time, it may be that the irritation proceeds from another nerve, from a nerve of touch or of hearing, and, penetrating to the brain, affects it so strongly as to send on the concussion to the optic centre. It is this that takes place when, after having listened to disagreeable sounds, you are seized with certain sensations in the nerves of touch, for instance, in those of the teeth; or, heving gazed into the bright light, you become aware of a tickling sensation in the nose, causing you to sneeze. In a word, it is here a question of so-called *sympathy*, to be explained by transmission of the irritation from one nerve to the other.

The disposition to such sympathetic sensation is increased by a general irritability of the nervous system; while, in a calmer state of the nerves, the excitations run more regularly in the paths directly affected by the originating causes. In this manner, those indirectly-provoked visual impressions which preponderate in circumstances of sickness and disease are augmented.

In these indirect visual sensations, as in the direct excitation of the mechanism of the visual nerve, only subjective sight has been treated of, cut off from from every relation with the outer world. We are quite ready to attach credit to the fact that, at exhibitions of somnambulism, when the natural irritability of nervously-disposed individuals is heightened, subjective visual impressions are produced in an unusual degree. Should, however, any connection with surrounding objects be founded on these results, or any transmission of the specific sensory action into other parts, as, for instance, transmitting to the skin of the abdomen the power of producing objective visual perceptions, such as are necessary for reading, these assurances are to be ranged in the same category of physiological blunders as the Münchausen hunting-story.

By what means, then, does the mechanism of the visual nerve, which we have hitherto regarded merely as the instrument of subjective sight, become a practical bridge between our ideas and the outer world, and a medium of the true and accredited *operation of the senses?* I answer, by a normal relation to a definite irritation proceeding from an object. This, which we might call the *adequate sensory irritation*, is *light*.

Let us consider the general relation between light and the organ of sight. Unable to discover with certainty the nature of light, it is explained in physics as being the undulating motion of an elastic body called ether, diffused throughout the universe. According to this, the irritation by light represents the shock of the undulations of ether on the irritable nervous matter, and at once takes its place among the mechanical excitations mentioned above when speaking of subjective sight.

The cord of the optic nerve is insensible to the undulations of the ether; the peripheral expansion of the retina is alone susceptible of irritation by light. This peculiarity has to do with the arrangement called the *terminal apparatus*, with which it is now proved every nerve is furnished. The *nervous cords* themselves are preëminently conductors; their irritation, when it does take place, necessarily produces impressions which come under the head of qualitative, for the eye, therefore, of the quality of luminous sensations; those impressions do not, however, stand in any closer relation to the adequate sensory irritation, and may be, as far as we are concerned, quite devoid of sensitiveness.

According to physics, light is the same species of motion in the ether as warmth; only, in order to affect the retina, the undulations must take place within certain limits of rapidity. Relatively they possess the greatest velocity in the violet-colored part of the spectrum, and the least in the red. In the same proportion as the velocity of the undulations diminishes, does light become invisible, and only dark rays of warmth are emitted, while on its being more highly heated, from the increased rapidity of the undulations, it reaches the glowing-point, that is, it emits rays of red light.

From this we see that the idea of light depends essentially on the organization of the retina. Were it different from what it is, did it possess any susceptibility for ethereal vibrations of a less degree of velocity than those at the red end of the spectrum, then we should call *that* light which we now term a dark warmth.

In certain cases of natural color-blindness, the susceptibility of irritation in the retina is quite undeveloped for the extremest red of the spectrum.

Now, while the light coming from external objects irritates the retina variously according to its color and power, the impressions made by luminous objects are also very various, and herein lies the first link of connection with the outer world.

It is only the visual organs of the lower animals which lose themselves in such a general and vague relation to the surrounding ocean of light and color. The organ which now occupies our attention has a far higher design to serve, viz., to awaken a perception of separate objects, and of their peculiar forms and colors. Were the retina as you see it in Fig. 1, a surface curving outward, then such a design could not be fulfilled; for every part would receive light from all the points of the outside world. In order to fulfil this condition, every individual point of the retina must enter into a separate and individual relation with the light proceeding from a point beyond it; nor till this takes place can the irritation of each separate spot of the retina produce a peculiar impression corresponding to the presence of the object-point; in short, according to the optical expression for such a relation, *a picture of the outside world* must be painted on the retina.

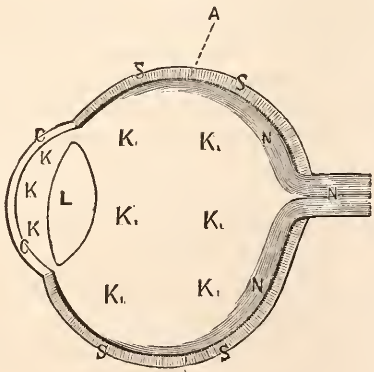
And this is indeed what takes place. As, on the one hand, the retina stands as the terminal apparatus of the optic nerve; on the other hand, it acts as a shade subservient to optical purposes; a screen, on which a perspective picture of the outside world is projected. If you compare it with the dull glass on which the picture in the *camera-obscura* falls, or the prepared plate in the photographer's camera, you have a correct notion of what I mean. As, in the photographer's camera, the picture falls on the sensitive plate, and is impressed on it by means of chemical changes produced by light, so in the eye it falls on the sensitive plate of the retina, whose irritations are telegraphed to the brain in due form.

We henceforth have to consider this *image painted on the retina* as the real object of the *operations of the senses.*

But how does the picture imprint itself on the retina? This is done by an optical apparatus close behind the retina and in connection with it; and, in short, by means of that mechanism known to us as the *eye.*

If we compare the retina with the sensitive plate in a camera-obscura, we shall perceive that the eye has indeed an undeniable resemblance with this well-known optical instrument, the camera-obscura.

Fig. 2.



S, Sclerotic; C, Cornea; L, Crystalline Lens; K, Aqueous Humor; K′, Vitreous Humor; A, Choroid; N, Optic Nerve and Retina.

This is essentially a box painted black in the inside, with an opening fitted with a collective lens, turned on the objects of the outside world, and which receives the images produced by this lens on the wall behind. In order to show us the image, the one side of the box is replaced by a dim plate of glass. Now cast a glance at Fig. 2; and first suppose the box to be round; next, instead of the wooden wall, an organic tissue; and the window glazed with a transparent organic coat or tunic, instead of with a crystal lens, and which fulfills the same purpose as a collective lens, and strengthened by one or more lenses placed one behind the other. Further, suppose, instead of the blackened inside of the walls of the box, the organic sclerotic coat overlaid from the inside by a second dark-colored tissue; and, lastly, the retina at the farther end as sensitive plate, and you have certainly an imperfect, but still, as far as an outline goes, a good general idea of the chief parts of the eye.

To the clearer understanding of these parts, the figure is provided with letters.

The tissue marked at the different sections with an S, is the enveloping tissue called the *sclerotic* or sclerotic coat.

To the front, overlapped by the above, lies the transparent tissue, the *cornea*, C, which represents the window, and at the same time contributes essentially to collecting the rays of light. At the back enters the optic nerve, which, spreading out to right and left within the sclerotic, receives the name retina, likewise marked with an N.

The chief business of the *lens*, L, lying well back, and rendered perfect by the humors (K, aqueous, K′, vitreous), which fill the spaces or chambers, is the refraction of the rays, whose admission has already been prepared by the cornea.

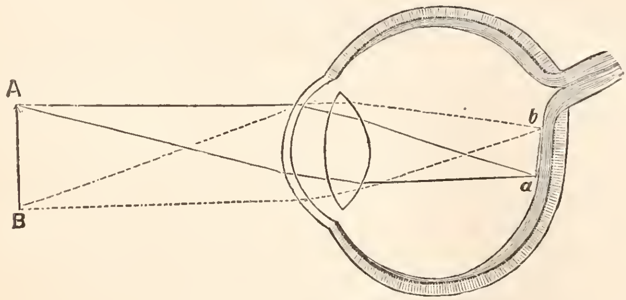
And, lastly, overlying the interior surface of the sclerotic, is the *choroid* with its pigment, being the substitute for the black paint in the camera. You find it marked with an A.

Now, if this eye with its cornea, like a camera-obscura with its window, is turned on the objects of the outer world, we shall behold what Fig. 3 shows us: The light proceeding from a point A, beyond the eye, throws a pencil of rays on the cornea; this is already refracted here and there on the surface of the lens, but in a manner so as to collect all its rays again in the one point *a* of the retina. This *a*, then, is the image-point of the object-point A. In the same manner, *b* becomes the image-point of the object-point B, and all the object-points between A and B will find their image-points on the retina between *a* and *b*. In a word, an *inverted perspective* image of all the objects comprehended in the space A B will be found reflected on the retina.

Let us now examine a little more closely the structure of the eye, together with the object it is designed to serve, taking the separate parts in the direction from without inward.

The *sclerotic*, a stout and not very elastic coat, wants no further description. On the other hand, however, the *cornea*, as the transparent window, deserves your whole attention. In the construction of the cornea Nature has had to overcome exceptional difficulties. If you remember how apt every organic body exposed to the air is to fall a prey to desiccation, under the influence of which the optical homogeneousness, on which transparency depends, is lost, you will readily acknowledge the amount of resistance the cornea is enabled to offer. But further, consider that the cornea does not possess a homogeneous structure, but consists of five different, partly compound layers; that it hides in its interior numerous cellular bodies, canals for the passage of the humors, and a net-work of nerves—and then assuredly you will not refuse your admiration to the optical excellence of this most indispensable of all windows.

FIG. 3.



A B, Object of Sight; *a b*, Image on the Retina.

However, the difficult task implied in the structure of the cornea could not be fulfilled without the aid of some extraneous appliances. Thus, two movable covers lie over the eye, namely, the *eyelids*, whose inner surface is a compound *humorous matter*,[1] a brackish, mucilaginous, fatty solution. After having used our eye for a while, there arises a certain sensation of dryness on the cornea, from exposure to the air; the ever-recurring necessity of renewing the moistness causes us to close the lids, or, as we say, to *wink*. This is at least the chief design of the dropping of the lids, which besides lend their aid to the periodical exclusion of the irritation of the sight, as in sleep, for defence against the dazzling light, and for protection against the impurities in the atmosphere. The cornea is likewise being continually moistened by the posterior humors. But, with all the expedients and appliances used by Nature, perfect transparency cannot be always preserved: dull spots are formed on the window of the cornea, often causing derangement of vision. Unimportant irritations, which on the surface of the body are not noticed, seriously affect the cornea.

Let us now notice the second coat, the *choroid*. This we compared to the black coating of paint in the camera-obscura. Thinking of the dazzling and delusive visions which are a consequence of the gradual consuming away of the pigment in the choroid, or which accompany the entire want of it, as with the albinos, we cannot doubt that one

[1] This matter receives the name of *mixed tears*, contrary to the *briny tears*, which, by mechanic irritation or during weeping, flow from the eye.

essential design of this tissue is to intercept the scattered rays. But, apart from its office of conducting nourishment to the eye, and secreting the humors by means of its numerous blood-vessels, the choroid has a *second optical* design to fulfil, which now brings us to the characteristic signs of the eye.

As you will perceive from Fig. 4, which gives a section of an eye from life, the choroid, after having accompanied the sclerotic to the edge of the cornea, goes on expanding anteriorly, and from henceforth bears another name, that of the *iris*, or, as we might say, the *rainbow tissue.* As this process, which likewise contains a quantity of pigment, lies behind the transparent cornea, it can be observed in all its minutiæ; and, on account of the rayed arrangement adopted by its fibres, it is frequently called the eyeball, or star. The iris is broken in the centre by an opening to which we apply the term *pupil*, being the *visual aperture.* It usually seems to be black.

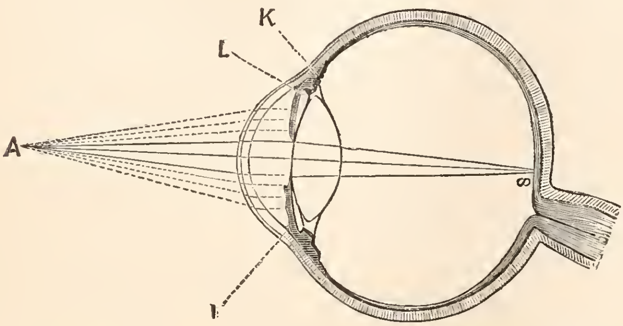
The presence of the iris greatly diminishes the extent of surface designed for the reception of light; the whole pencil of rays that falls on the cornea, as supposed, in Fig. 3, not reaching the retina, but only as shown in Fig. 4, on that section of it which enters the pupil. Though much of the volume of light is thereby lost, the restriction is highly beneficial, by sharpening the image on the retina; for the refraction of the rays is much more equal in the centre than toward the margin.

The iris, however, has a still more important function to perform. It *regulates the entrance of the light*, being furnished with a muscular apparatus (ciliary muscle), which provides that in strong light the pupil contracts, and in duller light expands. Thus the iris plays the part of a so-called movable diaphragm, a common appliance in optical instruments, used to dull the light for the purpose of seeing better. You cannot but have observed this play of the pupil, and how it accommodates itself to the volume of light; nor can you be ignorant that the iris with its varied coloring from light blue to deepest brown is what we know as the color of the eye. It is perhaps less well known to you, however, that the peculiar pigment required for the darker colors of the iris comes only as we advance in life, and that, therefore, we all commence our earthly course with blue eyes; a fact already known to Aristotle.

The *crystalline lens*, which is held fast in its place by a very fine tissue, as shown in Fig. 4, from the curve of its surface, and its strong power of refraction, plays an important part by conducting the collected light to the picture on the retina. It has, however, another and extremely important design, which must here be carefully considered.

The requirements made on an optical instrument depending on lenticular effect, are different according as it is expected to project images of nearer or more distant objects. The light with very divergent rays, and proceeding from near objects, is collected to a picture behind the lens, while that of the distant objects falls with almost parallel lines. To return to the camera-obscura, you must draw out the tube with the lens, in other words, remove the latter farther from the intercepting plate if nearer objects are to be impressed, and on the other, push it in, if more distant ones are wanted. The same effects might be produced at equally the same distance by simply substituting lenses of different power. Now, the human eye has to fulfil the requirement of projecting clearly-defined images on the retina, whether they are but a few inches off, or at an immeasurable distance. The eye being strictly subject to lenticular laws, either the space between the lens and the retina must have the power of varying, or the lens itself, by a change of form, must exercise now a stronger now a weaker power of refraction.

FIG. 4.



The same parts as in Fig. 2, besides: I, Iris; K, Ciliary Muscle; L, Suspensory Ligament of the lens (zonula).

The conclusion has now been arrived at, that this power of accommodation depends on a *varying curve of the lens.*[1]

In order to effect this, a great degree of *elasticity*, chiefly of the outer capsule, was obviously necessary, and we find this requisite complied with by an admirably delicate structure of concentric layers, according to which its density reaches the minimum at the periphery of the lens, while its aggregate power of refraction is increased, as if it were composed entirely of the strong refracting substance of which the centre consists.

As the power of accommodating its focus rests on this quality of the lens, it is necessarily accompanied by a loss of elasticity with increasing age. The eye of a man of sixty, that sees distinctly at a dis-

[1] The mode of procedure is now known down to the last and most minute detail. The surfaces of the lens give back extremely delicate reflections, which with the proper aids may be measured in the living eye, and from the size of which the curve may be calculated as in convex and concave mirrors. As auxiliary of this change of form, there is a peculiar agent—a muscle embedded in the choroid (K, Fig. 4)—which has the power of contracting and expanding the suspensory ligament of the lens.

tance, is unable to distinguish an object five inches off; and, if, against all rule, it see sharply at five inches off, this benefit is counteracted by the inconvenience of seeing distant objects with great indistinctness. The gradual hardening of the lens is accompanied by a decrease of power of adjusting its focus, and is even subject to such small individual fluctuations that, by an exact calculation of its play,[1] we may sometimes arrive at the most indiscreet conclusions respecting the age.

Should the lenticular elasticity no longer admit of a sufficient scope for refraction, we must then either adjust the distance of the objects, as we see a far-sighted individual do, by holding the book proportionably farther off, or we must afford the eye assistance by accommodating it with movable auxiliary lenses, *spectacles*, which replace the lost power of adjusting forms to the natural eye. This power of accommodating the focus disappears beyond recall if the lens has sustained an injury, or if we remove it entirely, from its having grown turbid. This takes place in the operation for *cataract*, which is a dimming of the sight from a thickening of the lens.

The lens, however, is not altogether free from optical irregularities, as when the focus of the eye has not been perfectly adjusted for seeing in the distance. Those of you who are short-sighted, on looking at a distant street-lamp, perceive, instead of the clearly-defined image, an irregular circle of light, and you will at the same time observe within that circle a number of peculiar rays and dots, which are nothing but irregularities in the lens, i. e., the reaction of those irregularities on the retina. Even an eye whose sight is quite normal, makes an analogous observation if it directs its gaze to a very fine point of light, as, for example, to a star. Both the star and the atmosphere are equally innocent of the small beams that radiate from it; they are the rays of our own lens which we transplant to heaven. So little aware are we of what takes place in the depth of our sensory organs, or in the immeasurable distances of the universe.

The spaces between the lens and the cornea, as also between the lens and the retina, are filled with a liquid medium, called *humors;* the latter, which constitutes by far the largest chamber of the eye, is filled with a gelatinous substance called the *vitreous humor*. This medium likewise contributes essentially to the concentration of the rays of light, as, lying between two curved partitions, they exercise a similar influence as the lens.

The vitreous humor, optically speaking, is, however, not pure; small granular or wavy forms, which all of you at times have seen hovering within your field of view, and which pursues so many hypochondriacal persons on their summer trip to a watering-place, are occasioned by shadows thrown on the retina by a partial, delicate opaqueness in the vitreous humor. Those bodies are so light as only to be

[1] The diminution of the play does not commence in the second period of our lives, but, as Donders has proved, in a regular manner from childhood onward.

perceptible, either in certain effects of light, or on a peculiar exertion in the straining of the attention. By a simple experiment it is possible to make every person acquainted with these guests of his field of view, the so-called *muscæ volitantes ;* only, one must be prepared for those formerly overlooked, but once honored with attention, never again stirring from their post.

In order, likewise, to preserve space for the play of these variations in the form of the lens, in the act of adjustment, it was necessary to surround the lens with a liquid or elastic medium. That the aqueous humor bears a part in moistening the cornea, has already been stated, but in the voluminous vitreous humor we behold the *regulator of the shape and tension* of the eye. Such an auxiliary medium is of urgent necessity to keep up the regularity of refraction, the quality of tension in the retina as a sensitive surface, and the action of the optic nerve. Some years ago, I was happy in being able to demonstrate that a comprehensive range of diseased conditions and also blindness, the causes of which had been successively sought for in different parts of the eye, simply arose from too great a tension being exercised by the vitreous humor—a discovery which imparted so much the more pleasure, as a suitable remedy was likewise at hand.

Let us imprint on our memories, from the model of a magnified eye, the positions and dimensions of the different parts. For the present, I begin with the cord of the optic nerve, which, as you perceive, does not enter the sclerotica exactly opposite to the cornea. This part, as well as the larger posterior chamber of the eye, is embedded in the orbit, and is therefore not visible externally; while, on the other hand, between the lids, you remark the white of the eye, which is the anterior chamber of the choroid; next the transparent cornea; and away through it the colored iris, with the pupil in the centre.

The black appearance of the latter used to be ascribed solely to the dark layer formed by the choroid for the interior of the eye, absorbing all the light. More patient and minute investigations have, however, proved that the pupil derives its blackness only partially from the above circumstance, and mostly from the refraction of the light. Helmholtz has succeeded in banishing that darkness from the pupil of the human eye. By a simple arrangement, called the *speculum oculi*, he uses the light which is reflected from the deeper parts of the eye to illuminate the whole of the interior, as also the image itself projected on the retina. This invention exercises an influence not only on the peculiar branch of the oculist, but likewise on the broad field of medical investigation, seeing it affords an insight into the optic nerve, a direct process of the brain, and other structures, which, along with their analogies, were hidden from observation in the body.

The dimensions of the eyeball among strong-sighted individuals is more equal than you perhaps imagine. The apparent differences of size lie almost exclusively in the shape of the slit of the lid. If it has a wide slit, it affords a view over a greater part of the eyeball, and we think it bigger, simply because we see more of it. In the same manner, our judgment is deluded by the different degrees of prominence of the eye. A staring or protruding eye impresses us as being larger, although it is only pressed forward; while in advanced age, or in consuming sickness, the sunken eye is thought smaller.

If the eye really is larger, then the distance between the cornea and the lens will be greater; and if the effects of the refracted light remain the same in the latter, the image will no longer be projected on the cornea, but in front of it. And this is what really takes place in that wide-spread malady called *short-sightedness.* Here we have especially to note that the mean axis of the eye is too long. There are others called *far-sighted* eyes, whose visual axis is too short, the image for such eyes falling behind the retina. In order to reëstablish the conditions of keen vision in both cases, the effects of refraction must be diminished for the short-sighted, by diverging or concave glasses; for the far-sighted, by collective or convex glasses. Those conditions have nothing to do with the want of the power of adjustment of focus. If you correct the defective construction of the short-sighted eye with a concave glass, and that of a far-sighted with a convex one, the lens—its mobility being preserved—can with their aid accommodate itself to near and distant objects, which neither an old man, deprived altogether of the power of adjustment, nor an individual who has been operated on for the cataract, is capable of doing.

Let us now pursue the analysis of the model in the same order as at the outset. First, then, fold back the cornea with the anterior section of the sclerotica; the margin of the eye to the front is now interrupted by the pupil, and is for the rest formed by the tissue of the iris, and the anterior section of the choroid. The space (at present wanting) in front of the iris-curtain was filled with aqueous humor, which you are to suppose has escaped. Let us now remove the posterior half of the tissue of the visual nerve; the whole eye will then be closed up by the passage of the choroid and iris, which now meets with no break, except anteriorly from the pupil, and posteriorly from the entrance of the optic nerve. If, now, as with the sclerotica, we fold back the anterior division of the choroid along with the iris, in doing which we have an opportunity of convincing ourselves of the true nature of the pupil, and that it is indeed an opening, we then come upon the hard lens lying behind. Taking this away, as also the gelatinous vitreous humor, we at length remove the posterior section of the choroid, and have nothing left but the optic nerve and the retina. Thus we have again arrived at the starting-point of our reflections; and it only now remains for me to bring before you the retina.

Before, however, entering on this division of my subject, let me call your attention to a few fundamental processes in the act of seeing. First, the picture or image on the retina is perfectly sharp only at one particular spot, situated somewhat beyond the optic nerve and exactly opposite the centre of the cornea. The light which falls along the main axis of the eye converges at this point. This spot in the retina is marked by a small *hollow*. For the rest, it is filled up with a structure of its own; and we have reason for assuming that it furnishes the most exact perceptions, not only on account of the greater optical sharpness of the image, but also on account of the higher energy or activity with which it is endowed. It is this spot we make use of when we desire to go into details; for, if we wish to examine closely into the nature of an object, either we approach it to the eye, or bring the eye to bear on the object; but, in both cases, in such a manner as to cause the image to fall exactly on the hollow of the retina, or on the spot of *direct vision*. This arranging of a position for an object is what we mean when we speak of adjusting the eye.

The images which are not projected on the spot of direct vision are not sharp; for the necessary light falls on the refracting media more or less obliquely. This, and the decrease in the activity of the sight from the hollow to the sides, explain how the objects, the farther they are removed from the fixed point, appear with so much less clearness and sharpness of outline. *Indirect* or *eccentric* vision, as it is termed, makes us aware simply of the presence of objects, by giving us some notion of their shapes; but we are unable to distinguish even the biggest letters, if the image of them should fall only one hair's breadth off that one spot in the retina. In reading, the eye must constantly move onward to the end of the line, the single letters thus gradually imprinting themselves on the direct point of vision. On the other hand, indirect vision offers hints for fixing the object in our eye; it warns us of, and prepares us for, the object previous to our devoting our whole attention to it, and it is further of use in procuring a *wide survey*, by enabling us to see and examine what lies before us. There are some who only possess direct vision. Any one can put himself in the place of an individual so afflicted, by holding a long tube of small calibre to his eye. You naturally distinguish the most minute objects enclosed within the restricted range of vision; but, deprived of the lateral impressions, you could not guide your steps in the street. In short, you must fancy the image of the external world that is imprinted on the retina, like a picture *highly finished in the middle*, and only *roughly sketched out at the sides.*

The distance from the spot of direct vision, at which the objects may be perceived by eccentric vision, has its limits. When looking straight before you, you can just perceive a hand which stretches down the whole length of the face, in the direction of the temples. This is the extremest point from which it is possible for light to fall on the retina; but, if you attempt to go beyond it, the hand disappears, its image not being projected on the retina. The combination of all the extreme points from which, with a set eye, impressions may be received, forms the frame of the field of view, and what is within this frame is itself the *field of view.*

This space, immovable as regards the head, becomes the arena to which both those excitations produced by the senses, and those belonging to subjective sight, are transposed; and this transposition always takes place in the same direction as that in which a regular act of sight would in any case lie. Although long experience has taught us it is a delusion, still we always place the image projected by a mirror behind it, because the reflected light falls into our eye just as if the object were behind it. But the sparks produced by pressing the eye from the side of the temples, we seem to see in the opposite side of the field of view; but we do so because, in the normal act of sight, the retina is irritated (from the side of the temples) by light falling from the opposite side. By the *action of projection*, the reversed image naturally regains its upright position in the field of view.

A general irritation of the retina unaccompanied by a perception of objects will give us a *light* field of view, and, on the other hand, a perfect repose of those parts will give us a *dark* field of view. The former represents the sense of the repose of a mechanism endowed with the power of action; the latter corresponds to the absence of all mechanism whatever. The *feeling of darkness*, therefore, results merely from the expansion of your field of view as opposed to your retina, if I may so say; while behind your back you have the feeling neither of light nor of darkness; you simply miss all sensation of light.

Touching the *size of the images on the retina*, as compared with the objects themselves, I need merely remind you of the rules of perspective. The images on the retina stand in reversed proportion to the distance of the objects. The image of a pencil, held a foot from your eye, covers the trunk of the tree before your window; that of a pea, at a like distance, covers the moon in the sky. If, notwithstanding, we think the moon bigger than the pea, and the tree than the pencil, the reason is that, apart from our being well acquainted with the tree, our judgment is a combination of the size of the image on the retina and the distance of the object. Now, as consciousness is for the most part founded on experience, so just and correct *perspective sight* is in the main something we *acquire.* A child will assuredly not appreciate the difference between the pencil and the trunk of the tree in the same degree as an individual who by experience has learned to know the value of his impressions. What the child first knows of the moon is, that he cannot reach it with his hand; "But," as I once heard a child say, "mother can reach it down." Other inferences have helped him to this conclusion. We are so accustomed to merely play with children, that we are easily blinded to the full seriousness of such requests.

We cannot break off these reflections on the image of the retina without making mention of a remarkable spot in the background of the eye—the yellow spot marking the entrance of the optic nerve. All perception whatever is arrested within the bounds of this spot—it is a *blind* point in our field of view.

The *blind spot* is by no means so excessively small. At the distance of four paces, it would cover a man's head in the centre of your field of view; and almost a hundred moons in the sky would find room within its bounds. When Mariotte made this important discovery, it caused so much commotion that the experiment had to be repeated before the King of England in 1688. In the endless variations of the experiment, the remarkable fact only received a new confirmation. For the rest, this discovery had almost proved fatal to the doctrine of perception; for, as at that time the optic nerve and the retina being considered as essentially the same, one might deduce, *a priori*, the inference that, just at that point of entrance at which all the conducting fibrils converged, a heightened sensibility might be argued. But, now proving to be insensitive, the retina itself could no longer be regarded as the regular conductor of the sensation of light. And this was the conclusion to which Mariotte did arrive, transferring the sensibility to the choroid behind the retina, till at length Bernoulli and Haller again restored it to its rights.

This apparent enigma is explained by what I told you of the general relation of light to the visual organ. The part the optic nerve plays is only that of a conductor, while the sensations of the vibrations of the ether, as also of the specific sensory irritation, is committed to the retina, or, more correctly speaking, to its external layer.

Another question is, Why does the existence of the blind spot usually escape our attention? The chief reason is that, as the gap is regularly situated in the same spot in the field of view, the *idea* has learned to fill it up in the most natural manner, and as is suitable for the connection of objects. For instance, I draw the figure of a cross on the board, and fix my eye on it, so as to cause the centre of this figure enclosing the point of intersection to fall on the blind spot; in this manner I believe indeed that I see a cross, while in reality I only see what lies beyond; fancy supplementing the rest. The cross is a commonly-known figure, and when any two lines take a perpendicular direction toward each other, they as a rule really do intersect each other. The best proof of this being the case is that, when you obliterate all that lies within the district, you still continue to see the cross; and, to make the experiment more elegant, if you place some photograph in the empty space, you do not perceive it, you still continue to see only the cross. You have here, then, a conjunction of objective sensory action and subjective influence, apparently with the help of the central extremity of the optic nerve, which is highly significant for the whole doctrine, and which to a certain degree combines what I have been endeavoring to explain to you on both of those branches of the subject.

ON THE DISCOVERY OF THE ELEMENTS.[1]

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THE word "element" is used by chemists in a peculiar and very limited sense. In calling certain bodies elements, there is no intention on the part of chemists to assert the undecomposable nature or essence of the bodies so called. There is not even an intention on their part to assert that these bodies may not suffer decomposition in certain of the processes to which they are occasionally subjected, but only to assert that they have not hitherto been proved to suffer decomposition; or, in other words, to assert that their observed behavior, under all the different modes of treatment to which they have been exposed, is consistent with the hypothesis of their not having undergone decomposition.

The entire matter of the earth, then, so far as chemists are yet acquainted with it, is composed of some 63 different sorts of matter that are spoken of as elementary; not because they are conceived to be in their essence primitive or elementary, but because, neither in the course of Nature nor in the processes of art, have they been observed to suffer decomposition. No one of them has ever been observed to suffer the loss of any substance different from the substance of its entirety. Thus chemists are incapable of taking away from iron, for example, a something that is not iron; or of taking away from it any thing whatever, so as to leave a residue that is not iron; whereas they are capable of taking away from iron-pyrites a something which is not iron-pyrites but is sulphur, so as to leave a residue which is not iron-pyrites but is metallic iron.

The notion of all other material bodies being constituted of, and decomposable into, a limited number of elementary bodies, which could not themselves be proved to suffer decomposition or mutual transformation under any circumstances whatever, but could, on the contrary, be traced respectively through entire series of combinations, and be extracted at will from each member of the series, is a notion which, undergoing in course of time a gradual development, was first put forward in a definite form by Lavoisier; until whose time, some residue of the great alchemical doctrine of the essential transmutability of all things—that the substance of all things was the same, while the form above was different—still prevailed. To Lavoisier is due the enunciation of the principle—departed from, however, in a few instances by himself—that all bodies which cannot be proved to be compounded, are in practical effect, if not in absolute fact, elementary, and are to be dealt with accordingly.

[1] Lecture before the Royal Institution.

Of the many definite substances known to chemists before the discovery of hydrogen gas, the following were afterward recognized by Lavoisier and his colleagues as elementary: First, the seven metals known to the ancients, namely, gold, silver, mercury, copper, iron, tin, and lead, distinguished respectively by the signs of the sun, moon, and planets; and each conceived to have some mystic connection with the particular orb or planet of which it bore the sign, and not unfrequently the name. Then three metals which became known at the latter end of the fifteenth or beginning of the sixteenth century, namely, antimony, discovered by Basil Valentine in 1490; bismuth, mentioned by Agricola, 1530; and zinc, mentioned by Paracelsus, obiit 1541. An elementary character was also assigned to the non-metals carbon and sulphur, which had been known from the earliest times; to phosphorus, discovered by Brandt, of Hamburg, in 1669; and to boracic acid, now known to be a hydrated oxide of boron, first discovered by Homberg in 1702, and still occasionally spoken of as Homberg's sedative salt. The list was further swollen by four metals which, in Lavoisier's time, had been but recently discovered, namely, cobalt and arsenic, identified simultaneously in 1733 by George Brandt, of Stockholm; platinum, discovered in 1741 by Woods, assay-master at Jamaica; and nickel, discovered in 1751 by Cronstedt.

The only other bodies known before 1766, and afterward included in the class of elements, namely, the alkalies and earths, had during the quarter of a century immediately preceding been made the subjects of especial study. The differentiation of potash from soda, both previously known by the common name of alkali, was indicated by Duhamel in 1736, and more completely established by Marggraf in 1758. The differentiation from one another of lime or calcareous earth, silex or vitrefiable earth, alumina or argillaceous earth, and magnesia or bitter earth, was accomplished by the labor of many chemists, more particularly Marggraf, Bergmann, and Scheele; prior to whose researches, silex, alumina, and magnesia, together with their different combinations and commixtures with each other and with lime, were held to be but impure varieties of lime. The nature of the difference between the caustic alkalies and earths and their respective carbonates was made known by Black in 1756; while the real constitution of the alkalies and earths, as metallic oxides, though suspected by Lavoisier, was not established until the beginning of the present century, by Davy and his contemporaries and followers.

The successive recognition of the elementary gases, quickly following Black's remarkable discovery of carbonic-acid gas, began with the identification of hydrogen by Cavendish in 1766. This was succeeded by the discovery of nitrogen by Rutherford in 1772; of chlorine and fluoric acid, the latter now held to be a fluoride of hydrogen, by Scheele in 1774; and of oxygen by Priestley in the same year.

Thus prior to the discovery of the first of the elementary gases, 23 kinds of solid matter, and one liquid body, mercury, were known, which afterward became recognized as elements. Between then and the present time, 33 kinds of solid matter, and one liquid body, bromine, have been added to the list—the discovery of the earliest of them occurring almost simultaneously with, or even just preceding, that of the last discovered of the elementary gases.

Among the number of bodies discovered prior to 1803, when Davy effected the decomposition of the alkalies, several, at first thought to be elementary, are now known to be compounds of oxygen with other bodies still regarded as elements; and conversely, two bodies, namely, chlorine and fluorine, at one time thought to be oxides, have since become regarded as elementary; but in none of these cases did the discovery of what is now considered to be the real constitution of the bodies add or subtract an element to or from the list.

From the period of the modern or Lavoiserian conception of elements and compounds down to the beginning of the nineteenth century, the recognition of new elements occurred with much frequency at short but varied intervals. After then, the discoveries became somewhat less frequent; but, even within the last 50 years, no fewer than 12 new elements have been added to the list, being at the rate of one new element every four years. Throughout, the periods of discovery have been somewhat irregular in their occurrence. Thus, in the years 1802 and 1803, six new elements were discovered, namely, tantalum, cerium, palladium, rhodium, iridium, and osmium; within the succeeding 14 years only one new element, but that a very important one, namely, iodine; and in the fifteenth and sixteenth years, three new elements, namely, lithium, selenium, and cadmium. The longest barren interval, one of 13 years' duration, took place between the discovery of niobium, by Rose, in 1846, and that of cæsium and rubidium, by Bunsen, in 1859. The last discovered of the elements, namely, indium, being fully seven years old, and there being no reason to consider our present list as any thing like complete, or to apprehend any cessation of additions thereto, it is now quite time for some other new element to be made known. For we may reasonably anticipate the discovery of new elements to take place at irregular intervals possibly for centuries to come, and our list of the elements to be increased at least as much in the future as in the past.

The fresh discovery, however, of any abundant elementary constituent of the earth's crust would seem scarcely now to be expected, seeing that of the 32 elements which have become known since the year 1774—the year of the discovery of chlorine and oxygen and manganese and baryta—the great majority belong to the class of chemical curiosities; while even the four or five most abundant of the since discovered elements are found to enjoy but a sparing, although wide distribution in Nature, as is the case, for example, with bromine and iodine; or else to be concentrated but in a few specially-localized minerals, as is the case, for example, with strontium and chromium, and tungsten. Of course it is difficult to appraise the relative abundance in Nature of different elements; more especially from the circumstance of those which are put to commercial uses being everywhere sought for, and those not put to commercial uses being habitually neglected—save indeed by the man of science, to whom the peculiar properties of some of the less familiarly known elements, as palladium, osmium, erbium, didymium, uranium, and thallium, render them objects of the highest interest.

A very notable point with regard to the last-discovered four elements, namely, rubidium, cæsium, thallium, and indium, is their successive discovery within a few years of each other, by one and the same process, namely, that of spectrum analysis. This process, invented and made available as a means of chemical research by Bunsen and Kirchhoff in 1859, consists simply in allowing the light given off by different ignited gases and vapors, limited by means of a fine slit, to pass through a prism or succession of prisms; and in observing the so-produced, brightly-colored, widely-extended image of the slit. It has been known from the days of Newton, that, by the passage of heterogeneous light through a prismatic, highly-dispersive medium, its differently refrangible constituents become widely separated from each other, so as to furnish an elongated, colored spectrum. But, whereas the spectra of incandescent solid and liquid bodies are continuous, and not distinctive of the particular luminous bodies yielding them, the spectra of incandescent, gaseous, or vaporized bodies, are found to be discontinuous, and to consist of one or more bright lines of different color, thickness, and position, according to the nature of the particular incandescent gases or vapors from which the light through the slit is proceeding. In this way it is found that the spectra of the different chemical elements, alike when free and in combination, are perfectly definite, and characteristic of the particular elements vaporized and made incandescent.[1] And, in many cases, the spectra, or portions of the spectra of particular elements, even when present in the most minute proportion, are so extremely well marked and distinctive, that the presence or absence of these elements is determinable with the greatest ease and certainty, by a mere inspection of the emission spectra yielded by the incandescent gases or vapors under examination. Moreover, gases and vapors are further capable of affecting heterogeneous light which is passed through them; and of thus yielding absorption spectra, in which the characteristic lines of the above-described emission spectra are reversed, so as to appear, unaltered in position, as black lines or intervals in an otherwise continuous band of color.

Now, the salts of the alkali-metals, lithium, sodium, and potassium,

[1] For some qualifications of this statement, *vide* Roscoe's "Spectrum Analysis."

and certain of the salts of the alkaline-earth metals, calcium, strontium, and barium, being very readily volatile, upon heating these salts, in the non-luminous flame of a Bunsen gas-burner for example, they undergo vaporization, and their vapors become incandescent and capable of yielding the characteristic emission spectra of the particular metals. In examining in this way the alkali-salt residue of a mineral water from Durkheim, Bunsen observed in the spectrum before him certain colored lines not belonging to any one of the then known alkalies, potash, soda, or lithia; and yet necessarily belonging to some substance having the general characters of an alkali, since all other bodies than alkalies had been previously removed from the residue under examination. In full reliance upon the certainty of this conclusion, Bunsen evaporated some forty tons of the water in question; and from the alkali-salt residue succeeded in extracting and separating salts of two new alkali-metals, each characterized by a well-marked pair of lines in the blue or indigo, and one of them having in addition a pair of well-marked lines of extremely small refrangibility in the red of the spectrum. From its yielding those red lines, the one metal was named rubidium; the other, of which the bright-blue lines were especially characteristic, being called cæsium.

The very general distribution in Nature of these two elements was speedily established, and salts of each of them were, with much labor, eventually prepared in a state of purity and in reasonable quantity. From certain of their respective salts the metals themselves were obtained by the usual processes, and, together with their salts, were submitted to detailed chemical examination. And no sooner was this examination made, than the position of the newly-discovered elements, as members of the alkali-metal family, at once became apparent. Rubidium and cæsium were found in all their properties to present the most striking analogy to potassium, and evidently to stand to this metal in the same relation that strontium and barium respectively stand to calcium; while they differed from sodium, much as strontium and barium respectively differ from magnesium. This relationship in obvious properties was further borne out by the relationship of their atomic weights, thus:

Mg	24	Na	23	F	19	O	16
Ca	40	K	39	Cl	35.5	S	32
Sr	87	Rb	85	Br	80	Se	79
Ba	137	Cs	133	I	127	Te	129

It is observable that the sequence of atomic weight in the thus completed alkali-metal family is strictly parallel to the previously well-known sequences in the alkali-earth metal family, and in the halogen and oxygen families respectively. Moreover, just as the basylity of the alkaline-earth metals increases in the order of their several atomic weights—calcium being less basylous than strontium, and far less basylous than barium—so also is the basylity of potassium inferior to that of rubidium, and the basylity of rubidium inferior to that of cæsium, which is indeed the most powerfully basylous, or oxidizable, or electro-positive element known.

Since 1860, both rubidium and cæsium have been recognized as minute constituents of a considerable number of minerals and mineral waters, rubidium having been met with for the most part in a larger proportion by weight than cæsium. Unlike potash, originally known as vegetable alkali, cæsium has not been recognized in the vegetable kingdom; but rubidium has been found as a very common, minute constituent of vegetable ashes, as those of beet-root, oak-wood, tobacco, grapes, coffee, tea, etc. On the other hand, cæsium, free from rubidium, has been found in a tolerably well-known, though rare, mineral from the island of Elba, to the extent of 32 per cent. by weight of the mineral. The history of this mineral is curious: from the circumstance of its always occurring in association with another mineral, a variety of petalite, the two were called Castor and Pollux. Castor was found to be substantially a silicate of alumina and lithia; pollux a silicate of alumina, and, as it was thought, of potash. The constituents of pollux, namely, silica, alumina, and potash, with small proportions of ferric oxide, lime, soda, and water, were duly estimated; but the quantities of these constituents, found in 100 parts of the mineral, instead of amounting to 100 parts or thereabouts, amounted only to 88 parts, there being somehow a loss of 12 per cent. in the analysis. After Bunsen's discovery of the new alkali-metals, pollux was analyzed afresh by Pisani, who soon perceived that what had formerly been taken for potash, and estimated as potash, was not potash at all, but cæsia. Then calculating out his own analysis with cæsia instead of potash, substituting the one for the other in the proportion of 133 + 8, or 141 parts of cæsia, for 39 + 8, or 47 parts of potash, he found that the quantities of the different constituents furnished by 100 parts of the mineral yielded by their addition the full sum of 100 parts required.

In submitting to spectroscopic examination a certain residue left by the distillation of some impure selenium, Mr. Crookes, early in 1861, recognized in the spectrum before him a brilliant-green line, from which he inferred the presence in the above residue of a new element; and by the end of the same year he had succeeded in establishing the tolerably wide distribution of this element, to which he gave the name of thallium; in procuring it, though but in small quantity, in a separate state; and in satisfying himself of its metallic character. Soon afterward, and without knowledge of Mr. Crookes's later results, the metal was obtained by M. Lamy, on a comparatively large scale, and was exhibited by him in the form of small ingots at the London Exhibition of 1862. He procured it from the fine dust met with in some oil-of-vitriol factories, as a deposit in the flues leading from the pyrites burners to the leaden chambers. In these deposits, the minute proportion of thallium contained originally in the pyrites becomes concentrated, so as to form in some instances as much as eight per cent. by weight of the dust. Independently, moreover, of its occurrence in iron pyrites, thallium, though never forming more than a minute constituent of the different minerals and mineral waters in which it occurs, is now known to be capable of extraction from a great number and variety of sources. But from no other source is it so advantageously procurable as from the above-mentioned flue-deposit; and so early as the autumn of 1863, at the meeting of the British Association in Newcastle, the then mayor, Mr. J. Lowthian Bell, exhibited several pounds, and Mr. Crookes no less than a quarter of a hundred-weight of thallium obtained from this comparatively prolific source. In one respect, the discovery of thallium presented even a greater degree of interest than attached to the discovery of cæsium and rubidium. For whereas these two elements were at once recognized as analogues of the well-known metal potassium, thallium can hardly be said, even at the present time, to be definitely and generally recognized by chemists as the analogue of any particular metal, or as a member of any particular family of elements. With each of such differently characterized elements as potassium, lead, aluminum, silver, and gold, it is associated by certain marked points of resemblance; while from each of them it is distinguished by equally well-marked points of difference. Hence the necessity for subjecting thallium and its salts to a thorough chemical examination, so as to accumulate a well-ascertained store of facts with regard to it. And, thanks to the careful labors of many chemists, more particularly of Mr. Crookes, in London, and of Messrs. Lamy and Willm, in Paris, our knowledge of the properties of thallium and of its salts may compare not unfavorably with our similar knowledge in relation to even the longest known of the metallic elements. Still, it was not until our knowledge of indium had culminated in the determination of its specific heat, only last year, that the position of thallium, as an analogue of indium and a member of the aluminum family of elements, became unmistakably evident.

Indium was first recognized in 1863, by Drs. Reich and Richter, in the zinc blende of Freiberg, in Saxony, and by reason of the very characteristic spectrum afforded—consisting of two bright-blue or indigo bands; the brightest of them somewhat more refrangible than the blue line of strontium, and the other of them somewhat less refrangible than the indigo line of potassium. Since its first discovery, indium has been recognized in one or two varieties of wolfram, and as a not unfrequent constituent of zinc-ores, and of the metal obtained therefrom, but always in a very minute proportion. Indeed, indium would appear to be an exceedingly rare element, far more rare than its immediate predecessors in period of discovery. Its chief source is metallic zinc—that of

Freiberg, smelted from the ore in which indium was first discovered, containing very nearly one-half part of indium, per one thousand parts of zinc. A considerable quantity of indium extracted from this zinc, was shown in the Paris Exhibition of 1867; and an ingot from the Freiberg Museum, weighing two hundred grammes, or over seven ounces, has within the last few days been kindly forwarded by Dr. Richter himself, for inspection on the present occasion. To Dr. Schuchardt, of Goerlitz, also, the members of the Institution are indebted for his loan of nearly sixty grammes of metallic indium; and of fine specimens of other rare chemical products, prepared with his well-known skill, in a state of great purity and beauty.

When zinc containing indium is dissolved not quite completely in dilute sulphuric or muriatic acid, the whole of the indium originally present in the zinc is left in the black spongy or flocculent residue of undissolved metal, with which every one who has prepared hydrogen gas by means of zinc and acid is so well acquainted. Besides some zinc, this black residue is found to contain lead, cadmium, iron, and arsenic, less frequently copper and thallium, and in some cases, as that of the Freiberg zinc, a small proportion of indium. From the solution of this residue in nitric acid, the indium is separated by ordinary analytical processes, based chiefly on the precipitability of its sulphide by sulphuretted hydrogen from solutions acidulated only with acetic acid, and on the precipitability of its hydrate both by ammonia and carbonate of barium. From its soluble salts, metallic indium is readily thrown down in the spongy state by means of zinc. The washed sponge of metal is then pressed together between filtering-paper, by aid of a screw press, and finally melted under a flux of cyanide of potassium.

Thus obtained, indium is a metal of an almost silver-white color, apt to become faintly bismuth-tinted. It tarnishes slowly on exposure to air, and thereby acquires very much the appearance of ordinary lead. Like lead, it is compact and seemingly devoid of crystalline structure. Moreover, like lead and thallium, it is exceedingly soft, and readily capable of furnishing wire, by the process of "squirting" or forcing. The specific gravity of indium, or 7.4, is very close to that of tin, or 7.2; and much above that of aluminum, 2.6, and below that of lead, 11.4, and that of thallium, 11.9. In the lowness of its melting-point, namely, 176° C., indium occupies an extreme position among the metals permanent in air; the next most fusible of these metals, namely, tin and cadmium, melting at 228°; bismuth at 264°; thallium at 294°; and lead at 235°. Though so readily fusible, indium is not an especially volatile metal. It is appreciably less volatile than the zinc in which it occurs, and far less volatile than cadmium. Heated as far as practicable in a glass tube, it is incapable of being raised to a temperature sufficiently high to allow of its being vaporized, even in a current of hydrogen.

Indium resists oxidation up to a temperature somewhat beyond its melting-point, but at much higher temperature it oxidizes freely; and at a red heat it takes fire in the air, burning with a characteristic blue flame and abundant brownish smoke. It is readily attacked by nitric acid, and by strong sulphuric and muriatic acids. In diluted sulphuric and muriatic acids, however, it dissolves but slowly, with evolution of hydrogen. Oxide of indium is a pale-yellow powder, becoming darker when heated, and dissolving in acids with evolution of heat. The hydrated oxide is thrown down from indium-solutions by ammonia, as a white, gelatinous, alumina-like precipitate, drying up into a horny mass. The sulphide is thrown down by sulphuretted hydrogen as an orange-yellow precipitate, insoluble in acetic but soluble in mineral acids. The hydrate and sulphide of indium, in their relations to fixed alkali solutions more particularly, seem to manifest a feebly-marked acidulous character. Chloride of indium, obtained by combustion of the metal in chlorine gas, occurs as a white micaceous sublimate, and is volatile at a red heat, without previous fusion. The chloride itself undergoes decomposition when heated in free air, and the solution of the chloride upon brisk evaporation, with formation in both cases of an oxichloride.

THE CAUSES OF PHYSICAL DEGENERACY.

By A. K. GARDNER, M.D.

WHETHER the human race is degenerating, and, if so, by what causes, are questions of much speculative interest to scientific thinkers, and of much practical interest to each father and mother in the community. The subject is complicated by many conditions. Physical health and vigor, and mental strength and power, are to a great degree a matter of hereditary transmission, over which the individual has no control. Yet, taking our natures as they are, we can renovate, reinvigorate, and advance them by attentive study of and conformity to the laws upon which health and vigor are based. I propose in the present article briefly to glance at the chief physical agencies—air, exercise, clothing, food, and rest—and at some of the mental and moral influences, by the bad or good employment of which the physical stock is deteriorated or improved.

Air.—Probably the inhabitants of the globe generally were never so thoroughly sheltered as at present. The house keeps off rain, dew, and the moistures from evaporation—certainly very desirable—but it also to a greater or less degree modifies the temperature and the quality of the air that we breathe.

Theoretically, air is admitted to be an agent conducive to life; practically, it is almost utterly disregarded. The necessity of breathing is recognized, and we have various formulated sayings implying that to stop breathing is to stop living. But, practically, the world is trying to see how little air can be actually used—and, with some, this is almost their only economy—and next, to see how poor a quality of air can sustain their life.

One-half of the civilized race—i. e., all the women, and some men—so dress themselves that by no possibility can they take a full breath. As the lungs are never fully inflated, their capability of expansion is gradually lessened. The result is, a contraction and diminution in the size of the chest, a want of roundness and fulness, and both men and women are "flat-chested," round-shouldered, and "sunken in." The eye will recognize this, and measurement will add certainty to judgment.

Take the men of New York to-day, and not one in five hundred can make a difference in the dimensions of the chest, from a full inspiration to a complete expiration, of five inches, measured at the nipple. Nor will the majority show an expansive capacity of even three inches. With the women it is still less; probably never since extreme childhood—for romping days end early now—have they been capable of taking a full breath in the daytime, the nearest approach to it being effected, not by the expansion of the chest, but by the action of the abdominal muscles and the downward withdrawal of the diaphragm.

Nor is this stated as a matter of simple curiosity; it has a practical and most important bearing on the subject under consideration. Supposing that the blood is sufficiently aërated without the use of the full capacity of the lungs, say by an increased number of respirations—are not the necessities of Nature thus adequately supplied, and consequently no injury done?

By no means, as every housewife's experience will abundantly illustrate. In the quiet and secluded angles and nooks gather the lint and dust of the whole apartment. In the corners and recesses of a hospital-ward gather the miasm and the pestilence. In the unused portions of machinery do we find the rust and tarnish, and the mildew blasts the quiet and the still parts of all Nature. In the same way, in those portions of the lungs, every minute extremity and division of which is a reticulated net-work of fibres, and vessels, and tubes, through which, at every expiration and subsequent inspiration, there should be an unceasing ebb and flow, with new elements constantly adding, and effete material perpetually renovating, yet, by reason of mechanical impossibility, there gather the results of this stagnation, the crassness of the blood, and those discordant elements which, had they not been allowed to accumulate in these undusted retreats, would have continued in the circuit of the blood, till they had arrived, in due course, at some of the great glandular strainers and purifying alembics of the system, where they would have been duly eliminated and discharged. These localities are the nuclei of disease, and here are deposited the tubercle and the germs of death.

This is the result of disuse—the farmer's neglected spot, the receptacle of odds and ends, never ploughed nor cared for, where weeds run riot, and whence every light-winged breeze wafts the myriad progeny of evil all over the adjoining fields.

How aggravated is this condition when the air, too, is deteriorated, full of miasm and pestilence! See the air of the swampy, undrained country, laden with agues and typhus, or the city atmosphere, shut in from sun and breeze, respired over and over again by the healthy and the sickly, by animals of every description, full of the dust of every production of the world, with the fumes of every volatile liquid and deleterious gas!

When we contrast this single vital element as it enters into the life of the modern man, compared with its free use by the men of the past, who are reported to have lived to a great age in health and comparative vigor, does there not seem to be almost reason enough for it in this fact alone?

The Greeks, like all Eastern nations, lived in the open air. The patriarchs of the Bible lived in tents. Even those of later date, who lived in the small cities of former days, occupied no tightly-glazed, windowed apartments, but slept a great part of the time on the unbedewed roofs of their houses, covered only by the radiance of the gentle moon and the twinkling stars.

In those days the heat came from the vigor of the system, and exercise at some useful employment, while wide-mouthed, gaping chimneys, consuming huge logs of timber, carried away, on their upward draught (with most of the heat indeed), the air wasted by respiration.

Nor was pure air a royal prerogative; for, down to quite recent times, these immense chimneys were the gates to health to our own ancestors, and we ourselves learned somewhat of our early astronomy by gazing at the stars through these huge telescopes, thickly hung around with the flitches of bacon and fat hams quietly absorbing the pyroligneous acids from the consuming logs of oak and walnut burning below.

Contrast those long winter nights in rooms through whose open cracks the wintry blast not unfrequently blew out the candle by whose dim light we groped our shivering way to bed; contrast them with the air we breathe, heated by the unceasing furnace, poisoned by ever-present tobacco-smoke, and at the best loaded with the impurities of a city, and passing on its course from house to house, constantly becoming more and more impure.

Sunlight.—This portion of the subject cannot be honestly left without some allusion to the marked influence which the sun has upon all Nature, both animate and inanimate. Hygienic writers have generally most astonishingly ignored the powerful effects of this luminary, the centre of life and heat, and without which vegetable life would be a nullity. Can we, therefore, doubt its energizing potency upon animal life?

It is not only poets and sentimentalists that have acknowledged the importance of the moon and the stars as hygienic mental and spiritual influences upon man, but grave doctors and learned searchers after truth have been ready to add the weight of their judgment to the superficial imaginings of the common thought. The moon has been deemed almost the arbiter of man's destiny, for every thing was supposed to be attached to the mystery of its quarterings, and its coming or going was (and is) supposed to have a gravity utterly untenable upon any scientific principle; and yet to the great orb of day, of which the moon and stars are but reflections, and to which we are compelled to directly ascribe life and vigor, so little attention has been paid—perhaps from the comparative absence of mystery—that its importance has been, till lately, unrecognized by hygienic writers.

The long-lived generations of the past did better than worship the sun: they lived in its light, bathed in its warmth, and had their spirits and material substance imbued with its life-giving potency. Instead of sun-penetrated tents, men now live in thick-walled dwellings, through whose stony externals the solar warmth cannot strike to dry up the dank humidity, and the sparse and infrequent rays, that might perchance enter through the narrow windows, are carefully shut out by the voluminous folds of ornamental silks, lest the rich carpets be faded thereby. And the dwellers within live in darkness of vision and intellect, ignorant that they are excluding the royal visitor to whose gracious coming every avenue should be thrown wide open, to admit the king possessing a true "royal touch," potent to the cure of more ills than was ever ascribed to earthly sovereign.

There is a prospect of some return to a renewal of the beneficent influences of the sun, from the sheepish followers of fashion. This fickle goddess has recently started the doctrine that, as a reaction from the tanning effects of a summer's out-of-door exposure, the winter's change adds new brilliancy and transparence to the complexion. Fashionable butterflies now seek for the most complete tanning that the summer's solstice can effect, in order to secure a corresponding reaction, and insensibly gather health and invigoration.

Contrast the myopic and weak-eyed men of the day with the eagle-eyed men of the plain and forest, whose sight needs no screening from the sunlight, by broad visor and head-apparel or dainty parasols. To their unshrinking eyes light has no perils or disagreeableness.

Have we not here another great contrast between the past and the present? Where picturesqueness may have gained from the embowered cottage and the shaded dwelling, has not health suffered. The city, thronged with high residences and warehouses, has shut out the potent rays of the sun, and humanity has grown pallid in its shade, like the inhumed celery-plant or the wide-spreading, spindling sprout of a cellared potato. Here in New York, and in London, Paris, and Berlin, the typhus sick are removed from the hospitals and placed in tents open to air, and purified by the radiance of the health-giving sunbeams. If thus potent for cure, how irresistible for prevention!

Exercise.—The Greeks made exercise a part of education, and the athlete, if not also a philosopher and a poet, or a tragedian and orator, was at least esteemed as highly by the community. Exercise was a part of every one's life, a business, a pleasure, and a necessity.

Till quite recent days, there were no lazy people, no gentlemen, none inactive. War and its martial exercises, labor and its attendant fatigues of the body, the chase and its toils, housewifery, the fabrication by hand of all the necessities of life—these healthy exercises have been done away with by excessive wealth, the fashion of indolence, and steam appliances. Work being now denounced by fashion, and delegated to servants, the women of the country have no severer toil than playing the piano and dancing, with an occasional saunter in the street on a very fine day. Consequently, the languid blood flows through unstimulated veins, resembling the stagnant, slime-covered waters of an undisturbed canal.

The city man, if very vigorous, priding himself upon his powers, walks down to his business from 8 to 10 A. M., and occasionally back again, in a gentlemanly manner, which means not fast enough to be ungraceful, or to moisten his shirt-collar. During the interval between these periods, he sits or stands at a desk or behind a counter. If there is a box to be opened, a bale of goods to be sent aloft, or put into a cart, he calls the porter. Possibly he takes a half-hour turn with some Indian clubs or dumb-bells, in the house, and, of course, where fresh air is tabooed. If he has means, he gets a trotter in a motionless buggy, and over a level road he walks six miles, and then trots fast two miles in great excitement, using his arms and possibly his lungs with some vigor. This is the exercise of the modern athlete, philosopher, and business-man.

Clothing.—The anti-imaginative character of the nineteenth century sets aside the fanciful ideas of the origin of clothing being due to a sudden outburst of modesty. It undoubtedly originated from the exigencies of climate; it was a shelter from the burning sun and a protection from cold and wet. By degrees, this original design became forgotten, and fashion, driving out both original necessity and created modesty, usurped the control of dress, and, like most conquerors, has endeavored to eradicate every possible trace of its original design. Health and comfort and life are disregarded as much as possible. The young child is so dressed as to expose its dimpled arms and its sweet amplitude of neck, and sent to walk, no matter how chill and blustering the weather, with its plump legs unstockinged and bare.

But the improvement in manufactures and the general adoption of machinery into the making of cloths, and especially the general use of the sewing-machine in the fabrication of garments, have made such a difference in the comparative cost of clothing, that it may be believed that never before was the world so comfortably dressed as at present; and the future has still further assistance for the poor, for even now the great labor of cutting is so far modified by mechanical appliances that by the same operation of a single shears a dozen garments are simultaneously struck out, and the final cost is thus materially diminished.

The tendency of daily dress throughout the world, imperfect as it is, is yet an improvement upon the past, and life is rather prolonged than curtailed by the change. The corset, allowing all the objections—and they are not entirely correct—that may be urged against its use and abuse, is yet far in advance of the steel bars, like animal cages, of former days. So far, then, as clothing is concerned, no physical degeneration can be ascribed to modern changes, but, on the contrary, the slight alteration has been for the better; and, other things being equal, its beneficial effects would be markedly evident.

Food.—If we look at the entire population of the inhabitable globe, in the different centuries, we can, with each succeeding age, note an alimentary improvement. We see now few famines bearing widespread destruction in their path. The intercourse of nations, the sympathy of a recognized common humanity, the spirit of trade and commerce, the rapid communication by telegraph, and the power of applied steam, have united to prevent the possibility of a great national famine in the future. The world now feeds the world, and a dearth in one locality is supplied by the affluence of another.

The continual opening of new territories of immense extent, and seemingly inexhaustible richness, and most of all the frequent discovery of new grains, roots, and fruits, and the development and improvement of the old, seem to insure the world for the future against local destitution and suffering of this nature. More than any one thing else, the discovery of the potato has effected this end; while the introduction of Indian corn and the utilization of the animal life that roam over the immense prairies of America, in both a wild and domesticated state, add a large quota to the alimentation of the world, and have raised the physical stamina of humanity.

But while it is acknowledged that the race down to its lowest strata of humanity is improved and improving, the same statement is not true respecting the higher classes. While the average stamina is greater, theirs is unquestionably deteriorated.

We have already shown the injurious results which wealth brings, in depriving the rich of exercise, by taking away its mainspring, in substituting fashion for necessity; it exerts a far more deleterious influence when it ministers to the appetites.

There is a wealth of wisdom in the remark of Abernethy to the rich dyspeptic, the extent of which he probably never dreamed of himself when he uttered it: "Live on a shilling a day, and *earn it*."

This sentence, translated into the language of the present, in New York, would be to each individual, "Earn a dollar a day and feed yourself with that alone." This would approximate to living healthily—as did our forefathers—though it is impossible for a man of ordinary means to feed himself healthily in New York, because bread is a prime necessity. The greater part of the flour which comes to the market is but little different from pure starch, so thoroughly is it bolted by the miller, so thorough-bred (no play on the words) is the grain itself. The wheat itself has suffered in its nutritious qualities by the extreme care taken in its cultivation. The canary-bird fancier, in his zeal to raise high-colored birds by interbreeding, obtains his buttercup-yellow, but at the cost of a very scanty plumage. The stock-raiser gets his thorough-bred horse with his thin neck, small head, diminutive ears, greyhound legs, and peculiar barrel, but with them a high nervous organization and uncertain temper, that make the animal impracticable for the ordinary pursuits of life. The same state of things is seen in the wheat of the country, which, having first nearly exhausted the unfertilized soil, finishes by being itself exhausted of the nutritious phosphates and nitrogenous elements so necessary for the bone and nervous tissues of the human frame. This is very important, especially for the young, a great portion of whose alimentation comes from bread. Add to this deprivation of essential elements, the substitution of starchy substances capable of but imperfect assimilation by any stomach, especially that of a young child, and we have an important source of animal imperfection and debility.

We find like cause of degeneration if we look at another leading source of the life of children—*milk*. Dr. Nathan Allen, in his recent elaborate article ("Physical Degeneration," JOURNAL OF PSYCHOLOGICAL MEDICINE, October, 1870), says that American women are to a great extent incapable of nursing their children, and that they necessarily resort to the bottle and cow's milk. How bad is this substitute, very few have even surmised. We know there is no exaggeration of the ill results from the use of the so-called swill-milk, which, in greater or less quantities, furnishes the chief supply of all our large cities and towns. The present writer made the initial observations on swill-milk, in New York, and his report to the Academy of Medicine was the basis of the subsequent general interest in the subject. This milk is deleterious, because new principles are introduced into the milk, and the normal ones distorted and rendered almost nugatory.

But, setting this matter aside, let us look at the healthy milk of the whole country, and perhaps of the world. What is it?

When a woman, in the vigor of health, while nursing her own child at the breast, becomes again pregnant, her first knowledge of and attention to this fact frequently arise from the effects of her milk upon her nursing babe. Sometimes the child grows meagre, pallid, is evidently not thriving; occasionally has spasms from apparent indigestion; at others, it is often nauseated, and ejects the curdled milk, with or without accompanying diarrhœa. The child is withdrawn from the breast, proper food is substituted, and a manifest improvement commences immediately.

There is a similar cause for a depraved condition in all the milk of the country. No sooner is the calf taken from the dam—say, when six weeks old—than she is again impregnated. In the ordinary course of Nature, her milk would "dry up" on the occurrence of this event; but she is regularly milked twice a day, and thus it happens that all the milk upon which our children are raised has been first deprived of its essential ingredients to nourish the next year's calf.

If any one questions the effect of this double attempt at nutrition, let him compare the milk in ordinary use with that of a "farrow" cow. The latter is small in quantity, thick, redundant in cream, dark in color, of a very high flavor, so as to render it quite unpalatable. This is the milk destined to strengthen the bones and invigorate the energies of the young offspring. It is such milk as this, undrained of its essential elements, that the child demands from his mother. It asks for bread, and you give it starch. It asks for milk, and you give it—what?

In the lack of the natural maternal nutriment, as alleged by Nathan Allen and other eminent writers on this and kindred topics, does not the general use of this deteriorated cows' milk for so many years, as a substitute or as a supplement to supply this general deficiency, point to one among the many causes of physical deterioration?

If any evidence is wanted to show the imperfect nutrition of the better classes, it may be found in the frequency of dyspepsia, scrofulous diseases, and deaths from diseases of exhaustion and debility, as contrasted with the general vigor, capacity for prolonged exertion, digestion of immense dinners, excessive drinking, and general deaths from inflammations, plethora, apoplexies, congestions, gout, and the like, which were the main causes of the death of our forefathers.

If it is also noticeable that the mean of life is now shorter than formerly—as we think it is—then it is deducible that, among other causes, imperfect nutrition holds a prominent place.

Now, when we compare the diet of the past with the present, we find to-day evidences of a delicate and finical appetite, and an enfeebled digestion. The name of "the roast-beef of old England" lives almost but in name; for the degenerate Britons and allies seek for the kickshaws, spiced *entremets*, and flavorous nothings, of still more degenerate nationalities. The vigorous appetites are wanting, and, possibly, the debile gastric juice, arising from a lack of physical exertion and an excess of mental stimulus, may be the active cause of the general physical deterioration so markedly present throughout the civilized world.

There are certain enthusiasts who ascribe all the ills of flesh to certain special causes of comparative trivial importance, but their crude theories are based upon such imperfect data as necessarily to render their deductions of little value. The most cadaverous-looking of them all are the ultra-Grahamites, whose appearance alone is generally sufficient to contradict the assertions that human decadence is due to an animal diet.

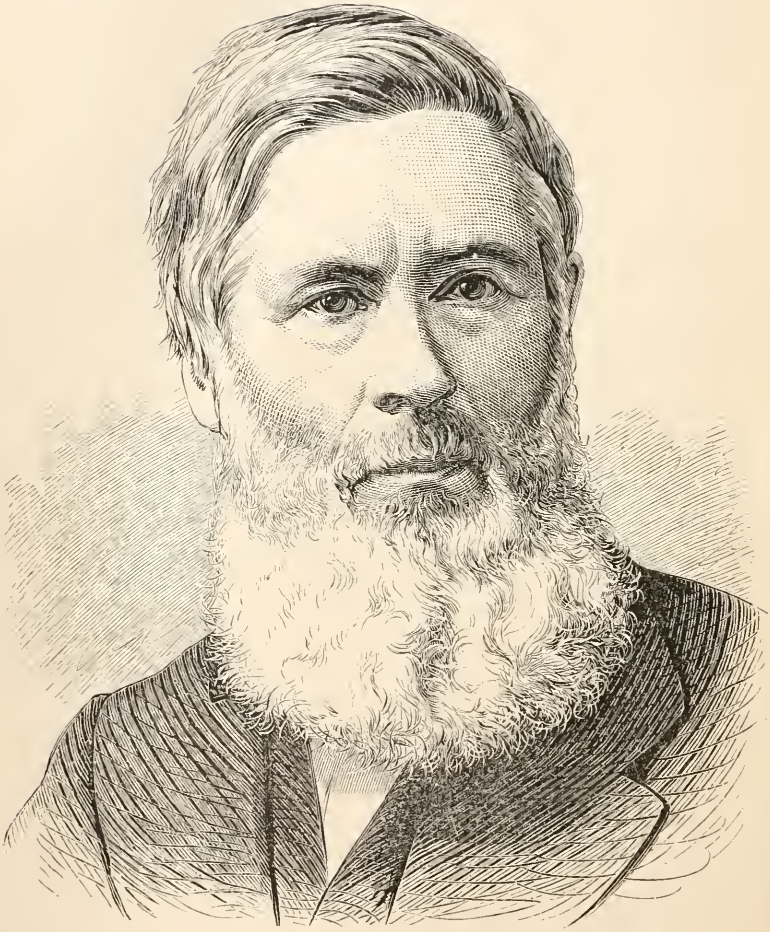
The ultra-temperance partisans have a far stronger argument for the entire disuse of all stimulating beverages, upon moral rather than upon physical grounds; as it is undoubtedly the fact that the character of the diseases of the world has been more modified by the disuse of liquors, etc., than from any one other cause; and to this is ascribed the substitution of the present diseases of inanition for the former inflammatory and congestive affections resulting from over-stimulation.

Still a third class ascribe the deterioration of the race to the increasing use of narcotics, and mainly of opium and tobacco. Every instance of present disease and the use of either of these drugs, in large or small quantities, are considered to be cause and effect.

Unquestionably the excessive use of all these powerful nervines and narcotics has a deleterious effect upon the animal economy, but the extravagant accusations of these ultraists prevent the truth from being acknowledged, and perhaps any consideration of the subject from being entertained. One writer's assertion may be mentioned in illustration of this remark. He says that one using tobacco freely is so permeated by its deleterious properties, that the ordinary mosquitoes, flies, and household vermin, flee from his presence, a statement so at variance with generally-recognized facts, that the entire theory of the perhaps otherwise correct writer is discredited thereby.

Unquestionably, the excessive use of tobacco and spirits—as some sensualists constantly continue under their influence—must have a marked effect upon the nervous energies, thereby interfering with the powers of assimilation and reproduction. It may be, as alleged, that this loss of vigor is entailed upon succeeding generations, and that to these influences may be in truth ascribed some considerable portion of the physical decadence which so characterizes the present epoch.

Rest.—Perhaps it may be true that all Nature requires rest. This is remarkably evident in most, if not all, forms of vegetable and animal life. Plants have their alternate periods of growth and apparent rest. Animals have their periods of activity and repose. The muscle cannot keep up its continued contraction; and the body, wearied by persistent toil or action, however light or pleasing, sooner or later demands rest, and the entire muscular system gives itself up to repose, with the exception of the continuous breathing and the persistent beating of the heart. So far as we can judge, the action of the brain must also have its period of quiescence, with complete abnegation of its wondrous voluntary and involuntary activities.



ASA GRAY,

President of the American Association for the Advancement of Science.

The laboring-man, fatigued by the wearisome hod, takes his nooning in any sequestered spot; but his inactive brain requires not sleep to refresh it, for no task has been imposed upon it, and he needs but to rest his limbs in the pleasant shade. A too prolonged exertion is followed by muscular irregularities, cramps, exhaustion, and rheumatic incapacities, effects disagreeable enough, but generally of temporary duration, and with little or no permanent effect on the general constitution or on succeeding generations.

SKETCH OF PROF. GRAY

WHEN we enumerate the few great living botanists, the list must include Dr. Asa Gray, Fisher Professor of Natural History at Harvard University. To the average reader, this may not imply any great distinction, as a botanist is too commonly looked upon as merely one who can call plants by name. Making specimens and naming plants no more make a botanist than taking an altitude makes an astronomer.

It is not our purpose to show here the scope of botany, nor to consider its claims to an equal rank with other departments of science.

Suffice it to say that it affords exercise for the keenest observation and the most skilful diagnosis; that the closest reasoning, the most thoughtful weighing of evidence, the acutest application of the logic of facts, in short, those qualities of mind that are required in any other scientific pursuit, are demanded of one who would take a high rank as a botanist. We would not be understood as speaking disparagingly of the humbler laborers in botany, for each one in his way does something for the general good. In all sciences the units are accumulated by patient workers whose isolated facts seem to have but little importance of themselves, but, when brought by some master-mind into relation with other facts, they often prove to be the missing links to a heretofore incomplete chain.

Prof. Gray was born at Paris, Oneida County, New York, November 18, 1810, and took the degree of M. D. at Fairfield College in 1831, but relinquished the medical profession for the purpose of prosecuting the study of botany. He was appointed botanist to the United States Exploring Expedition, in 1834, but, in consequence of the delay of that enterprise, resigned his post in 1837. He was elected Professor of Botany in the University of Michigan, but, before that institution went into operation, he took the position of Fisher Professor of Natural History in Harvard University, in 1842, where he now is.

One of the earliest if not the very first contribution of Dr. Gray to botanical literature is his "North American Gramineæ and Cyperaceæ." Two volumes of this were published in 1834–'35, each containing a hundred species, illustrated by dried specimens. Several new species were described in these volumes, and much was done toward revising the characters and synonymes of the older ones. The work was published by subscription, and, from the labor involved in its preparation, only a limited edition could be sent out. It is now a very rare work, but one which must be quoted by whoever would write upon the grasses or sedges of North America.

A paper was read before the New York Lyceum of Natural History, in December, 1834, entitled "A Notice of Some New, Rare, or Otherwise Interesting Plants from the Northern and Western Portions of the State of New York, by Asa Gray, M.D." This first brought its author prominently before the botanists of the day. It was a matter of no little surprise that a young man, working in a field heretofore thought to be well explored, should not only bring to light several new species, but clear up the confusion that surrounded many which had long been kept in a state of uncertainty by the older botanists.

In 1838, the first part of the "Flora of North America" appeared under the joint authorship of John Torrey, M. D. and Asa Gray, M. D. It proposed to give "abridged descriptions of all the known indigenous and naturalized plants growing north of Mexico." This was published in numbers from time to time, and was suspended at the end of *Compositæ*. The value and thoroughness of this work, the faithfulness with which it embodied all that was known of our plants up to the time of publication, can only be appreciated by those who have had occasion to use the work. It is so frequently quoted as "Torrey and Gray," that had these two eminent coworkers made no other contributions to the science, they would still be accorded the title of our first botanists. The union of these botanists upon the Flora was most fortunate, as each had special fondness for certain parts of the work, and thus, the labor being divided, the whole became more complete than if either had undertaken the entire task. If we mistake not, the *Compositæ* of the Flora was mainly the work of Dr. Gray—a task the difficulties of which can only be appreciated by working botanists. The relations between the authors of the Flora have been charming to those whose pleasure it has been to know of them, and are most touchingly expressed by Dr. Gray in the dedication of his Manual in 1867, in which he writes: "To John Torrey, LL. D. Almost twenty years have passed since the first edition of this work was dedicated to you —more than thirty since, as your pupil, I began to enjoy the advantage of being associated with you in botanical pursuits and in a lasting friendship. The flow of time has only deepened the sense of gratitude due to you from your attached friend." We have said thus much about Torrey and Gray, for it is not possible to speak of the botanical career of one without reference to the other.

It was stated that the "Flora of North America" was suspended with the completion of the Composite Family. When the work had reached this point the phrase "growing north of Mexico" had a widely-different meaning from that expressed by the same term when the work was commenced. The annexation of Texas, the acquisition of California and other territory by the Mexican War and, later, the Gadsden Purchase, changed not only our geographical but our phytographical boundaries. Individual and government explorations were pushed not only into the newly-acquired Territories, but our older possessions were more thoroughly examined, and materials came in at such a rate that to continue the Flora as then commenced would require an appendix larger than itself. Each of its authors then occupied himself with studying the new materials as they came to hand, and in giving their results to the scientific world. This interruption of the Flora was followed by the publication, by both Dr. Gray and Dr. Torrey, of a series of most valuable botanical memoirs, sometimes conjointly, but oftener separately. These may be found in the various Government Reports, and in the transactions of the American Academy of Arts and Sciences, of the Smithsonian Institution, and other learned bodies.

The most conspicuous of these contributions to our North American Botany by Dr. Gray are, "*Plantæ Lindheimerianæ*," giving an account of the plants collected in Western Texas, by F. Lindheimer; in this memoir he was aided by Dr. George Engelmann; "*Plantæ Fendlerianæ Novi-Mexicanæ*," a description of the plants collected in New Mexico, by Aug. Fendler; "*Plantæ Wrightianæ Texano-Neo-Mexicanæ*," describing the extensive collections of Charles Wright, A. M. This paper is in two parts, and illustrated. Another memoir, "*Plantæ Novæ Thurberianæ*," though shorter than those already named, is important as describing an unusual number of new genera and species. These contributions are not confined to the working up of the materials of the particular collections of which they treat, but in many cases whole genera are elucidated and rearranged in a masterly manner.

These memoirs are mentioned out of their chronological sequence, as they may be considered, as well as those published by Dr. Torrey, as material accumulated for the use of whoever may undertake that Flora of North America for which botanists are hopefully looking.

In 1848 appeared the first volume of "*Genera Floræ Americæ Boreali-Orientalis Illustrata*," or, as it is best known, under its shorter title, "Gray's Genera." The object of this work was to give a typical specimen of one or more species of each genus of North American plants, with accurate analyses. The drawings for this work were made by Isaac Sprague, and for accuracy of detail and neatness of execution have not been excelled. Two volumes, containing one hundred plates each, were published, when, to the regret of all American botanists, the publication was suspended for the same reasons that we have given for the discontinuance of the "Flora."

The most voluminous and in some respects the most important of Dr. Gray's contributions to science relate to extra-American botany; we refer to the "Botany of the United States Exploring Expedition."

All the various collections made by the expedition of Commodore Charles Wilkes, during the years 1838–1842, save those collected upon our own Pacific coast, were placed in Dr. Gray's hands for elaboration. The collection comprised plants from widely-separated, insular, and continental floras, and the work was one which a less able botanist would have hesitated to undertake. How well the task was performed, two elegant volumes, which are better known in Europe than they are with us, stand as abundant evidence.

In this brief *résumé* of his labors, in systematic botany, we can but merely allude to a host of *opuscula*, or minor contributions—minor only in reference to their size, but of the highest value in their relations to science. These exist in the form of contributions to scientific journals, and to the proceedings of societies or academies. Some are devoted to the clearing up a knotty point in physiology or in classification; some contain the revision of a whole family or genus; while others are devoted to the working up of smaller collections than those comprised in the memoirs already referred to. Nor must we overlook the contributions which for years have appeared in almost every number of the *American Journal of Science and Arts*, of which Dr. Gray has long been one of the editors. In these notes the American reader has been kept *au courant* with all the best work of European botanists.

Such is an imperfect enumeration of our first botanist's contributions to the science; but there remains a greater than these to mention—his elementary works. However we value his labors in the higher departments of science, we render him our gratitude when we look upon what he has done to open a welcome door, through which not only the student, but the reader of average intelligence, and even the child, can enter the heretofore exclusive domain of Botany. Those who now take up the study of botany can have little idea of the difficulties that beset us of a generation or so ago. Where we groped and guessed, doubtful whether we were on the right path or the wrong one, the way is now made clear. The old rubbish is brushed aside, and the student now can walk in pleasant paths, guided by the clearest light of modern science. It is his untiring efforts to popularize science (in the true sense of the word) that has given Dr. Gray a lasting claim upon all who are interested in education and culture. As early as 1836, he published the "Elements of Botany," which grew into the "Structural and Systematic Botany," or "Botanical Text-Book," of the present day, a work that, through its various editions, has kept pace with discovery, and at each issue has stood as the best exponent of the state of *vegetable physiology* in any language.

In 1848 appeared the "Manual of the Botany of the Northern United States," in which our Flora was presented in a compact volume, with concise descriptions. This admirable work has passed through several editions, each one an improvement upon its predecessor, and it now stands unequalled as a local Flora.

When this work first appeared, distinguished botanists abroad thought it either a waste of time or beneath their dignity to be engaged upon popular works; but of late years we find that the most eminent of them are putting out their "Hand-books" and "Popular Floras."

As highly as we value the "Text-Book," we think that in books of this character his "First Lessons" is not only a superior work, but the best work upon elementary science of any kind that we are acquainted with. It is indeed a wonderful attempt at popularizing science. What are considered abstruse points in physiology are told with such a matter-of-fact simplicity, that the reader is charmed as with a tale, and, after reading it, is in possession of more of the philosophy of botany than he could obtain from a dozen more pretentious volumes. We can only just allude to his charming works for young people, "How Plants Grow" and "How Plants Behave," works which, though written for children, will be found to contain bits of wisdom for older heads.

The work that we have indicated implies a great amount of labor, and Dr. Gray is essentially a worker. No mechanic goes to his daily task more faithfully or continues at it with more assiduity than he. Very few, who are not familiar with the laboratories and studios of scientific men, have any idea of the amount of labor performed in them. Their work is by the many looked upon as a sort of half play, not to be compared, in its demand upon the physical and mental resources, with the daily task of the book-keeper or cashier. There are not many who work harder than Dr. Gray, but, when work is over, few more keenly enjoy the relaxation. One of of our pleasantest recollections of him is seeing him, after a hard day's work, engaged in a rough-and-tumble frolic with an enormous Newfoundlander.

It is supposed by many that a student's life diminishes bodily vigor. We can name several striking illustrations to the contrary, and eminent among them is the subject of our sketch. We have not tried a walk with him for several years, but we venture to say that few young men of twenty could take an afternoon's tramp with him and not feel a sense of relief when the excursion was ended.

Outside of the domain of botany, Prof. Gray's contributions to literature are not a few, but, as these were contributed to the *North American Review* and other magazines anonymously, their authorship is not known outside of a small circle. Some of his reviews are remarkable specimens of acute criticism, in which the subject could forget the sharpness with which he was flayed, in admiration at the dexterity of the operator. The estimation in which Dr. Gray is held by his scientific compeers is attested by the fact that he has for several years been the president of that distinguished body of scientists, *The American Academy of Arts and Sciences*, and is for the current year the president of the *American Association for the Advancement of Science.*

EDITOR'S TABLE.

MODERN STUDIES IN EDUCATION.

We hold educational reform to be the first and most important of all reforms. There are many things in this world that need amendment, and, happily, there are plenty of people willing to help on the work. By diverstiy of tastes and division of labor, the business of reform is taken up piecemeal, and it is but natural that each party should clamor for the precedence of its own projects over all others. Some think the world is only to be regenerated by reforming its drinks, others its meats, others its recreations, and others its times of labor. Some are sure that what society most needs is better land-laws, others that it is better revenue regulations, and others, again, wider suffrage or free-trade, or a closer sorting of office-holders. Admitting that much good is yet to be attained in all these directions, there still remains a more radical and comprehensive task of reform. Our notion is. that the great agency which undertakes to prepare human beings for their work in life by awakening and directing their feelings, and by furnishing them with ideas and knowledge, is in extreme need of thorough amendment. Because, as men feel and think, so will they act; as are its constituents, so will be society; and, until people are better instructed in the things which pertain to their true welfare, all other reformatory schemes will yield but partial and unsatisfactory results.

But the phrase "educational reform" is vague and capable of various meanings. That phase of it which is destined to work out the most extensive and salutary effects will consist, we believe, in reconstituting the general methods of study upon a scientific basis. What the world wants now, to give effect to philanthropic aspiration, is to know what to do and how to do it, and the great means to this end must be found in comprehensive scientific education. But there is much misapprehension and some misrepresentation as to what is properly meant by scientific education. Its advocates urge the increasing study of science, and it is charged that they would make education consist in the bare acquisition of physical facts. They protest against the excess of traditional studies, and are reproached with the desire to sever our mental connection with the past. They object to the time given to Greek and Latin, and are accused of being the enemies of language in education. In short, they ask the introduction of new studies into an old system which already covers the whole ground and occupies all the time; and, as this can only be done by abandoning much that is established and venerated, the advocates of this change are characterized as the narrow-minded foes of all liberal culture.

These imputations are, however, erroneous and unjust. What the advocates of scientific reform in education demand is, not that everybody shall become chemists, or astronomers, or geologists, or that the past shall be ignored, or language neglected; but they demand that the unfolding mind of the age shall be put into more direct relation with the present realities of the world than our traditional culture allows. They ask but the thorough modernization of educational systems; and, as the characteristic and controlling element of modern thought is science, they maintain that this should be the characteristic and controlling element of culture. They are the enemies of neither literature, language, nor history, but they insist upon a better opportunity for modern literatures, modern languages, and modern history; and that modern science, by which all these subjects are more and more interpreted, and which is itself the transcendent intellectual interest of the age, shall have the leading place in schools of all grades. Holding to the practical value of positive knowledge for use and guidance in both private and public life, and seeing that it is as true now, as it was in the days of the prophets, that the people perish for lack of it, they demand such a reorganization of educational work as shall most effectually secure this end. The reform now required is, to make available for society the stores of valuable applicable truth which is the latest and highest result of human thought.

And this is a work that remains yet to be done. If it be said that changes have already been made and institutions modified so that modern knowledge is practically attainable, we reply that it has been nothing more than attempted. Notwithstanding the endless talk, the tide of influence is powerfully against the reformers. The question is not what special arrangements may have been made to meet special cases, but what is the ascendant ideal which governs the general practice. When a mother is ambitious that her son shall have a liberal education, and commits him to the accredited agencies, the question is, "What will become of him?" It is notorious that a pupil can go through a course of so-called liberal study, and graduate with honor at the highest institutions, in complete ignorance of that vast body of facts and principles which has arisen in modern times under the name of science, and the object of which is to explain the existing order of the world. There are great educational establishments from which modern knowledge is almost entirely barred out, and which oppose its intrusion with all their power. They fight the "encroachments" of modern science, modern literature, modern language, and modern history, at every point; and it is equally certain that this scheme of higher education in the ancient seats of learning reacts with great power upon inferior institutions, making them also unsympathetic with modern ideas as means and objects of culture.

It is true that we have scientific schools, and that they are doing an excellent work; but the shape they are compelled to take sufficiently attests the vigor and vitality of the traditional system. Where allowed to exist at all, they generally take the form of separate and supplementary institutions — outside appendages to the older colleges which, having grudgingly made this concession to "popular clamor," cling resolutely to their inherited methods. The new schools, in fact, became an excuse for resisting all modifications in the policy of the old, for it is said that the new wants are abundantly supplied by the new arrangements. Meantime it is assiduously maintained that the technical schools are only fitted to make chemists and engineers, and cannot educate in any broad or liberal sense, while thorough culture — the complete training of men—can only be accomplished by the old classical colleges. It is, therefore, as far as possible from true that the public have as yet realized the advantages of modern knowledge in education.

In an able article in our present number, Canon Mozely has shown not only the educational importance of modern literature, but he has shown also how grossly it is neglected in the English universities; and this testimony is the more valuable, as coming from a doctor of divinity, trained in the classical system, and holding a distinguished place in the University of Oxford. How desperate has been the struggle for the past generation to get even the nominal recognition of the sciences in these establishments is well known; and how they have languished, when introduced, is equally notorious. The modern languages have fared no better, although, after a long contest, a point has at last been gained in their favor at Cambridge, which is thus described in *Nature* of June 6th:

"An event occurred on Thursday last at Cambridge, not in itself, perhaps, of imposing magnitude, but yet fraught with very important consequences. For this long while back an agitation has been going on with the purpose of making Greek no longer absolutely essential to the Previous Examination (or 'Little Go,' as it is popularly called), but of allowing French or German, or both, to be substituted for it at the option of the candidate. As any long-headed man might have foreseen, the genuine scholarship and liberal intelligence of the university are in favor of such a change; but the opposition has been neither feeble nor silent. Discussion has abounded more and more, and 'fly-sheets' have fallen like the latter rain. The advocates of the change seem to have been more or less governed by a dislike to many words, and to have had large faith in the merits of their cause; their opponents, on the other hand, appear to have believed in the efficacy of much speaking, and in the effects of arguments drawn from all quarters, and looking all ways; their papers and speeches, all put together, form as pretty a piece of incoherence as may be found in a literary day's march, and would have been a perfect godsend to the great Skepsius when he wrote his famous tract '*An hominibus mens absit.*' The reasons, indeed, for making the change were so clear and cogent, that there seemed hardly any hope of its being accomplished. Yet, by one of those freaks of fortune which are met with even in the universities, wisdom prevailed; and by the vote of the Senate on Thursday last, which will, in all probability, be speedily ratified at a second meeting, the student who desires to go out in an 'honors' examination henceforth need not at his Little Go scratch up a smattering of bad Greek, if he satisfies his examiner that he possesses a real knowledge of French or German. We trust that the scientific workers at Cambridge will take heart at this happy issue of the struggle, and gird up their loins for the heavy task of introducing order and system into the chaos in which the natural-science studies at Cambridge are now lost. It is not a little to the credit of this university that she should have been actually the first to remove one more of the old-fashioned swaddling-clothes which have been checking the development of youthful science, and we trust it is an earnest of still greater changes which she means to take in hand. Science has been too long at that old university a sort of blind Samson, bound with many cords, and serving chiefly to make sport for mocking Philistines of the classical and mathematical tribes. It is time his cords were loosed, and his strength made use of for the general advancement of the university."

ANTHROPOLOGY AND ETHNOLOGY.

These are hard words, and will be ranked by many among those pestilent "ologies" of which so much is said by the learned, and which are supposed to be of so little use or importance to ordinary people. Yet they are significant and indispensable terms, and stand for very weighty things; and, moreover, they represent subjects which are forcing themselves more and more upon the attention of intelligent people. It is, therefore, desirable to have distinct conceptions of what they mean.

Anthropology is the term now applied to the general science of man. It, therefore, comprehends many things, and has, perhaps, not yet reached its full and final definition. It embraces men's physical, mental, and moral characteristics; their religious conceptions, mythology, and traditions; their mental traits and development; their civil and political organizations and institutions; their language, literature, arts, and monuments; their customs and modes of life. This statement may seem sufficiently comprehensive, yet it is really incomplete, and, in fact, hardly touches a whole tract of inquiry, which Prof. Huxley regards as the principal thing. According to his definition, "anthropology is the great science which unravels the complexities of human structure; traces out the relations of man to other animals; studies all that is human in the mode in which man's complex functions are performed; and searches after the conditions which have determined his presence in the world. And anthropology is a section of *Zoology*, which again is the animal half of *Biology*—the science of life and living things."

Ethnology is a branch of anthropology, and is defined as the science of races. The family of mankind is divided up into great groups, which are characterized by numerous and important differences; it is the business of ethnology to trace these differential characters, to estimate their value, and, if possible, to ascertain their source. The ethnologists are divided into two schools: one school holds to the theory of *monogenesis*, or that the human race has had a single origin, or sprung from a single ancestral pair; and the other school holds to the theory of *polygenesis*, or plurality of origins. These schools, of course, take different views of the nature and character of the differences among races. Those who maintain that racial differences have been brought about by natural causes, speak of races as "modified men," and it is with reference to this idea that Prof. Huxley defines the science. He says: "Ethnology is the science which determines the distinctive characters of the persistent modifications of mankind, which ascertains the distribution of those modifications in present and past times, and seeks to discover the causes or conditions of existence, both of the modifications and of their distribution. I say 'persistent' modifications, because, unless incidentally, ethnology has nothing to do with chance and transitory peculiarities of human structure. And I speak of 'persistent modifications,' or 'stocks,' rather than of 'varieties,' or 'races,' or 'species,' because each of these last well-known terms implies, on the part of its employer, a preconceived opinion touching one of these problems, the solution of which is the ultimate object of the science; and, in regard to which, therefore, ethnologists are especially bound to keep their minds open, and their judgments freely balanced."

It is obvious that ethnology covers a large field in the domain of anthropology, and it in fact involves so much of the larger subject that there has been found great practical difficulty in pursuing them separately. The larger subject is the later in the order of cultivation. Ethnological societies were the first to be formed in Paris, London, and New York, but they have disappeared in their distinctive forms, and are now merged in organizations for the promotion of anthropological knowledge. This, however, is but a matter of practical convenience, for the spirit and methods of investigation in both are essentially the same. It is the aim of this science, to study man as all other parts of Nature are studied, with the simple aim of ascertaining and classifying the facts. Putting aside all preconceived views that might vitiate the strict scientific character of the inquiry, the anthropologist asks simply: What are the phenomena presented by the different groups of men? What are their aspects, modes of life, beliefs, traditions, institutions? In short, what are the data which, when authentically presented, will serve as the basis for generalizations respecting the attributes and nature of man?

We publish, in the present number of the MONTHLY, an interesting ethnological sketch of the Calmucks of the Volga. It is translated from the Russian, and is derived from the work of Nebalsine, who resided for a long time at Astrakhan, at the mouth of the Volga, on the Caspian Sea, and he was employed at the "Court of Domains," by which these singular people are governed. At this place he had opportunity to study them carefully and intimately. No Mongol or Turkish race presents such characteristic traits as the Calmucks. They display the persistence of race character in a remarkable degree; answering exactly to the description given of them by Jornandez thirteen centuries ago, when, under the name of Huns, they devastated Southern Europe. Chambers describes the Calmuck as short in stature, with broad shoulders, a large head, small black eyes, always appearing to be half shut, and slanting downward toward the nose, which is flat with wide nostrils, hair black, coarse, and straight, complexion deeply swarthy, while his ugliness is the index of the purity of his descent. The beliefs of the Calmucks, as represented in the article, form an instructive comment on the dogma of the "wisdom of the East."

It is not to be supposed, however, that the wisdom of the West would at all approve the life of these restless nomadic vagrants. They would be told to settle down somewhere, change their religion, go to work, build schoolhouses, and make money, like good Christians. It is, however, probable that the Calmucks would not be without a reply. A traveller, who had studied their customs, made this significant statement: "If it could be proposed to all the academies of Europe to point out the best means to convert those enormous and sterile deserts, which are completely lost for agriculture, into habitable and productive lands, they would with difficulty find a more practical solution of this problem, than that actually put in operation by the Calmucks themselves. In fact, with these poor herbs, so thin and so arid, which they find in these enormous wastes burnt up by the sun, the Calmucks nourish millions of horses, cows, goats, sheep, and camels, and transform these sterile districts into a true and rich source of wealth to Russia. By making a great trade of wool, hair, fat, skins, and pelts, the Calmucks contribute to furnish illumination and defence against cold to a great portion of the northern provinces of the empire. In this particular, the economic part played by the Calmucks is very important."

LITERARY NOTICES.

THEORY OF HEAT. By J. Clerk Maxwell, M. A., F. R. S. D. Appleton & Co.

IT is only recently that the general public has been admitted to a knowledge of the researches which are carried on by the leading physicists of the world. Perhaps an educator would consider the desire of the public to be so admitted one of the most encouraging signs of the times, and he undoubtedly would hail the fellowship of the scientists and their audiences as a good omen. It is a very interesting phenomenon which we are now called upon, almost daily, to witness—this affiliation of the student and the public; and it has many good features, as well as some bad ones. Among the good there are the obvious ones of the acquisition of mere knowledge, of the acquaintance with the rigid and exacting logic of the physicists, of the perception of the real beauty in the order and harmony of Nature, and the familiarity with daring thought which stops short of wild speculation, and displays that poise of intellect which is a striking characteristic of the modern school. And, so far, we have noticed only the good points of this intimacy, which indeed is a novel one.

The scientific man of to-day has a large and attentive audience; and, except he be a devotee to the more abstract of the sciences, he is sure of immediate praise. This, too, is a good result from the close connection. But the effect has been, partly, to make the scientist speak in a manner almost too elementary; in endeavoring to make all things plain, he has been obliged to hide the very highest of his researches, because their demonstration has required too great a stretch of intellect from his hearers.

This has been, partly, inseparate from the form of instruction by lectures, in which form it is, of course, impossible to obtain much close attention to the more complex of his truths, which only allow themselves to be stated in mathematical symbols. We may assume the public of a scientist like Tyndall or Huxley to be composed of three classes: 1. Of scientists themselves, who can and must consult their original memoirs, and who have besides the power to supply any lacunæ in reasoning; 2. Of the general public; and, 3. Of a large and important class of young men, students, to whom science is a cultivator, and who desire didactic treatises which shall give concisely and rigorously the essence of a subject, and which shall not require them to consult publications of scientific societies, which works are often beyond their reach, and to which, at any rate, but few would go.

It is, therefore, with real gratitude that we must look to Prof. Maxwell for his essay on the Theory of Heat.

It fills, exactly, a place before vacant. By it we are led in a logical order, which is very beautiful, from the simple idea of *temperature*, through the *registration* of this *temperature*, and finally to the complex idea of the *measure* of *heat*. From this point an analysis of the book would be almost a history of the development of the science. The subjects of isothermals and adiabatics are fully treated, and the elementary principles of heat engines are stated and proved.

While all this is done, so that a young student, with due attention, may follow the argument, we warn him that the book is no child's play. There are no useless words spent on explanations, but enough is left to keep his mind clear and busy. And it is here, too, that we may speak of the admirable manner of the book which is rigorous throughout. It is an excellent preparation, too, to the memoirs of Clausius, whose mathematical essays are the acknowledged classics on the subject of heat, and who still leads us in the most startling way and at once to differential equations, as if they were our daily bread.

We are sure that there is no one who will not read Clausius "On the Steam-Engine" with much greater ease for having previously read this little book of 312 pages. The foundations of thermodynamics are laid in a simple way; and the chapters on intrinsic energy, on radiation, and on viscosity, are models of their kind.

It is, indeed, to Prof. Maxwell that we owe a beautiful essay on this last subject, mathematical in form, which is printed in the proceedings of the Royal Society. There is also in this volume a discussion of the molecular constitution of bodies, which contains much that is valuable, particularly as an introduction to the various advanced essays on the same interesting topic.

The volume is of a handy size, and is fairly well printed, and there are fewer blemishes in it than in any other of its kind. We notice on pages 139, 152, and 183 (second edition), a looseness which a little more care might have avoided.

On page 139, the author, in speaking of Carnot's reversible engine, says, "It is of a species entirely imaginary, one which it is impossible to construct, but very easy to understand;" thus putting it as a theoretical device solely, as he ought. Again, on page 152 our author proves, or intends to prove, that this engine has a greater efficiency than any other engine, which he attempts to do by an appeal to ordinary experience, which he cites to show that no real working engine "can convert the entire heat of its parts into work," even if this engine consists in part of the theoretical Carnot reversible engine. Now, he has not proved this of any engine, except of those actually in use, and he has expressly declared, as above, that the Carnot engine cannot be made: so that his proof falls to the ground. And, to make matters worse, on page 183 he says: "If we possessed a perfect reversible engine and a refrigerator at the absolute zero of temperature, we might convert the whole of the heat which escapes from the body into mechanical work." On pages 99 and 100 we have a similar carelessness, in the use of the term *strain:* this is defined on page 99 to mean "the alteration of form of any body;" while on page 100 he speaks of the "product of the strain into the average value of the stress," i. e., of the product of a force into a change in shape, which of course is a misnomer, and could be corrected by interpolating the phrase *in any direction* after "strain."

There are but few of even such errors as these, and we must welcome the book as a most valuable one, in which the golden mean between too great simplicity and too great difficulty is admirably kept; and in the name of the ordinary student we are thankful to Prof. Maxwell for his most admirable essay. E. S. H.

How Plants behave. By Asa Gray. New York: Ivison, Blakeman & Taylor.

Fourteen years ago, Prof. Gray published a little school-book, entitled "How Plants grow," which was designed as a first step, for young people and common schools, of his excellent series of botanical text-books. The present volume of forty-six pages, "How Plants behave," is Part II., or a continuation of "How Plants grow," and is devoted to a description of certain remarkable actions and effects in the vegetable kingdom which are open to familiar inspection. The author's object in the preparation of these little works is thus stated in his preface:

"That young people, that all students, indeed, should be taught to observe, and should study Nature at sight, is a trite remark of the day. But it is only when they are using the mind's eye as well, and raising their conceptions to the relations and adaptations of things, that they are either learning science or receiving the full educational benefit of such a study as Botany or any other department of Natural History.

"There is a study of plants and flowers admirably adapted, while exciting a lively curiosity, to stimulate both observation and thought, to which I have long wished to introduce pupils of an early age. The time has now arrived in which I may make the attempt, and may ask young people to consider not only, 'How Plants grow,' but how plants act in certain important respects, easy to be observed—everywhere open to observation, but (like other common things and common doings) very seldom seen or attended to. This little treatise, designed to open the way for the young student into this new, and, I trust, attractive field, may be regarded as a supplement to the now well-known book, the title of which is cited at the beginning of this prefatory note. If my expectations are fulfilled, it will add some very interesting chapters to the popular history of plant-life.

"Although written with a view to elementary instruction, and therefore with all practicable plainness, the subjects here presented are likely to be as novel, and perhaps as interesting, to older as to young readers."

Prof. Gray has well succeeded in his purpose, and the pages of his little book are full of interest to all who care for the curiosities of the vegetable world. His volume is divided into three chapters. The first shows how plants move and climb and take positions; the second tells how plants employ insects to work for them; and the third describes how certain plants capture insects. Among all the surprising effects presented by natural objects, none are more curiously interesting than the habits and adaptations of vegetable structures, and Prof. Gray tells the story in his own clear and graphic way. The pages of his little book are full of pleasant information, and cannot fail to be instructive; and, if the pupils are attracted to go beyond its pages to examine for themselves the structures and actions described, the experience will be invaluable as a cultivation of the observing powers.

MISCELLANY.

Death of Dr. Stimpson.—In the recent death of Dr. William Stimpson, secretary of the Chicago Academy of Sciences, American science has suffered an irreparable loss. He was born near Boston, February 14, 1832, and was drawn by a strong impulse to the study of science in his boyhood. His chosen field was natural history, and before he was nineteen, at which age he published his first scientific paper on conchology, he had made extensive collections. In his search for specimens at the bottom of the sea, he pushed out into deep water and claimed to be the first to enter upon the work of deep-sea dredging. He studied with Agassiz, and in 1852 accompanied him to Norfolk to investigate the marine fauna of that region. He was appointed naturalist to the North-Pacific Exploring Expedition, and spent three and a half years (1852–1856) in observations and collections. For nine years after his return, he remained for the most part in the Smithsonian Institution, working up the results of his world-wide explorations. He became curator of the Chicago Academy of Sciences in 1864, and was soon after elected secretary.

In an able obituary address before the Chicago Academy, President Foster has enumerated his chief contributions to science, and thus speaks of his labors in the institution:

> He maintained a correspondence with not less than fourteen kindred societies at home and over one hundred abroad. He organized a system of exchanges by which our library was supplied with the scientific journals and Transactions, and our museum enriched with natural-history specimens from every quarter of the globe. He edited, with an accuracy of proof-reading rarely surpassed, the two parts of our Transactions, and prepared our annual reports with an almost commercial exactness. So thoroughly classified were the collections, that he could instantly refer the scientific inquirer to the particular specimen required. Under his directorship, the collections in certain departments of natural history had grown to be the most complete in the country; and learned foreigners, in pursuit of information, resorted here as to one of the chosen seats of science. This vast collection had been accumulated within the short space of five years; for, on the 7th of June, 1866, our previous accumulations were almost wholly destroyed by fire. Under this calamity Stimpson bore up manfully, but when the tremendous catastrophe of the 8th of October occurred he was, as it were, crushed to earth. From that time, I think, his spirit lost its buoyancy; and, while he assumed an air of cheerfulness, in his quivering lip and tremulous voice it was easy to detect what he would fain conceal. The iron had entered his soul. Let him who would accuse our friend of undue weakness, read over the melancholy catalogue of losses prepared by the secretary, and dated the 30th of October last, and then call to mind that, in addition to the total destruction of the Academy's collections, which he had arranged and classified, his own collections had been involved in the general calamity; rare books, obtained with difficulty, or presentation copies bearing the autographs of the authors; shells which he had dredged from the ocean all the way from Nova Scotia to the Japanese Sea; and manuscripts in which were embodied the results of twenty years of almost unremitting scientific labor, and whose publication he fondly hoped would form the solid basis of his fame.

Dr. Stimpson had long suffered from weakness of the lungs, and died of hemorrhage May 26, 1872, aged 41.

Purification of Coal-Gas.—In the ordinary process of manufacturing coal-gas it is found necessary to put the product through a course of purification before it is fit for illuminating purposes. The sulphur compounds are the most deleterious of its impurities, and how these may be best removed forms the subject of an instructive lecture, recently delivered by Mr. Vernon Harcourt at the Royal Institution, from which we condense the following: Sulphur being an almost constant constituent of the coal from which gas is made, it is volatilized in the retorts and passes over with the gas in combination with its two principal elements, carbon and hydrogen. Unpurified coal-gas thus contains sulphuretted hydrogen—the gas of rotten eggs—and bisulphide of carbon. A considerable part of the sulphuretted hydrogen is removed in the "condensers" and "scrubbers" by the action of water and ammonia. It has, however, been found that, if coal-gas is washed too much, its illuminating power is greatly impaired, and indeed all washing does some injury to it in this respect. To complete the removal of sulphuretted hydrogen, the washed coal-gas is passed through large boxes, containing either lime or oxide of iron, and which are termed purifiers. Either of these substances acts very effectually in depriving coal-gas of its sulphuretted hydrogen. Lime is the cheaper material, but has the serious drawback that when saturated with sulphuretted hydrogen its smell is very offensive, so that when taken out of the purifiers it becomes a nuisance of a very obnoxious character. Oxide of iron absorbs sulphuretted hydrogen equally well, and has the great superiority that, when taken out of the purifiers and exposed to the air, it not only creates no nuisance, but becomes in a short time fit to be used again. The same oxide may thus be used over and over again for twenty times or more, and when it becomes unfit for the purifiers it is still more valuable on account of the quantity of sulphur it contains.

But neither lime nor oxide of iron exerts any action on the other sulphur impurity, the compound of sulphur and carbon, and at the present time this bisulphide of carbon remains in the gas without any attempt being made to remove it.

The bisulphide of carbon, when burnt, forms for the most part sulphurous acid, which, being a gas, is removed with the carbonic acid by efficient ventilation. But a small part of the sulphur in this compound is converted into sulphuric acid, which, with the aqueous vapor formed, condenses on the walls of the apartments, and has been proved to destroy the leather bindings of books, and the canvas of pictures.

If coal-gas is to be burnt in rooms as freely as oil or candles, it is absolutely essential that the amount of sulphur it contains should be reduced to the smallest possible quantity.

One means by which the elimination of sulphur may be achieved, a process by which the amount of sulphur may be brought down to one-fifth of the present legal maximum, namely, 30 grains in 100 cubic feet, is the following:

The coal-gas is made to pass through tubes which are filled with fragments of iron and heated to redness. When dry hydrogen, contaminated with the vapor of bisulphide of carbon, is passed through a heated glass tube, carbon is deposited, and sulphuretted hydrogen is produced. The action is precisely the same when coal-gas containing bisulphide of carbon is made to pass over strongly-heated surfaces; the bisulphide is decomposed, and sulphuretted hydrogen formed, which is speedily removed by the ordinary purifying apparatus.

Mr. Harcourt showed, by means of a jet-photometer, that there was no appreciable difference in illuminating power between the coal-gas which had passed through an iron tube filled with nails and heated to redness, and that of ordinary cannel-coal gas. He also demonstrated the truth of his statement that, after being thus treated, but one-fifth the quantity of sulphur remained that is found in common illuminating gas.

Facts in relation to Rainfall.—From observations at Fulwell, near Twickenham, England, it appears that the rainfall for that locality during the year 1871 was 22.42 inches. This is nearly the amount which falls at Paris and at San Francisco, California. A calculation made by John James Hall, which was published in *Nature*, April 18th, and corrected in a subsequent number, gives some interesting statistics of the rainfall at Fulwell:

He states that one inch upon an acre of ground gives 22,623 gallons. Now, 640 times this amount, multiplied by the depth of rainfall, 22.42 inches, gives the quantity on a square mile as 324,612,902 gallons.

If this amount be multiplied by 10, the number of pounds of water to the gallon, and the result divided by 2,000 for tons, we shall have, for the quantity of rainfall on the square mile, nearly 1,623,064 tons.

The coal-carriages used on railways in England and in the United States carry from 8 to 10 tons of coal each. We will assume the former number, and find that 202,883 such carriages would be required to convey the weight of the rainfall above given, and, if each carriage measures 20 feet in length, they would form a train 768 miles long.

The quantity of rain which falls at Flatbush, Long Island, in the immediate vicinity of New York City, is 43 inches yearly. This is based upon observations made during 26 years. It will be seen that this amount is nearly twice as great as that which falls in a year at Fulwell, and is not far from the annual average that falls on our coast from Maine to Florida.

The computation which gives the results for Fulwell will give the quantity for each square mile of our own coast. For Flatbush, with an annual rainfall of 43 inches, we have the enormous quantity of 622,594,960 gallons nearly, or 3,112,974 tons of 2,000 pounds each. This is just about one-half the estimated weight of the largest of the pyramids. To convey this amount by railway carriages, of 8 tons each capacity, would require 389,121 carriages, and, if of 20 feet length, they would make a train 1,473 miles long.

When we consider that for each year and upon each square mile of surface along our ocean border, and many miles inland, so vast a volume of water falls, we are astonished at the grandeur and vastness of some of the most common of the operations of Nature.

Prof. Agassiz's South-American Observations. — Prof. Agassiz and his scientific party are continuing their explorations of the South-American coast, in the steamer Hassler, and the professor has just made a second report to the Superintendent of the Coast Survey on the progress of his observations. As is well known, Prof. Agassiz undertook this expedition to accumulate evidence in regard to the extent of glacial action in producing geological effects. He has been a student of glaciers for forty years, grew up in a glacial region, and is familiar with the phenomena; early framed a theory upon the subject, and felt so certain of the truth of his views, that he predicted with great confidence the results of the explorations now undertaken. He says: "As soon as geologists have learned to appreciate the extent to which our globe has been covered and fashioned by ice, they may be less inclined to advocate changes of level between land and sea, wherever they meet with the evidence of the action of water, especially where no marine remains of any kind mark the presence of the sea." He confirms many of Darwin's observations made in the same region thirty years ago, but thinks he ascribed too much to the agency of upheavals. Nevertheless, he discovered a salt-pool with marine animals, in the interior, near Possession Bay, which were undoubtedly due to upheaval. He says:

About a mile from the shore bluff, I found, nearly 150 feet above the sea-level, a salt-pool, in which, to my great surprise, marine shells, identical with those now living along the shore, were abundant. They were in a perfect state of preservation, and many of them were alive; so that I gathered a number of specimens with the living animal, which I have preserved in alcohol. The most common were ferns, myrtilus, buccinum, fissurella, putella, voluta, etc., all found in apparently the same numeric relation as that in which they now exist in the sea below the cliff. The presence of this pool, with its living inhabitants, shows a very recent upheaval of the coast. The period at which it may have taken place it is hardly possible to determine without a more extensive survey.

But these and other evidences of upheaval do not disturb his profound conviction that ice has been the grand agency by which the southern continent has been moulded, as appears from the following:

It was not till we rounded Cape Froward that I felt confident that the range of hills immediately in sight along the channel we followed had assumed their present appearance in consequence of abrasion by ice. Now, however, that I have seen the whole length of the Straits of Magellan, have passed through Smyth's Channel, and visited Chiloe, I am prepared to maintain that the whole southern extremity of the American Continent has been uniformly moulded by a continuous sheet of ice. Everywhere we saw the rounded, undulating forms so well known to the students of glacial phenomena as *roches moutonnées*, combined with the polished surfaces scored by grooves and furrows, running in one and the same direction; while rocks of unequal hardness, dikes traversing other rocks, slates on edges, were all cut to one level. In short, the surface features of the Straits of Magellan have much the same aspect as the glaciated surfaces of the Northern Hemisphere. Whenever the furrows and scratches were well preserved, their trend was northern.

Notes on the Seychelles Islands. — In August, 1871, Nicholas Pike, Esq., U. S. consul at Mauritius, visited the Seychelles Islands, a group lying 900 miles northeast of Mauritius, in the Indian Ocean. They are 29 in number, some of them mountainous, comprising about 50,000 acres of land, and lie between 3° 33′ and 5° 45′ south latitude. Most of them are covered with tropical vegetation.

The shores are fringed with coral-reefs in all places favorable to their growth. Gigantic astræas, brain-corals, madrepores, and coral shrubbery of many hues, cover the reefs of which they form a part.

Consul Pike visited many of the islands and made an interesting sketch of their natural history, which has been published in pamphlet form at Port Louis. Landing at Mahé, he penetrated inland, and found upon the slopes of the hills groves of the jamrosa and the guava-tree.

The jamrosa is the favorite food of the curious leaf-fly (*Phyllium siccifolium*).

The peculiar dress of this insect enables it to elude the pursuit of the uninitiated. In form they imitate various leaves, and the resemblance is the more striking from the peculiar veining of their wings. They are sometimes over three inches in length, and their legs have curious leaf-like expansions. They hide on the under surface of leaves, and, when disturbed, double themselves up, so as to closely resemble crumpled leaflets. Probably no more perfect illustration of protective resemblance and mimicry is afforded by the animal kingdom, than by this little insect.

Scorpions abound on the islands, but are less dangerous and dreaded than a large spider of the genus *Phyrnus*. The female of the species, so plenty on the islands, is one-third larger than the male, being about fourteen lines long.

The many-jointed forelegs are of exceeding tenuity, and measure five inches in length.

These spiders attack by springing on their victim, and their bite causes inflammation, sometimes cramp, vomiting and swelling of the whole body. Ammonia is used by the natives as an antidote for their poison.

A species of mason wasp swarms on the islands, and intrudes everywhere. It builds in houses upon suspended strings, in caves, and in every accessible nook.

It is of a bright-brown color and about one and a quarter inch long. Their cells are about half an inch in length, and built of red mud. Like many species of their class in other parts of the world, they have a curious instinct for preparing food for their young, when in the larva state. After the egg is deposited in the cell, it is carefully filled with small spiders, and closed. The spiders are probably paralyzed by being stung. They continue fresh for several weeks, even retaining their natural colors, and afford the necessary food for the young larva.

The author gives a most interesting account of the wonderful palm-tree, the *coco de mer*. A century ago it was abundant on these islands, now it has nearly disappeared. For one of the nuts of this tree, it is said that the Emperor Rudolph offered 4,000 florins.

These nuts resemble the cocoa-nut in some respects, but are two-lobed, and four or five times larger.

A fine specimen forwarded by Consul Pike to the Long Island Historical Society of Brooklyn, N. Y., is now in its Museum of Natural History.

The tree grows sometimes a hundred feet high, with a slender stem and a ragged head of green and withered leaves. When the young plant attains the age of 20 or 25 years, and before fructification commences, the leaves have attained their greatest size and luxuriance. The stem then begins to rise.

It is nine months after planting before the germ begins to shoot; then, instead of rising directly, it shoots away like a root 15 or 20 feet, when it rises above the surface. Each leaf requires a year's elaboration in sun and air before the next appears. The early Dutch and Portuguese explorers found the immense nuts of this palm floating in the sea, and supposed it to be an ocean product, hence its name *coco de mer*.

Elevation of Lagoon Islands in the Pacific.—At a meeting of the Geological Society of London, held May 8th, Mr. D. Forbes is reported to have said that, "when in 1859 he spent some months in the Pacific, he had been requested by Mr. Darwin to examine into the evidence as to the origin of atolls by elevation, and had found that the asserted cases of the existence of masses of coral at a considerable elevation above the sea merely arose from blocks having been transported inland by the natives."

He, however, thought it possible that elevations had taken place in some instances.

The report, which is given in *Nature* for May 23d, undoubtedly fails, on account of its brevity, to express clearly the remarks and meaning of that eminent naturalist.

It is, we believe, conceded that the observations of Prof. Dana among the coral-islands of the Pacific are thorough and accurate. On pages 345 and 346 of his recently-published work on "Corals and Coral Islands" is given a catalogue of about forty islands in the Pacific which have been more or less elevated since the formation of their reefs. Of these, several are lagoon islands.

Penrhyn's Island has an extensive lagoon and a total elevation of 50 feet above the sea.

Tongatabu and Hapaii are elevated atolls of coral; both have lagoons; the one on Hapaii is now a salt lake 1½ mile long.

Of the elevated islands as given by Prof. Dana, the amount of elevation is from one or two feet to 600 feet in two instances.

The island of Mengaia is girted by a coral-reef 300 feet high.

Others have 25 feet, 60 feet, 90 feet, and 300 feet of elevation.

These reefs were formed as reefs are now being formed, near the surface of the ocean, and their great thickness is accounted for by long but slow subsidence of the land. But it is equally certain that important elevations must have followed in the instances given of elevated atolls and reefs. It is not contended that the elevation is as general as the subsidence was. Nevertheless, instances of elevation occur in various parts of the Pacific, but the amount is not uniform even with islands not very distant from each other. The fact appears to be, that in some cases single islands, in others groups of islands, as the Gilbert Group and part of the Tonga Islands, have risen after an indefinite period of subsidence, and this seems so well established as to be scarcely open for discussion.

Chloral-Hydrate in Hydrophobia.—The *Lancet* for April 20th contains an interesting account of a case of hydrophobia, where the disease was controlled, and terminated in recovery, under the use of hydrate of chloral. The patient was an active business-man, about forty years old, who had been bitten on the hand by his own dog some four or five months previous to the attack. The wound was cauterized at the time, and little more thought of it, until about a fortnight before the disease developed.

The patient states that he first felt a pricking sensation about that part of the hand which had been bitten, followed in two or three days by swelling, and a pain striking up the whole arm, which afterward became numb. He thought it was rheumatism. These symptoms increased, and he began to decline in health. His appetite failed; he had chills and heats, with an occasional headache; felt confused, anxious, and irritable; was easily startled and alarmed. When walking along the streets he would suddenly stop or turn round, and did not know the reason why. If a bird flew out of a hedge, or any unusual noise occurred, he felt agitated. When at chapel the Sunday previous to his being laid up, he experienced a sudden impulse to spring forward and jump over the front of the pew, and he restrained himself from the attempt by laying hold of the seat with both hands. The attack was characterized by the usual hydrophobic symptoms, great difficulty of breathing and of swallowing, distress at the pit of the stomach, convulsions, frightful struggling and howling, wild expression of countenance, frothy discharge from the mouth, and on one occasion a strong propensity to bite. The paroxysms succeeded each other at intervals of about ten minutes, and perceptibly grew worse as they continued. Shortly after being called in, the attending physician, who relates the case, began the administration of chloral-hydrate in twenty-grain doses. After the third dose, the violence of the symptoms began to moderate; the fourth dose was followed by still greater improvement, and the fifth dose put the sufferer to sleep. This soporific effect was kept up by giving the same dose of the chloral at longer intervals. For the next twenty-four hours nothing of any consequence occurred, with the exception of slight twitchings of the face and jerkings of the arms and legs during sleep. These were allayed at any time by an extra dose of the chloral. Beef-tea, mutton-broth, common tea, or water-gruel, was given him occasionally, which he swallowed without much objection when fairly roused up. During the next three days the somnolency was kept up by the medicine, with only a few twitchings showing themselves. On the morning of the fifth day he awoke out of a gentle slumber, and said to his wife, "I feel as if I should like to bite somebody." This was the last symptom noticed of a hydrophobic character. After the fifth day the chloral-hydrate was discontinued, and the quantity taken altogether amounted to 360 grains. When fit to travel, the patient went into the country, subsequently returning able to attend to business.

Northern Exploring Expeditions.—According to a correspondent of the *London Daily News*, four expeditions are now on their way or about to start from different ports in Europe for the north-pole. The Swedish Government sends out one of these under the control of Prof. Nordenskiold, an experienced arctic explorer, who will attempt to reach the pole from high latitudes, by means of sleighs drawn by reindeer. The expedition takes with it a portable house, which is to be put up on the Seven Islands in latitude 80° 30′, the most northern point at which an expedition has ever wintered in these regions. Fifty reindeer are also to be taken along, together with the necessary fodder, and a number of Lapps to attend them. The scientific mission of the expedition is as follows: During the autumn the expedition will take soundings eastward of Spitzbergen; the eastern part of Spitzbergen is to be thoroughly surveyed; a series of continuous meteorological and magnetic observations for the space of an entire year are to be made; pendulum observations for determining the oblate form of the earth, refraction observations, besides a series of careful observations of the abundant animal life found in the Polar Ocean in these high regions. The scientific gain, it is expected, will be exceedingly valuable. The chief object will, however, be to attempt in the spring of 1873, after pushing as far as possible northward by vessel, to proceed, by sleighs drawn by reindeer, in the direction of the pole, and if possible to reach that point.

An Austrian expedition, which has the enthusiastic support of Dr. Petermann, is to set out about the end of June. The object of this expedition is the further exploration of the ice-free ocean, which they met with last summer, to the east and north, and the exploration of the Arctic Ocean to the north of Siberia. The plan of the voyage is as follows: The expedition being provisioned for a period of three years, the first winter is to be spent on Cape Tschelinskin, the most northern promontory of Asia; during the second summer the exploration of the Central Polar Ocean is to be continued, and an effort made to reach the pole; the second winter will be spent on the new Siberian Island, and the third summer will be employed in reaching Behring's Straits and an Asiatic or American haven. A third expedition, which is to act as a sort of tender to the last mentioned, is being fitted out by a certain Count Wilczek, who has already given largely in aid of northern exploration.

Two Norwegian fishing-steamers, under the command of able captains, are also, at the end of the fishing-season, intending to proceed in the direction taken by the Austrian expedition, and make explorations in the Siberian ice-sea, largely with an eye to future business.

A French expedition is also reported, which goes out under the direction of Gustave Ambert, who likewise proposes to follow the track of the Austrian vessel, with a view to "practical" as well as scientific results. Another French explorer, it is said, intends to get at the north-pole by way of balloon; but, how he is to obtain in that locality the supply of gas necessary to enable him to return and announce the discovery, is not stated.

Preservation of Wood.—Since the telegraph system of England came into the hands of the Government, active preparations have been going on for the very considerable extension of some of the lines An important part of the work is the treatment of the poles for the purpose of preventing decay. Boucherie's process is the one employed. This was invented and largely used in France for the preservation of railroad ties and telegraph-poles, and is said to be both cheap and effective. It is thus applied by the English: The manufactory, as it may be termed, is situated in the middle of an extensive field, and consists, in the first place, of a quadrangular structure, four strong poles, some 60 feet in height, forming the angular points Within 6 feet of the top is a platform, on which are two or three vats, each capable of containing

200 gallons. In the bottom portion of this structure are pumps for the purpose of forcing a liquid, chemically prepared, into the vessels above. The principal ingredient, besides water, is sulphate of copper. From these vessels two systems of tubing are carried downward to the ground, and continued along the surface forward to a distance of a couple of hundred yards, in a direction at right angles to the front of the rectangular structure already mentioned. Raised at slight elevation from the ground, and placed at right angles to these tubes, lie the trees to be operated upon, with their thicker ends inward; at intervals of 12 or 15 inches, in this horizontal tubing, is placed a series of taps, each connected by a short India-rubber tube to the end of a tree, to which it is secured by means of cramps and screws, and rendered water-tight by a sort of nozzle. By means of cocks at the upper end of the horizontal piping, the solution in the vats is permitted to descend. The pressure exerted from above forces it into the pipes through the India-rubber tubing and into the trees, traversing them in the direction of their fibre. In a short time, the sap and a portion of the chemical solution are seen to ooze slowly from the smaller end of the tree, when it falls into a sort of wooden gutter, inclined at such an angle as causes it to run back to a cistern near to where it had been originally prepared. After undergoing some filtration here, it is placed along with the yet unused liquid, and again performs the circuit of the vats above and trees below. The time necessary for the complete saturation of the trees varies from ten days to three weeks, according to their quality and age. In this way an application of the principles of hydrodynamics, combined with what is little more than a mechanical chemical knowledge, enables the manufacturer to provide poles for telegraphic purposes which will resist the action of the atmosphere for at least five times as long as the telegraph-poles formerly in use.

Propagation of Disease.—At a late meeting of the Manchester Philosophical Society, the president, in some remarks on the propagation of disease, pointed out how this might occur through house-drains that emptied into sewers. The sewer, acting as a reservoir, receives the diseased emanations from one house, only to send them back through improperly-trapped drains into other houses. Proof of this being a possible mode of spreading disease was furnished by a case, where, in one of the streets of a town suffering from an epidemic of small-pox, several houses on one side of the street were visited by the disease, while on the other side every house escaped. This circumstance was all the more remarkable from the fact that, on the side affected, the yards and spaces about the houses were clean and dry, while on the other side "the privies and slops overflowed the yards and lanes, and the stench was almost unbearable." On the clean side, the houses were connected with the sewer, sewage-gas was within them, and so was the epidemic. On the dirty side, none of the houses communicated with the sewer, and all were free from the disease. "Thus untrapped or badly-trapped drains, terminating in sewers, may be worse than no drains at all."

Detection of Alum in Bread.—Anybody who wishes to test his bread or flour, for the presence of alum, may do so by the following process, which we find described and vouched for by Mr. John Horsley in a recent number of the *Chemical News*. First, make a tincture of logwood, by digesting, for eight hours, two drams of freshly-cut logwood-chips, in five ounces of methylated spirit, in a wide-mouthed phial, and filter. Second, make a saturated solution of carbonate of ammonia in distilled water. A teaspoonful of each solution mixed with a wineglassful of water, in a white-ware vessel, forms a pink-colored liquid. Bread containing alum, immersed in this liquid for five minutes or so, and then placed upon a plate to drain, will in an hour or two become blue on drying, but, if no alum is present, the pink color fades away. If, on drying, a greenish tinge appears, that is an indication of copper, as carbonate of ammonia produces that color, but never a blue.

A Singing Marmot. — Dr. Lockwood's theory of the latent singing capacity of the Rodents has received an interesting item of confirmation from an article in the June number of the *American Naturalist*, by Dr.

R. A. Kellogg, librarian of the Academy of Natural Sciences, San Francisco. He says that Dr. Lockwood's recent articles call out again a statement of his having a young Maryland marmot or woodchuck, when a boy, that "sung like a canary-bird, but in a softer, sweeter note." His impression was, that it was a female. "I used to watch the pet very closely to see how it sang, as children are apt to do. There was a slight motion of the nostrils and lips, and consequently of the whiskers, with an air of unmistakably happy or serene enjoyment."

Is the Singing of Musical Mice labial or guttural?—In answer to this question, which has been prompted by the reading of the article on musical mice in the last number of The Popular Science Monthly, Dr. Lockwood says: "The sound is undoubtedly produced in the upper part of the throat, although, while singing, the lips and nostrils keep up that movement noticeable in the upper lip, so to speak, of the rabbit.

The Rising of Circumpolar Land.—Mr. H. H. Howorth, in a letter to *Nature*, summarizes the evidence in favor of the view that the lands about the north and south poles are undergoing general upheaval. Concerning the northern polar lands, he quotes Captain Parry to the effect that Melville Island shows unmistakable signs of elevation, in the presence of bones of whales and drift-wood buried in the sand, in some cases 15 or 20 feet above the present level of the sea. Franklin gives similar testimony concerning the coast extending from the Mackenzie River to the Rocky Mountains; while Dr. Richardson found a like state of things to the east. The narratives of Maclune and Belcher contain evidence of similar purport. Though generally spoken of as subsiding, the islands in the vicinity of Behring's Straits bear all the traces of having recently been under water. The eastern coast of Asia, including China and Japan, is also being upheaved. The rise of Spitzbergen was observed to be going on as long ago as 1646, and is again affirmed by Parry, in the account of his journey toward the pole.

Evidence of upheaval of lands adjacent to the southern pole is also abundant. In South America, Mr. Darwin found that "the land from the Rio Plata to Terra del Fuego, a distance of 1,200 miles, has been raised in mass (and in Patagonia to a height of between 300 and 400 feet) within the period of now-existing shells." Unmistakable evidences of upheaval are met with at Parana, on the banks of the Uruguay, and below Buenos Ayres. On the west coast in Central and Northern Chili, Mr. Darwin also found the indications of rising land.

Speaking of Southern Africa, Griesback says, "There cannot be the slightest doubt that the upheaval of the country is still going on; for, along the whole coast of South Africa from the Cape to Durham Bluff, and still farther north, even as far as Zanzibar, modern-raised beaches, coral-reefs, and oyster-banks, may everywhere be seen. At the Gzinhluzabalungu Caves is such a point; where the rising of the coast is plainly visible, recent oyster-shells are now 12 feet and more above high-water mark. The same can be observed on the whole line of the Natal Coast."

Of Tasmania Mr. Wintle remarks: "Until a very recent period in the geological annals of this island, a great portion of what now constitutes the site of this city was under water. This is proved by the extensive deposits of comminuted shells, all of recent species, which are met with for miles along the banks of the Derwent. Some of these deposits are at an elevation of upward of 100 feet above high-water mark, and from 50 to 100 yards from the water's edge, plainly showing thereby that a very recent elevation of the land has taken place."

In New Zealand the evidence is the same. M. Reclus says the port of Lyttelton has risen three feet since it was occupied by the settlers. Mr. Forbes says that proofs of upheaving of the land are even now obvious to any intelligent traveller. Some of these changes have been witnessed by the present generation. Again, in the Middle Island upheaval of the land is observable in a marked manner through the entire length of the western coast from Cape Farewell to Dusky Bay. Some of the most extraordinary changes in these regions have taken place within the last few years.

In Australia, the proofs that elevation is now taking place are equally clear and abundant. "The whole coast round, to a distance of several miles inland, is eovered with reeent shells; the drainage of the country is apparently altering. Lakes known to have been formerly filled with salt water are now filling up with fresh or beeoming dry. The lagoons near the eoast are filled with salt and braekish water, and their banks are filled with marine shells with their colors in many eases preserved. Reefs of roeks are constantly appearing in plaees where there were none formerly. At Rivoli Bay the soundings have altered so mueh as to make a new survey requisite. A reef has lately almost closed this harbor. Other reefs have appeared at Cape Jaffa, ete. It would appear that a vast movement is taking plaee in the whole of the south of Australia. In Melbourne the observations of surveyors and engineers have all tended to confirm this remarkable faet."

From these and multitudes of other similar faets, Mr. Howorth coneludes that the circumpolar land is rising about both poles, and that there is a general thrusting out of the earth's periphery, in the direetion of its shorter axis. He also believes that an equally general subsidenee is at the same time going on in the intervening region, extending both north and south of the equator, until it reaehes the line of upheaval.

NOTES.

Prof. Tyndall remarks that the ordinary definition of the solid, liquid, and gaseous states, given in many text-books, is hardly correct. Cohesion is thought to be predominant in the first state of matter, absent in the seeond, and negative—that is to say, absolute repulsion exists among the molecules—in the third. But liquids may be strongly eohesive, and indeed the researehes of many physieists have shown that there is not an absenee of eohesion among, but sliding powers possessed by, the molecules of matter in the liquid state. If air is expelled from water, it is still liquid, but the eohesion of its molecules becomes very great.

A writer in the *Chemical News* states that iodine is set free in sea-water wherever rivers charged with offal and sewage meet the sea. Thus liberated, it passes into the atmosphere, and may sometimes be deteeted long distanees away during the prevalence of favoring winds.

A clergyman, acting in the capacity of chaplain to a lunatic asylum in England, has for the last four years been engaged in the attempt to traee the relations that may exist between meteorologieal states and the mental and physieal eonditions of the insane. He states, as the results of his observations, that the aeeessions of epileptie fits have, as a very general rule, been preeeded or accompanied by considerable alteration in atmospheric pressure, or solar radiation, or both; and he is led to the inferenee that it is not the moon, but the change in the weather, whieh direetly affeets epileptie patients. So far as his observation goes, he concludes that any marked change of atmospheric pressure, solar radiation, or both, either in the same or contrary directions, is almost eertain to be followed by an inereased number of fits among the epileptics, or by a development of mania or melancholia. Sometimes all three forms of disease are augmented at onee, sometimes only one; and it is deserving of notice that very often the maniaeal and melancholie patients seem to be affeeted in opposite ways, the latter being well when the former are exeited, and the reverse.

The following are the regulations adopted by the Prussian Chamber of Deputies to guard against the occurrence of steam-boiler explosions: 1. The owners or representatives are responsible for the observanee of the laws and deerees laid down by the government. They are, moreover, not exonerated from culpability in case of aceidents on aecount of ignorance of such teehnieal laws and rules as are aeknowledged by the profession. 2. The fine is fixed at a maximum of 200 thalers (£30), or, in case of default, three months' imprisonment. 3. The owners of steam-boilers must allow offieial tests to be made by competent engineers. They must bear the expense of the investigation, and furnish the examiners with all requisites.

Drs. Eulenberg and Wohl have been trying the effeets of animal ehareoal as an antidote for phosphorus-poisoning, and find it superior to any thing else heretofore employed. It is given in the form of pills made with gum-tragacanth; and is regarded as preferable to the oil of turpentine, whieh, though an effeetual antidote against phosphorus, eauses in many instanees very severe headaehes when taken internally.

The temperance question, now much agitated in Franee, brings to the surface one ingenious reformer, Dr. Prosper Despine, whose zeal for the cause is at least equal to his diseretion. He proposes to outlaw the growth of the grape, and to make the Freneh abstemious by eneouraging the propagation of worms which destroy the roots of the vine. He would thus do away not alone with the vines, but also with the vanity of the French, for, says the *Saturday Review*, "it is impossible to conceive that vanity could remain in a nation whose salvation had been effected by so humble and earthy an instrument."

In many places in England they have for several years been using a safety-valve for steam-boilers that appears to be an absolute safeguard against explosions from low water. The valve is entirely within the boiler, and so rigged that when the water falls to a certain point the valve opens and a jet of steam is discharged upon the fires, the valve closing again when the water in the boiler is restored to its proper level. Being beyond reach, the valve cannot be tampered with, and, having its working-parts above high-water level in the boiler, it is not liable to get out of order from corrosion. Where these valves have been used, they have proved to be perfectly efficacious as a complete safeguard against explosion and collapse; and they are most highly spoken of, not only by steam-users, but also by inspecting engineers of boiler-insurance associations.

The greater the specific gravity of a gallon of oil, the greater will be the amount of light obtainable from it; or, in other words, a gallon of heavy oil, burning with a flame of given size and luminosity, will last longer than a gallon of lighter oil, burning in the same manner. The light oil is more volatile, passes off into vapor, and is consumed more rapidly; thus the most dangerous oils are the least economical.

In the *Jardin d'Acclimatation* at Strasbourg is a machine contrived for the fattening of fowls. The fowls are placed in a kind of dove-cot ranged in five different stages, each stage holding forty-two birds, which are separated from each other by vertical partitions, and which are so secured that their head and wings alone remain free. The "feeder" stands in front, and, taking the head of the bird in his left hand, forcibly introduces down its neck a quill which is in communication, by means of a hose of India-rubber, with a kind of reservoir full of the food beneath. The operator presses with his food upon this novel species of bellows, and a dial placed opposite to him registers the exact amount of food to a fraction of a cubic inch. The amount of this singular dose differs according to the age and species of the patient, as well as to the degree in which it is desired he should be fattened. In eighteen days a fowl can be brought to the point of fatness desired, and in certain very favorable cases the weight has actually been doubled in that time.

The Annual Meeting of the American Association for the Advancement of Science, which it was expected would be held in San Francisco, is to take place at Dubuque, Iowa, commencing on Wednesday, August 21st.

A remarkable instance of tolerance by the human system of the excessive use of tobacco is afforded in the case of M. Klaës, of Rotterdam. This gentleman, who was known as the "King of Smokers," has just died, in his eightieth year, and is said to have consumed during his long life more than four tons of tobacco. The ruling passion was apparent in the will of the deceased, and in his eccentric request that his oak coffin might be lined with the cedar of his old cigar-boxes, and that a box of French caporal and a packet of old Dutch tobacco might be placed at his foot, and by the side of his body his favorite pipe, together with matches, flint and steel, and tinder.—*Lancet.*

Dip the hand into a finger-glass until the water in it is warmed one degree. An amount of energy is withdrawn from that hand sufficient to project that water to a height of 772, or, if the degree be centigrade, to a height of 1,390 feet above the earth's surface — three times the height of St. Paul's.—*Tyndall.*

Caoutchouc is easily joined and made as strong as an original fabric, by softening it before a fire and laying the edges carefully together, without dust, dirt, or moisture between. The edges so joined must be freshly cut. Tubing can be made by joining the edges of a sheet of India-rubber round a glass cylinder, which has previously been covered with paper. After the glass is withdrawn the paper is easily removed. Sift flour or ashes through the tube to prevent the sides from adhering from accidental contact.

In a note to the Paris Academy of Sciences, on the influence which changes in barometric pressure exert upon the phenomena of life, M. Bent describes the effects produced by exposing small animals to various degrees of atmospheric pressure. He has found that, up to a pressure of two atmospheres, sparrows die when the air in the receiver contains 25 per cent. of carbonic acid, but that, above this limit, and below a pressure of ten inches, this law does not apply.

At the recent meeting of the French Departmental Learned Societies, held at the Sorbonne, gold medals were awarded to M. Grandidier, for his geographical, geological, meteorological, and botanical works, in particular of the island of Madagascar; and to M. Houzeau for his discoveries respecting ozone, which he is enabled to produce in large quantities.

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THE STUDY OF SOCIOLOGY.

By HERBERT SPENCER.

III.—Nature of the Social Science.

OUT of bricks, well burnt, hard, and sharp-angled, lying in heaps by his side, the bricklayer builds, even without mortar, a wall of some height that has considerable stability. With bricks made of bad materials, irregularly burnt, warped, cracked, and many of them broken, he cannot build a dry wall of the same height and stability. The dock-yard laborer, piling cannon-shot, is totally unable to make these spherical masses stand at all as the bricks stand. There are, indeed, certain quite definite shapes into which they may be piled—that of a tetrahedron, or that of a pyramid having a square base, or that of an elongated wedge allied to the pyramid. In any of these forms they may be put together symmetrically and stably; but not in forms with vertical sides or highly-inclined sides. Once more, if, instead of equal spherical shot, the masses to be piled are bowlders, partially but irregularly rounded, and of various sizes, no definite stable form is possible. A comparatively-loose heap, indefinite in its surfaces and angles, is all the laborer can make of them. Putting which several facts together, and asking what is the most general truth they imply, we see it to be this—that the character of the aggregate is determined by the characters of the units.

If we pass from units of these visible, tangible kinds, to the units contemplated by chemists and physicists as making up masses of matter, the same truth meets us. Each so-called element, each combination of elements, each recombination of the compounds, has a form of crystallization. Though its crystals differ in their sizes, and are liable to be modified by truncations of angles and apices, and by partially merging into one another, yet the type of structure, as shown by cleavage, is constant: particular kinds of molecules severally have particular shapes into which they settle themselves as they aggregate. And though in some cases it happens that a substance, simple or compound, has two or even more forms of aggregation, yet the recognized interpretation is, that these different forms are the forms assumed by molecules made different in their structures by allotropic or isomeric changes. So constant is the relation between the nature of any molecules and their mode of crystallizing, that, given two kinds of molecules which are known, from their chemical actions, to be closely allied in their natures, and it is inferred with certainty that their crystals will be closely allied. In brief, it may be unhesitatingly affirmed, as an outcome of physics and chemistry, that throughout all phenomena presented by dead matter the natures of the units necessitate certain traits in the aggregates.

This truth is again exemplified by aggregates of organic matter. In the substance of each species of plant or animal, there is a proclivity toward the structure which that plant or animal presents—a proclivity conclusively proved in cases where the conditions to the maintenance of life are sufficiently simple, and where the tissue has not assumed a structure too finished to permit rearrangement. The perpetually-cited case of the polype, each part of which, when it is cut into several, presently puts on the polype-shape, and gains structures and powers like those of the original whole, illustrates this truth among animals. Among plants it is well exemplified by the Begonias. Here a complete plant grows from a fragment of a leaf stuck into the ground; and, in *Begonia phyllomaniaca*, complete plants grow even out of scales that fall from the leaves and the stem—a fact showing, like the fact which the polype furnishes, that the units everywhere present have for their type of aggregation the type of the organism they belong to; and reminding us of the universal fact that the units composing every germ, animal or vegetal, have a proclivity toward the parental type of aggregation.

Thus, given the natures of the units, and the nature of the aggregate they form is predetermined. I say the *nature*, meaning, of course, the essential traits, and not including the incidental. By the characters of the units are necessitated certain limits within which the characters of the aggregate must fall. The circumstances attending aggregation greatly modify the results; but the truth here to be recognized is, that these circumstances, in some cases perhaps preventing aggregation altogether, in other cases impeding it, in other cases facilitating it more or less, can never give, to the aggregate, characters that do not consist with the characters of the units. No favoring conditions will give the laborer power to pile cannon-shot into a vertical wall; no favoring conditions will make it possible for common salt, which crystallizes on the regular system, to crystallize, like sulphate of soda, on the oblique prismatic system; no favoring conditions will enable the fragment of a polype to take on the structure of a mollusk.

Among such social aggregates as inferior creatures fall into, more or less definitely, the same truth holds. Whether they live in a mere assemblage, or whether they live in something like an organized union, with division of labor among its members, as happens in many cases, is unquestionably determined by the properties of the units. Given the structures and consequent instincts of the individuals as we find them, and the community they form will inevitably present certain traits; and no community having such traits can be formed out of individuals having other structures and instincts.

Those who have been brought up in the belief that there is one law for the rest of the universe and another law for mankind, will doubtless be astonished by the proposal to include aggregates of men in this generalization. And yet that the properties of the units determine the properties of the whole they make up, evidently holds of societies as of other things. A general survey of tribes and nations, past and present, shows clearly enough that it is so; and a brief consideration of the conditions shows, with no less clearness, that it must be so.

Ignoring for the moment the special traits of races and individuals, observe the traits common to members of the species at large; and consider how these must affect their relations when associated.

They have all needs for food, and have corresponding desires. To all of them exertion is a physiological expense; must bring a certain return in nutriment, if it is not to be detrimental; and is accompanied by repugnance when pushed beyond this limit, or even before reaching it. They are all of them liable to bodily injury, with accompanying pain, from various extreme physical actions; and they are liable to emotional pains, of positive and negative kinds, from one another's actions. As says Shylock, insisting on that human nature which Jews have in common with Christians:

"Hath not a Jew eyes? hath not a Jew hands, organs, dimensions, senses, affections, passions? fed with the same food, hurt with the same weapons, subject to the same diseases, healed by the same means, warmed and cooled by the same winter and summer, as a Christian is? If you prick us, do we not bleed? if you tickle us, do we not laugh? if you poison us, do we not die? and if you wrong us, shall we not revenge? If we are like you in the rest, we will resemble you in that."

Conspicuous, however, as is this possession of certain fundamental qualities by all individuals, there is no adequate recognition of the truth that from these individual qualities must result certain qualities in an assemblage of individuals; that in proportion as the individuals forming one assemblage are like in their qualities to the individuals forming another assemblage, the two assemblages will have likenesses;

and that the assemblages will differ in their characters in proportion as the component individuals of the one differ from those of the other. Yet when this, which is almost a truism, has been admitted, it cannot be denied that in every community there is a group of phenomena growing naturally out of the phenomena presented by its members—a set of properties in the aggregate determined by the sets of properties in the units; and that the relations of the two sets form the subject-matter of a science. It needs but to ask what would happen if men avoided one another, as various inferior creatures do, to see that the very possibility of a society depends on a certain emotional property in the individual. It needs but to ask what would happen if each man liked best the men who gave him most pain, to perceive that social relations, supposing them to be possible, would be utterly unlike the social relations resulting from the greater liking which men individually have for others who give them pleasure. It needs but to ask what would happen if, instead of ordinarily preferring the easiest ways of achieving their ends, men preferred to achieve their ends in the most troublesome ways, to infer that, then, a society, if one could exist, would be a widely-different society from any we know. And if, as these extreme cases show us, cardinal traits in societies are determined by cardinal traits in men, it cannot be questioned that less-marked traits in societies are determined by less-marked traits in men; and that there must everywhere be a *consensus* between the special structures and actions of the one and the special structures and actions of the other.

Setting out, then, with this general principle, that the properties of the units determine the properties of the aggregate, we conclude that there must be a Social Science expressing the relations between the two with as much definiteness as the natures of the phenomena permit. Beginning with types of men who form but small and incoherent social aggregates, such a science has to show in what ways the individual qualities, intellectual and emotional, negative further aggregation. It has to explain how slight modifications of individual nature, arising under modified conditions of life, make somewhat larger aggregates possible. It has to trace out, in aggregates of some size, the genesis of the social relations, regulative and operative, into which the members fall. It has to exhibit the stronger and more prolonged social influences which, by further modifying the characters of the units, facilitate further aggregation with consequent further complexity of social structure. Among societies of all orders and sizes, from the smallest and rudest up to the largest and most civilized, it has to ascertain what traits there are in common, determined by the common traits of human beings; what less-general traits, distinguishing certain groups of societies, result from traits distinguishing certain races of men; and what peculiarities in each society are traceable to the peculiarities of its members. In every case it has for its subject-matter the growth, development, structure, and functions of the social aggregate, as brought about by the mutual actions of individuals whose natures are partly like those of all men, partly like those of kindred races, partly distinctive.

These phenomena of social evolution have, of course, to be explained with due reference to the conditions each society is exposed to—the conditions furnished by its locality and by its relations to neighboring societies. Noting this merely to prevent possible misapprehensions, the fact which here concerns us is, not that the Social Science has these or those special characters, but that, given men having certain properties, and an aggregate of such men must have certain derivative properties which form the subject-matter of a science.

"But were we not told some pages back that, in societies, causes and effects are related in ways so involved that prevision is often impossible? Were we not warned against rashly taking measures for achieving this or that desideratum, regardless of the proofs, so abundantly supplied by the past, that agencies set in action habitually work out results never foreseen? And were not instances given of all-important changes that were due to influences from which no one would have anticipated them? If so, how can there be a Social Science? If Louis Napoleon could not have expected that the war he began to prevent the consolidation of Germany would be the very means of consolidating it; if to M. Thiers, five-and-twenty years ago, it would have seemed a dream, exceeding all ordinary dreams in absurdity, that he would be fired at from his own fortifications, how in the name of wonder is it possible to formulate social phenomena in any thing approaching scientific order?"

The difficulty, thus put in as strong a form as I can find for it, is that which, clearly or vaguely, rises in the minds of most to whom Sociology is proposed as a subject to be studied after scientific methods, with the expectation of reaching results having scientific certainty. Before giving to the question its special answer, let me give it a general answer.

The science of Mechanics has reached a development higher than has been reached by any but the purely abstract sciences. Though we may not call it perfect, yet the great accuracy of the predictions which its ascertained principles enable astronomers to make, shows how near to perfection it has come; and the achievements of the skilful artillery-officer prove that, in their applications to terrestrial motions, these principles yield previsions of considerable exactness. But now, taking Mechanics as the type of a highly-developed science, let us note what it enables us to predict, and what it does not enable us to predict, respecting some concrete phenomenon. Say that there is a mine to be exploded. Ask what will happen to the fragments of matter sent into the air. Then observe how much we can infer from established dynamical laws. By that common observation which precedes the more exact observations of science, we are taught that all the fragments, having risen to heights more or less various, will fall; that they will reach the ground at scattered places within a circumscribed area and at somewhat different times. Science enables us to say more than this. From those same principles whence are inferable the path of a planet or a projectile, it deduces the truth that each fragment will describe a curve; that all the curves, though individually different, will be specifically alike; that (ignoring deviations caused by atmospheric resistance) they will severally be portions of ellipses so eccentric as to be indistinguishable from parabolas—such parts of them, at least, as are described after the rush of gases ceases further to accelerate the fragments. But, while the principles of Mechanics help us to these certainties, we cannot learn from them any thing more definite respecting the courses that will be taken by particular fragments. Whether, of the mass overlying the powder to be exploded, the part on the left will be propelled upward in one fragment or several? whether this piece will be shot higher than that? whether any, and, if so, which of the projected masses will be stopped in their courses by adjacent objects they strike?—are questions it cannot answer. *Not that there will be any want of conformity to law in these results*, but that the data, on which predictions of them are to be based, cannot be obtained.

Observe, then, that, respecting a concrete phenomenon of some complexity, the most exact science enables us to make predictions that are mainly general, or only partially special. Seeing that this is so, even where the causes and effects are not greatly involved, and where the science of them is well developed, much more may we expect it to be so among the most involved causes and effects, the science of which is but rudimentary. This contrast, between the generalities that admit of prevision and the specialties that do not admit of prevision, will be still more clearly seen on passing from this preliminary illustration to an illustration in which the analogy is closer.

What can we say about the future of this newly-born child? Will it die of some disorder during infancy? Will it survive awhile, and be carried off by scarlet fever or whooping-cough? Will it have measles or small-pox, and succumb to one or the other? None of these questions can be answered. Will it some day fall down-stairs, or be run over, or set fire to its clothes; and be killed or maimed by one or other of these accidents? These questions also have no answers. None can tell whether in boyhood there may come epilepsy, or St. Vitus's dance, or other formidable affection. Looking at the child now in the nurse's arms, none can foresee with certainty that it will be stupid or intelligent, tractable or perverse. Equally beyond possibility of prediction are those events which, if it survives, will occur to it in maturity—partly caused by its own nature, and partly by surrounding conditions. Whether there will come the success due to skill and perseverance; whether the circumstances will be such as to give these scope or not; whether accidents will thwart or favor efforts—are wholly unanswerable inquiries. That is to say, the facts we ordinarily class as biographical do not admit of prevision.

If, from quite special facts, we turn to facts of a somewhat less special kind which the life of this infant will present, we find, among those that are *quasi*-biographical, a certain degree of prevision possible. Though the unfolding of the faculties is variable within limits, going on here precociously and there with unusual slowness, yet there is such order in the unfolding as enables us to say that the child will not be a mathematician or a dramatist at three years old, will not be a psychologist by the time he is ten, will not reach extended political conceptions while his voice is still unbroken. Moreover, of the emotional nature we may make certain predictions of a kindred order. Whether he will marry or not, no one can say; but it is possible to say, if not with certainty still with much probability, that after a certain age an inclination to marry will arise; and though none can tell whether he will have children, yet that, if he has, some amount of the paternal feeling will be manifested, may be concluded as very likely.

But now, if looking at the entire assemblage of facts that will be presented during the life of this infant as it becomes mature, decays, and dies, we pass over the biographical and *quasi*-biographical, as admitting of either no prevision or but imperfect prevision; we find remaining classes of facts that may be asserted beforehand: some with a high degree of probability, and some with certainty—some with great definiteness and some within moderate limits of variation. I refer to the facts of growth, development, structure, and function.

Along with that love of personalities which exalts every thing inconstant in human life into a matter of interest, there goes the habit of regarding whatever is constant in human life as a matter of no interest; and so, when contemplating the future of the infant, there is a tacit ignoring of all the vital phenomena it will exhibit—phenomena that are alike knowable and important to be known. The anatomy and physiology of Man, comprehending under these names not only the structures and functions of the adult, but the progressive establishment of these structures and functions during individual evolution, form the subject-matter of what every one recognizes as a science. Though there is imperfect exactness in the generalized coexistences and sequences making up this science; though general truths respecting structures are met by occasional exceptions in the way of malformations; though anomalies of function also occur to negative absolute prediction; though there are considerable variations of the limits within which growth and structure may range, and considerable differences between the rates of functions and between the times at which functions are established; yet no one doubts that the biological phenomena presented by the human body may be organized into a knowledge having the definiteness which constitutes it scientific, in the understood sense of that word.

If, now, any one, insisting on the incalculableness of a child's future, biographically considered, asserted that the child, therefore, presented no subject-matter for science, ignoring altogether what we will for the moment call its anthropology (though the meaning now given to the word scarcely permits this use of it), he would fall into a conspicuous error—an error in this case made conspicuous because we are able daily to observe the difference between an account of the living body, and an account of its conduct and the events that occur to it.

The reader doubtless anticipates the analogy. What Biography is to Anthropology, History is to Sociology—History, I mean, as commonly conceived. The kind of relation which the sayings and doings, that make up the ordinary account of a man's life, bear to an account of his bodily and mental evolution, structural and functional, is like the kind of relation borne by that narrative of a nation's actions and fortunes its historian gives us, to a description of its institutions, regulative and operative, and the ways in which their structures and functions have gradually established themselves. And if it is an error to say that there is no Science of Man, because the events of a man's life cannot be foreseen, it is equally an error to say that there is no Science of Society, because there can be no prevision of the occurrences which make up ordinary history.

Of course, I do not say that the parallel between an individual organism and a social organism is so close that the distinction to be clearly drawn in the one case may be drawn with like clearness in the other. The structures and functions of the social organism are obviously far less specific, far more modifiable, far more dependent on conditions that are variable and never twice alike. All I mean is that, as in the one case so in the other, there lie underneath the phenomena of conduct, not forming subject-matter for science, certain vital phenomena, which do form subject-matter for science. Just as in the man there are structures and functions which make possible the doings his biographer tells of, so in the nation there are structures and functions which make possible the doings its historian tells of; and in both cases it is with these structures and functions, in their origin, development, and decline, that science is concerned.

To make better the parallel, and further to explain the nature of the Social Science, we must say that the morphology and physiology of Society, instead of corresponding to the morphology and physiology of Man, correspond rather to morphology and physiology in general. Social organisms, like individual organisms, are to be arranged into classes and sub-classes—not, indeed, into classes and sub-classes having any thing like the same definiteness or the same constancy, but nevertheless having likenesses and differences which justify the putting of them into major groups most markedly contrasted, and, within these, arranging them in minor groups less markedly contrasted. And just as Biology discovers certain general traits of development, structure, and function, holding throughout all organisms, others holding throughout certain great groups, others throughout certain sub-groups these contain; so Sociology has to recognize truths of social development, structure, and function, that are some of them universal, some of them general, some of them special.

For, recalling the conclusion previously reached, it is manifest that, in so far as human beings, considered as social units, have properties in common, the social aggregates they form will have properties in common; that likenesses of nature holding throughout certain of the human races, will originate likenesses of nature, in the nations arising out of them; and that such peculiar traits as are possessed by the highest varieties of men must result in distinctive characters possessed in common by the communities into which they organize themselves.

So that, whether we look at the matter in the abstract or in the concrete, we reach the same conclusion. We need but to glance, on the one hand, at the varieties of uncivilized men and the structures of their tribes, and, on the other hand, at the varieties of civilized men and the structures of their nations, to see inference verified by fact. And thus recognizing, both *a priori* and *a posteriori*, these relations between the phenomena of individual human nature and the phenomena of incorporated human nature, we cannot fail to see that the phenomena of incorporated human nature form the subject-matter of a science.

And now to make more definite the conception of a Social Science thus shadowed forth in a general way, let me set down a few truths of the kind indicated. Some that I propose to name are very familiar; and others I add, not because of their interest or importance, but because they are easy of exposition. The aim is simply to convey a clear idea of the nature of sociological truths.

Take, first, the general fact that along with social aggregation there always goes some kind of organization. In the very lowest stages, where the assemblages are very small and very incoherent, there is no established subordination—no centre of control. Chieftainships of settled kinds come only along with larger and more coherent aggregates. The evolution of a governmental structure, having some strength and permanence, is the condition under which alone any considerable growth of a society can take place. A differentiation of the originally homogeneous mass of units, into a coördinating part and coördinated part, is the indispensable initial step.

Along with evolution of societies in size there goes evolution of their coördinating centres; which, having become permanent, presently become more or less complex. In small tribes, chieftainship, generally wanting in stability, is quite simple; but, as tribes become larger by growth, or by reduction of other tribes to subjection, the coördinating apparatus begins to develop by the addition of subordinate governing agencies.

Simple and familiar as are these facts, we are not, therefore, to overlook their significance. That men rise into the state of social aggregation only on condition that they lapse into relations of inequality in respect of power, and are made to coöperate as a whole only by the agency of a structure securing obedience, is none the less a fact in science because it is a trite fact. This is a primary common trait in social aggregates derived from a common trait in their units. It is a truth in Sociology, comparable to the biological truth, that the first step in the production of any living organism, high or low, is a certain differentiation, whereby a peripheral portion becomes distinguished from a central portion. And such exceptions to this biological truth as we find in those minute non-nucleated portions of protoplasm that are the very lowest living things, are paralleled by those exceptions to the sociological truth, seen in the small incoherent assemblages formed by the very lowest types of men.

The differentiation of the regulating part and the regulated part is, in small primitive societies, not only imperfectly established but vague. The chief does not at first become unlike his fellow-savages in his functions, otherwise than by exercising greater sway. He hunts, makes his weapons, works, and manages his private affairs, in just the same ways as the rest; while in war he differs from other warriors only by his predominant influence, not by ceasing to be a private soldier. And, along with this slight separation from the rest of the tribe in military functions and industrial functions, there is only a slight separation politically: judicial action is but very feebly represented by exercise of his personal authority in keeping order.

At a higher stage, the power of the chief being well established, he no longer supports himself. Still he remains undistinguished industrially from other members of the dominant class, which has grown up while chieftainship has been getting settled; for he simply gets productive work done by deputy, as they do. Nor is a further extension of his power accompanied by complete separation of the political from the industrial functions; for he habitually remains a regulator of production, and in many cases a regulator of trade, presiding over acts of exchange. Of his several controlling functions, this last is, however, the one which he first ceases personally to carry on. Industry early shows a tendency toward self-control, apart from the control which the chief exercises more and more as political and military head. The primary social differentiation which we have noted between the regulative part and the operative part is presently followed by a distinction, which eventually becomes very marked, between the internal arrangements of the two parts: the operative part slowly developing within itself agencies by which processes of production, distribution, and exchange are coördinated, while coördination of the non-operative part continues on its original footing.

Along with a development which renders conspicuous the separation of the operative and regulative structures, there goes a development within the regulative structures themselves. The chief, at first uniting the characters of king, judge, captain, and often priest, has his functions more and more specialized as the evolution of the society in size and complexity advances. While remaining supreme judge, he does most of his judging by deputy; while remaining nominally head of his army, the actual leading of it falls more and more into the hands of subordinate officers; while still retaining ecclesiastical supremacy, his priestly functions practically almost cease; while in theory the maker and administrator of the law, the actual making and administration lapse more and more into other hands. So that, stating the facts broadly, out of the original coördinating agent having undivided functions, there eventually develop several coördinating agencies which divide these functions among them.

Each of these agencies, too, follows the same law. Originally simple, it step by step subdivides into many parts, and becomes an organization, administrative, judicial, ecclesiastical, or military, having graduated classes within itself, and a more or less distinct form of government within itself.

I will not complicate this statement by doing more than recognizing the variations that occur in cases where supreme power does not lapse into the hands of one man (which, however, in early stages of social evolution is an unstable modification). And I must explain that the above general statements are to be taken with the qualification that differences of detail are passed over to gain brevity and clearness. Add to which that it is beside the purpose of the argument to carry the description beyond these first stages. But duly bearing in mind that, without here elaborating a Science of Sociology, nothing more than a rude outline of cardinal facts can be given, enough has been said to show that, in the development of social structures, there may be recognized certain most general facts, certain less general facts, and certain facts successively more special; just as there may be recognized general and special facts of evolution in individual organisms.

To extend, as well as to make clearer, this conception of the Social Science, let me here set down a question which comes within its sphere. What is the relation in a society between structure and growth? Up to what point is structure necessary to growth? after what point does it retard growth? at what point does it arrest growth?

There exists in the individual organism a duplex relation between growth and structure which it is difficult adequately to express. Excluding the cases of a few low organisms living under special conditions, we may properly say that great growth is not possible without high structure. The whole animal kingdom, throughout its invertebrate and vertebrate types, may be cited in evidence. On the other hand, among the superior organisms, and especially among those leading active lives, there is a marked tendency for completion of structure to go along with the arrest of growth. While an animal of elevated type is growing rapidly, its organs continue imperfectly developed—the bones remain partially cartilaginous, the muscles are soft, the brain lacks definiteness; and the details of structure throughout all parts are finished only after growth has ceased. Why these relations are as we find them, it is not difficult to see. That a young animal may grow, it must digest, circulate blood, breathe, excrete waste products, and so forth; to do which it must have tolerably-complete viscera, vascular system, etc. That it may eventually become able to get its own food, it has to develop gradually the needful appliances and aptitudes; to which end it must begin with limbs, and senses, and nervous system, that have considerable degrees of efficiency. But, along with every increment of growth achieved by the help of these partially-developed structures, there has to go an alteration of the structures themselves. If they were rightly adjusted to the preceding smaller size, they are wrongly adjusted to the succeeding greater size. Hence, they must be remoulded—unbuilt and rebuilt. Manifestly, therefore, in proportion as the previous building has been complete, there arises a great obstacle in the shape of unbuilding and rebuilding. The case of the bones shows us how this difficulty is met by a compromise. In the thigh-bone of a boy, for instance, there exists, between the condyle, or head, and the cylindrical part of the bone, a place where the original cartilaginous state continues; and where, by the addition of new cartilage and new osseous matter, the shaft of the bone is lengthened: the like going on in an answering place at the other end of the shaft. Complete osssification at these two places occurs only when the bone has ceased to increase in length; and, on considering what would have happened had the bone been ossified from end to end before its growth was complete, it will be seen how great an obstacle to growth is thus escaped. What holds here, holds throughout the organism: though structure up to a certain point is requisite for further growth, structure beyond that point impedes growth. How necessary is this relation we shall equally perceive in a more complex case—say, the growth of an entire limb. There is a certain size and proportion of parts, which a limb ordinarily has in relation to the rest of the body. Throw upon that limb extra function, and within moderate limits it will increase in strength and bulk. If the extra function begins early in life, the limb may be raised considerably above its usual size; but, if the extra function begins after maturity, the deviation is less: in either case, however, being great. If we consider how increase of the limb is effected, we shall see why this is so. More active function brings a greater local supply of blood; and, for a time, new tissue is formed in excess of waste. But the local supply of blood is limited by the sizes of the arteries which bring it; and though, up to a certain point, increase of flow is gained by temporary dilatation of them, yet beyond that point increase can be gained only by unbuilding and rebuilding the arteries. Such alterations of arteries slowly take place—less slowly with the smaller peripheral ones, more slowly with the larger ones out of which these branch; since these have to be altered all the way back to their points of divergence from the great central blood-vessels. In like manner, the channels for carrying off waste products must be remodelled, both locally and centrally. The nerve-trunks, too, and also the centres from which they come, must be adjusted to the greater demands upon them. Nay, more; with a given visceral system, a large extra quantity of blood cannot be permanently given to one part of the body, without decreasing the quantities given to other parts; and, therefore, structural changes have to be made by which the drafting-off of blood to these other parts is diminished. Hence, the great resistance to increase in the size of a limb beyond a certain moderate limit. Such increase cannot be effected without unbuilding and rebuilding not only the parts that directly minister to the limb, but, eventually, all the remoter parts. So that the bringing of structures into perfect fitness for certain requirements, immensely hinders the adaptation of them to other requirements—readjustments become difficult in proportion as adjustments are made complete.

How far does this law hold in the social organism? To what extent does it happen here, too, that the multiplying and elaborating of institutions, and the perfecting of arrangements for gaining immediate ends, raise impediments to the development of better institutions and to the future gaining of higher ends? Socially, as well as individually, organization is indispensable to growth: beyond a certain point there cannot be further growth without further organization. Yet there is not a little reason for suspecting that beyond this point organization is indirectly repressive—increases the obstacles to those readjustments required for larger growth and more perfect structure. Doubtless the aggregate we call a society is much more plastic than an individual living aggregate to which it is here compared—its type is far less fixed. Nevertheless, there is evidence that its type tends continually to become fixed, and that each addition to its structures is a step toward the fixation. A few instances will show how this is true alike of the material structures a society develops and of its institutions, political or other.

Cases, quite insignificant, perhaps, but quite to the point, are furnished by our appliances for locomotion. Not to dwell on the minor ones within cities, which, however, show us that existing arrangements are impediments to better arrangements, let us pass to railways. Observe how the inconveniently-narrow gauge (which, taken from that of stage-coach wheels, was itself inherited from an antecedent system of locomotion) has become an insuperable obstacle to a better gauge. Observe, also, how the type of carriage, which was derived from the body of a stage-coach (some of the early first-class carriages bearing the words "*tria juncta in uno*"), having become established, it is immensely difficult now to introduce the more convenient type later established in America; where they profited by our experience, but were not hampered by our adopted plans. The enormous capital invested in our stock of carriages cannot be sacrificed. Gradually to introduce carriages of the American type, by running them along with those of our own type, would be very difficult, because of our many partings and joinings of trains. And thus we are obliged to go on with a type that is inferior.

Take, again, our system of drainage. Urged on as it was some 30 years ago as a panacea for sundry sanitary evils, and spread as it has been by force of law through all our great towns, this system can not now be replaced by a better system without immense difficulty. Though, by securing decomposition where oxygen cannot get, and so generating chemical compounds that are unstable and poisonous, it has in many cases produced the very diseases it was to have prevented; yet it has become almost out of the question now to adopt those methods by which the excreta of towns may be got rid of at once innocuously and usefully. Nay, worse—one part of our sanitary administration having insisted on a sewage-system by which Oxford, Reading, Maidenhead, Windsor, etc., pollute the water London has to drink, another part of our sanitary administration makes loud protests against the impurity of the water, which it charges with causing disease (not remarking, however, that law-enforced arrangements have produced the impurity). And now there must be a reorganization that will be immensely impeded by the existing premature organization, before we can have either pure air or pure water.

Our mercantile arrangements, again, furnish abundant illustrations teaching the same lesson. In each trade there is an established course of business; and, however obvious may be some better course, the difficulties of altering the settled routine are, if not insurmountable, still very considerable. Take, for instance, the commerce of literature. In days when a letter cost a shilling and no book-post existed, there grew up an organization of wholesalers and retailers to convey books from publishers to readers: a profit being reaped by each distributing agent, primary and secondary. Now that a book may be ordered for a half-penny and sent for a few pence, the old system of distribution might be replaced by one that would diminish the cost of transfer, and lower the prices of books. But the interests of distributors practically negative the change. An advertised proposal to supply a book direct by post, at a reduced rate, offends the trade; and by ignoring the book they check its sale more than its sale is otherwise furthered. And so an old organization once very serviceable now stands in the way of a better organization. The commerce of literature furnishes yet another illustration. At a time when the reading public was small and books were dear, there grew up circulating libraries, enabling people to read books without buying them. At first, few, local, and unorganized, these circulating libraries have greatly multiplied, and have become organized throughout the kingdom: the result being that the demand for library-circulation is in many cases the chief demand. This arrangement being one which makes few copies supply many readers, the price per copy must be high, to obtain an adequate return on the edition. And now reading people in general, having been brought up in the habit of getting books through libraries, they usually do not think of buying the books themselves—would still get most of them through libraries even were they considerably cheapened. We are, therefore, except with works of very popular authors, prevented, by the existing system of book-distribution in England, from adopting the American system—a system which, not adjusting itself to few libraries but to many private purchasers, issues large editions at low prices.

Instances of another class are supplied by our educational institutions. Richly endowed, strengthened by their *prestige*, and by the bias given to those they have brought up, our colleges, public schools, and other kindred schools early founded, useful as they once were, have long been enormous impediments to a higher education. By subsidizing the old, they have starved the new. Even now they are retarding a culture better in matter and manner; both by occupying the field, and by partially incapacitating those who pass through them for seeing what a better culture is. More evidence of a kindred kind is offered by the educational organization developed for dealing with the masses. The struggle going on between Secularism and Denominationalism in teaching might alone show to any one, who looks for the wider meanings of facts, that a structure which has ramified throughout a society, acquired an army of salaried officials looking for personal welfare and promotion, backed by classes, ecclesiastical and political, whose ideas and interests they further, is a structure which, if not unalterable, is difficult to alter in proportion as it is highly developed.

These few examples, which might be supported by others from the military organization, the ecclesiastical organization, the legal organization, will make comprehensible the analogy I have indicated; while they make clearer the nature of the Social Science, by bringing into view one of its questions. That with social organisms, as with individual organisms, structure up to a certain point is needful for growth is obvious. That in the one case, as in the other, continued growth implies unbuilding and rebuilding of structure, which therefore becomes in so far an impediment, seems also obvious. Whether it is true in the one case, as in the other, that completion of structure involves arrest of growth, and fixes the society to the type it has then reached, is a question to be considered. Without saying any thing more by way of answer, it is, I think, manifest enough that this is one belonging to an order of questions entirely overlooked by those who contemplate societies from the ordinary historical point of view; and one pertaining to that Social Science which they say does not exist.

Are there any who utter the *cui bono* criticism? Probably not a few. I think I hear from some, whose mental attitude is familiar to me, the doubt whether it is worth while to ask what happens among savage tribes; in what way chiefs and medicine-men arise; how the industrial functions become separated from the political; what are the original relations of the regulative classes to one another; how far the social structure is determined by the emotional natures of individuals, how far by their ideas, how far by their environment. Busied as men of this stamp are with what they call "practical legislation" (by which they seemingly mean legislation that recognizes proximate causes and effects, while ignoring remote ones), they doubt whether conclusions, of the kind Social Science proposes to draw, are good for much when drawn.

Something may, however, be said in defence of this study which they thus estimate. Of course, it is not to be put on the same level with those historical studies so deeply interesting to them. The supreme value of knowledge respecting the genealogies of kings, and the fates of dynasties, and the quarrels of courts, is beyond question. Whether or not the plot for the murder of Amy Robsart was contrived by Leicester himself, with Queen Elizabeth as an accomplice; and whether or not the account of the Gowrie Conspiracy, as given by King James, was true; are obviously doubts to be decided before there can be formed any rational conclusions respecting the development of our political institutions. That Friedrich I. of Prussia quarrelled with his step-mother, suspected her of trying to poison him, fled to his aunt, and when he succeeded to the electorate intrigued and bribed to obtain his kingship; that, half an hour after his death, his son Friedrich Wilhelm gave his courtiers notice to quit, commenced forthwith to economize his revenues, made it his great object to recruit and drill his army, and presently began to hate and bully his son—these, and facts like these about all royal families in all ages, are facts without which the progress of civilization would be incomprehensible. Nor can one dispense with full knowledge of events like those of Napoleon's wars—his Italian conquests and exactions, and perfidious treatment of Venice; his expedition to Egypt, successes and massacres there, failure at Acre, and eventual retreat; his various negotiations, alliances, treaties of peace and breaches of them; and so on with details of his various campaigns in Germany, Spain, Russia, etc., including accounts of his strategy, tactics, victories, defeats, slaughters, etc., etc.; for how, in the absence of such information, is it possible to judge what institutions should be advocated and what legislative changes should be opposed?

Still, after due attention has been paid to these indispensable matters, a little time might, perhaps, with advantage be devoted to the natural history of societies. Some guidance for political conduct would possibly be reached by asking, What is the normal course of social evolution, and how it will be affected by this or that policy? It may turn out that legislative action of no kind can be taken that is not either in harmony with, or at variance with, the processes of national growth and development as naturally going on; and that its desirableness is to be judged by this ultimate standard rather than by proximate standards. Without claiming too much, we may at any rate expect that, if there does exist an order among those structural and functional changes which societies pass through, knowledge of that order can scarcely fail to affect our judgments as to what is progressive, and what retrograde—what is desirable, what is practicable, what is Utopian.

To those who think such an inquiry worthy to be pursued, will be addressed the chapters that are to follow. There are sundry considerations important to be dwelt upon, before commencing Sociology. To a clear idea of the nature of the science have to be added clear ideas of the conditions to successful study of it. These will henceforth occupy us.

CLEVER FISHES.

By FRANCIS FRANCIS.

WHETHER we owe many of the matters we are about to glance at to fishes or no, it is certain that the fishes possessed them long before we did, and though man may be said to have invented them, yet in his savage state he must have taken more or less of hints from Nature, and have adopted the methods which Nature pointed out to him as the most effective in hunting or war (which were his principal occupations) whenever they could be adapted to his needs and appliances. However this may be, it is certainly singular that we should find so many existing similarities of a peculiar kind between the habits and attributes of men and fishes. For example, there is scarcely a sport we practise or a weapon of offence that we use which has not a parallel among fishes. As to weapons—daggers, spears, swords, are all possessed by fish in a very high state of natural perfection, and even guns have a representative institution among fishes. A Shooting-Fish would no doubt be looked upon almost as a *lusus naturæ* by the average Englishman, who rarely includes ichthyology among his studies—a fact which is very much to be lamented, for we have large national interests bound up in that science; in fact, we owe a great deal more to fishes than any other nation, not even excluding the Dutch, some of whose cities were formerly figuratively described as built on fish-bones, and a professorial chair of Ichthyology at the universities would be by no means an unwise institution. It is not many years since, that a review which was published in an influential paper, dealing, among other things, with this special point, contemptuously dismissed the fact (as a traveller's tale) of there being such a thing as a shooting-fish. The ignorance among the general public on every thing relating to fish is at times perfectly surprising. I have seen small, worthless bass passed off as gray mullet; I have seen even nasty, gravid pond-roach hawked about as gray mullet; I have seen large bass actually sold for salmon at one of our fashionable watering-places. After this, if the Londoner constantly buys coarse, dry, tasteless bull-trout as fine Tay salmon, it is not to be wondered at.

The Eton boy hastening home for the holidays provides himself with a tin tube and a pocketful of peas. We beg the present Etonian's pardon; we should have said he used to do so formerly, when there were boys at Eton, and, backed by some skill as a marksman, therewith constituted himself an intolerable nuisance to every village and vehicle he passed on his road home. The Macoushee Indian makes a better use of his blow-tube; he puffs small arrows and hardened balls of clay through it with unerring aim, doing great execution among birds and other small game. Now, the Chætodon (*Chætodon rostratus*), which is more or less a native of the Eastern seas from Ceylon to Japan, rather perhaps resembles the Macoushee Indian than the Eton boy, though his gun, shooting-tube, or blow-pipe, or whatever it may be termed, is a natural one. His nose is really a kind of "beak," through which he has the power of propelling a small drop of water with some force and considerable accuracy of aim. Near the edge of the water is perhaps a spray of weed, a twig, or a tuft of grass; on it sits a fly, making its toilet in the watery mirror below. Rostratus advances cautiously under the fly; then he stealthily projects his tube from the water, takes a deadly aim, as though he were contesting for some piscatory Elcho shield, and pop goes the watery bullet.

"Poor insect, what a little day of sunny bliss is thine!"

Knocked over by the treacherous missile, drenched, stunned, half drowned, she drops from her perch into the waters below, to be sucked in by the Chætodon.

But if we have fishes who can shoot their game, we have also fishes who can fish for it; ay, and fish for it with rod and line, and oait, as deftly as ever angler coaxed gudgeons from the ooze of the New River or salmon from the flashing torrent of the Spey. Witness this clumsy-looking monster the Fishing-Frog (*Lophius piscatorius*). Frightful and hideous is he, according to our vulgar notions of loveliness, which the Lophius possibly might disagree with. The beast is sometimes five or six feet in length, with an enormous head in proportion to the rest of its body, and with huge sacs like bag-nets attached to its gill-covers, in which it stows its victims; and what a cavernous mouth! Surely a fish so repulsive, and with a capacity so vast and apparently omnivorous, would frighten from its neighborhood all other fish, and would, if its powers of locomotion were in accordance with its size, be the terror of the seas to fish smaller than itself; but Providence knoweth how to temper its gifts, and the Lophius is but an indifferent swimmer, and is too clumsy to support a predatory existence by the fleetness of its motions. How, then, is this huge capacity satisfied? Mark those two elongated tentacles which spring from the creature's nose, and how they taper away like veritable fishing-rods. To the end of them is attached, by a line or a slender filament, a small glittering morsel of membrane. This is the bait. The hooks are set in the mouth of the fisherman down below. But how is the animal to induce the fish to venture within reach of those formidable hooks? Now mark this perfect feat of angling. How does the Thames fisherman attract the gudgeons? They are shy; he must not let them see him, yet he must draw them to him, and he does it by stirring up the mud upon the bottom. "In that cloud of mud is food," say the gudgeons. Then the angler plies his rod and bait. Just so the Lophius proceeds, and he too stirs up the mud with his fins and tail. This serves not only to hide him, but to attract the fish. Then he plies *his* rod, and the glittering bait waves to and fro like a living insect glancing through the turbid water. The gudgeons, or rather gobies, rush toward it. "Beware! beware!" But when did gudgeon attend to warning yet? Suddenly, up rises the cavernous Nemesis from the cloud below, and "snap!" the gobies are entombed in the bag-net, thence to be transferred to the Lophius's stomach, when there are enough of them collected to form a satisfactory mouthful.

But we have still other sportsmen-fish; we have fish who hunt their prey singly, or in pairs, or even in packs, like hounds. The reader, possibly, has never witnessed a skäll in Scandinavia. It is a species of hunt in which a number of sportsmen take in a wide space of ground, where game exists, drawing a cordon around it, and narrowing their circle little by little, and driving the game together into a flock, when they shoot them down. There was some years ago a capital description of porpoises making a skäll upon sand-eels, written by the late Mr. James Lowe, sometime editor of the *Critic* and "Chronicler" of the

Field, who saw the sight while fishing near the Channel Islands with Peter le Nowry, the pilot. Having searched for this passage several times, without being able to find it, I am reluctantly compelled to quote from memory. They were fishing off Guernsey, when Mr. Lowe called Peter's attention to several porpoises, which seemed to be engaged in a water-frolic, swimming after one another in a circle. "That is no frolic, but very sober earnest for the sand-eels," said Peter. "Now," he continued, "I will show you a sight which I have only chanced to see two or three times in my life, and you therefore are very lucky to have the opportunity of seeing it at all. There is a great shoal of sand-eels yonder, and the porpoises are driving them into a mass; for, you see, the sand-eel is only a very small morsel for a porpoise, and to pick them up one by one would not suit Mr. Porpoise, who would get hungry again by the time he had done feeding on them singly; so they drive them into a thick crowd, in order that when they make a dash at them they may get a dozen or two at a mouthful. But, as we want some for bait, we will join in the hunt." And they edged down to the spot till they were within the circle. The porpoises, following one another pretty closely, were swimming round, now rising to the surface, now diving below, and gradually contracting the circle. The terrified sand-eels were driven closer and closer, and in their fear came to the surface all about the boat; and, just as two or three porpoises made a dash into the crowd, snapping right and left, the fishermen plunged their nets into the water, and brought them up quite full of these little fish. Of course the shoal soon broke up and dispersed, but the skill with which the skäll was conducted and the beauty of the sight were much dilated on by Mr. Lowe, and it must have been a very interesting one.

There are many fish which hunt their prey singly, as the pike and trout, and the way in which a large pike or trout will course and run down a smaller fish resembles nothing so much as a greyhound coursing a hare. Now the unhappy little fish turns from side to side in its efforts to escape, while its pursuer bends and turns to every motion, following close upon his track, and cutting him off exactly as a greyhound does a hare. Now he rushes among a shoal of his fellows, hoping to be lost sight of in the crowd and confusion; but the grim foe behind is not to baffled or deceived, and, singling him out and scattering the small fry, which fly in all directions, ruffling the surface of the water like a sudden squall of wind in their fright, follows up his victim with unerring instinct. In an agony of terror the poor little quarry springs again and again frantically from the water, only to fall at last exhausted into the gaping jaws of his ravenous foe, who, gripping his body crosswise in his mouth, sails steadily away to his lair, there to devour his prey at leisure. Other fish hunt their food like dogs or wolves in packs, as does the bonito chase the flying-fish, and one perhaps of the fiercest, most savage, and resolute of these is the Pirăi, of South America. So fierce and savage are these little pirates, when their size and apparent capability are taken into consideration, that their feats of destructiveness are little short of the marvellous. Stand forth, then, "piräi" of the Carib, "black, saw-bellied salmon" (*Serra salmo niger*) of Schomburgk; so called, doubtless, from the possession of the peculiar adipose fin, common only to the salmon tribe, though in no other respect does it resemble a salmon, there being positive structural differences between the species. Let us take the portrait of this fish. Doubtless the reader figures to himself a fish of "a lean and hungry look," a very Cassius of a fish, with the lantern-jaws of a pike. But, in fact, the piräi is somewhat aldermanic and like a bream in figure, with a fighting-looking kind of nose, and a wondrously expressive eye—cold, cruel, and insatiable, and like to that of an old Jew bill-discounter when scrutinizing doubtful paper. There is 70 or 80 per cent. in that eye at the very least, and ruin to widows and orphans unnumbered if they come in its way. If it were a human eye, the owner would be bound sooner or later to figure at Execution Dock. The jaw is square, powerful, and locked into a very large head for the size of the fish; and that is a fat, plump head too, but radiated over with strong bone and gristle. The teeth—ah! they would condemn him anywhere, for here is a fish 16 inches long, with the teeth almost of a shark. Schomburgk speaks thus of its destructive power:

> This voracious fish is found plentifully in all the rivers in Guiana, and is dreaded by every other inhabitant or visitant of the river. Their jaws are so strong that they are able to bite off a man's finger or toe. They attack fish of ten times their own weight, and devour all but the head. They begin with the tail, and the fish, being left without the chief organ of motion, is devoured with ease, several going to participate of the meal. Indeed, there is scarcely any animal which it will not attack, man not excepted. Large alligators which have been wounded on the tail afford a fair chance of satisfying their hunger, *and even the toes of this formidable animal are not free from their attacks.* The feet of ducks and geese, where they are kept, are almost invariably cut off, and young ones devoured altogether. In these places *it is not safe to bathe*, or even to wash clothes, many cases having occurred of fingers and toes being cut off by them.

Schomburgk then relates astonishing instances of their voracity, in which the toes of the river Cavia are eaten off; a large sun-fish devoured alive; ducks and geese deprived of their feet, and walking on the stumps. Of course, the lines which are used to capture them have to be armed with metal, to prevent their being cut through. Their voracity is marvellous, and any bait will attract them the instant it is thrown into the water. Precaution is necessary, however, when the fish is lifted out of the water, or it will inflict serious wounds in its struggles. The fisherman, therefore, has a small bludgeon ready, with which he breaks their skulls as soon as they are caught.

Thus there are fish which shoot their prey, which fish for it, which course it and hunt it, in various ways. There are others which employ other fishes to hunt it up for them, as we use pointers and setters, such as the little Pilot-fish, which leads the huge shark to his prey; though this has been disputed, because the pilot-fish has been known to follow and play about a vessel just as it does usually about the body of a shark. The probability is, that the pilot-fish is a species of parasite or diner-out, who will make particular friends with any big person who will feed him, and no doubt would find food in the refuse cast from the vessel, even as he would from the fragments torn off by the shark when feeding on any large body. Doubtless, too, there is a certain amount of protection obtained from consorting with monsters against other predacious fish. The fact of the pilot-fish conducting the shark to his prey has been disputed, but veritable instances related by eye-witnesses leave no doubt that at times it does fulfil this office for the shark. Nor is there any thing singular in the fact. The pilot-fish is on the lookout for his own dinner probably, but will not venture on it until his protector has helped himself. We have numerous instances of this both in human and beast life.

In weapons of offence, besides the shooting apparatus already mentioned, fish have, first, the sword. This is represented by the blade of the sword-fish (*Xiphias gladius*). This fish possesses a tremendously powerful weapon, backed as it is by the great weight and impetus which it can bring to bear upon its thrusts. Many instances have been known in which the bottoms of ships have been pierced through by the sword of the Xiphias. Ships sailing quietly along have received a shock as if they had touched a rock, and, when they have been examined after the voyage, the broken blade of the fish has been found sticking in the ship's side. In the United Service Museum there is, or was formerly, a specimen of the sword-fish's handiwork in this respect. A portion of the weapon is shown sticking into the timbers of a ship, having pierced the sheathing and planking, and buried itself deeply in the stout oak knee-timber of the vessel. Xiphias would, however, be terribly bothered with the change in naval architecture; and we are inclined to wonder what he would make of an iron-clad. Perhaps a little rough experience in this direction may make him more chary of indulging naughty tempers, and he may be taught *qua* Dr. Watts that, like little children, he "should not let his angry passions rise." If so, the cause of humanity will be strongly pleaded by the iron-clads, and the poor, clumsy, harmless whale will be the gainer. The xiphias frequently weighs 500 or 600 pounds. The rapidity with which it can cut through the water is very great. It is a great enemy to the whale, and it is generally surmised that it mistakes a ship sailing through the water for a whale, and dashes at it with indiscriminating rage, often breaking and losing its sword by its blind fury. Persons bathing have not always been entirely safe from this fish, but have been stabbed to death by the xiphias. One instance of this occurred in the Bristol Channel, near the mouth of the Severn, in which a small fish of some 70 or 80 pounds weight was the malefactor. They abound in the Mediterranean, and a hunt after, with the harpooning and slaying of the xiphias, is usually a work of time and much excitement. Akin to the sword-fish in their offensive capabilities are the saw-fishes, though their weapons resemble rather such as are used by certain savage tribes than civilized saws. Nor does the word "saw" correctly describe them. They are terrible weapons, however, and the Indians who edge their spears with shark's teeth almost reproduce artificially the weapon of the saw-fish. The largest of them, *Pristis antiquorum*, is commonly found to grow to the length of 15 or 16 feet. The elongated snout is set upon either side with sharp spikes, thickly dispersed, and somewhat resembling the teeth of the shark. It forms a most fearful weapon, as the poor whale has good reason to know, to whom it is also a deadly enemy. There are several members of the saw-fish tribe; one of the most peculiar is the *Pristis cirratus*, or cirrated saw-fish, of New South Wales. In the saw of this fish the teeth are irregular, one long and three short ones being placed alternately.

The weapon of the Narwhal—which, by-the-by, is not strictly a fish, but a member of the Cetacea, found chiefly in the Arctic seas—is the most perfect specimen of a very complete and efficient spear, being composed of the hardest ivory, and tapering gradually to a point. But, what the special purpose of this spear is, is not known; whether it is used as a means of attack upon its enemies, or to secure its prey, or whether it is a mere implement for digging a passage through opposing ice-floes, as is often supposed, we can but conjecture. It is a very singular fact that the spear of the narwhal is always situated on one side of the nose, chiefly the left; it does not project from the middle of the head; it is no long snout or horn,[1] but an elongated tooth or tusk. The narwhal, when young, has the germs of but three teeth. Sometimes two of these become developed and grow out spiked tusks, pointing in divergent directions; oftener, however, but one is the mature result. Whatever the use of this formidable spear may be, we know that it is very excellent and valuable ivory; but, for any minute information as to the natural history of the animal itself, we should have to rely chiefly upon the knowledge of the Kamtchatkans, which amounts to little more than that it is good eating, produces much oil, and is possessed of a valuable tooth.

Of daggers various we have many specimens, more particularly among the family of the Raiidæ;[2] and fearful weapons they are, some of them being serrated or barbed, and capable of inflicting terrible lacerated wounds. In most of these fish the dagger, or spine, is situated on and some way down the elongated tail; and, as the animal

[1] These spears were brought home formerly and imposed upon the credulous as the horn of the unicorn.

[2] There are three species of rays in this country which have these weapons—the Sting Ray, the Eagle Ray, and the Horned Ray.

has great muscular power in the tail, and is able to whirl it about in any direction it may desire, it not unfrequently deals forth most savage retribution to its captors. It knows full well, too, how to direct its aim, and it is told of some of the members of this family that, if a hand, or even a finger, be laid upon the fish, it can, by a single turn of the tail, transfix with its spine the offending member. So dangerous are the consequences of these wounds, that it is customary (and in France and Italy it is made compulsory by law on the fishermen) to cut off the tails above the spines of the fish thus armed before they are brought to market; and in this way almost the only specimen of the Eagle Ray (*Myliobatis aquila*) ever captured alive in this country[1] was mutilated; so that the specimen was useless. The Picked Dog-fish is also provided with two short, sharp spines—one on each dorsal fin. Many other fish are furnished with spines, either upon the fins or as horns, or in sharp projections from the gill-covers. The spines of the Greater and Lesser Weaver inflict most painful wounds, and cause such agony that it is commonly reported they are in some way venomous. This has been denied, and demonstrated to be impossible; yet it seems difficult to account for the following facts upon any other hypothesis. Sir W. Jardine, in speaking of the greater weaver, says:

> It is much dreaded by the fishermen on account of its sharp spines, which are usually considered as venomous, but without any sufficient reason, as they are quite devoid of all poisonous secretion. Mr. Couch states that he has known three men wounded successively in the hand by the same fish, and *the consequences have in a few minutes been felt as high as the shoulder.*

Again, in treating of the lesser weaver, "If trodden on by bathers, as frequently happens, it inflicts," says Dr. Parnell, "a severe and painful wound, causing the part to swell and *almost immediately to assume* a dark-brown appearance, which remains for five or six hours."

In the teeth of the confident assertion of great authorities it would be rash to say that any poisonous secretion exists. But, if the above facts be quoted as proofs or instances of the absence of venom, they would appear to be singularly infelicitous ones.

Perhaps one of the most formidable weapons possessed by any fish is the natural and terrible pair of shears formed by the jaws of the Shark. The only parallel weapon of offence that can be cited as used by man would, perhaps, be the spiked portcullis, but the future *may*

[1] This fish was captured at Ramsgate some years ago and sent to me; it was 18 inches long, exclusive of the tail, which was missing, and about 2½ feet broad. Previous to this the tail of one was examined by Pennant, and a small one was found dead off Berwick by Dr. Johnson, but no living specimen had been captured. Since this was penned, however, but a few months ago, another was caught and attracted a good deal of notice. This fish was taken off the Devonshire coast, and was about the same size as, or a trifle larger than, mine. It was preserved in the Exeter Museum, where it now is. Mr. Buckland very kindly sent me an excellent photograph of the fish. The colors appear to have been most brilliant.

present us with steam shears with blades ten feet long, and intended to receive cavalry—who knows? There is no telling where the ingenuity of modern inventors in the destructive line may lead us. But there are not many instruments so efficient for their purpose as the tooth of a shark. It is difficult to handle one freely without cutting one's fingers; and when we consider the tremendous leverage of a shark's jaws employed against each other like scissors, armed with rows of lancets, it is evident that nothing in the shape of flesh, gristle, or bone, could withstand them. Their capacity, too, is equal to their powers, for a pair of jaws taken from a shark of not more than nine feet long has been known to be passed down over the shoulders and body of a man six feet high without inconvenience. It was thought to be an act of very unusual strength and dexterity on the part of the Emperor Commodus to cut a man in two at one blow, but the jaws of the white shark find no difficulty whatever in executing that feat. The vast number of teeth contained within the shark's jaw has been accounted for by some writers on the hypothesis that they are erected when the shark seizes its prey, at all other times lying flat on their sides. It is now, however, more generally admitted that the shark only employs the outer row of teeth, and that the inner ones are a provision of Nature against an accident which is, and must be, a very common one when the implements are considered, and the force with which they are employed—viz., the breaking of a tooth. In this case the corresponding tooth on the inside becomes erect, and is by degrees pushed forward into the place of the broken one—a wondrous and very necessary provision to keep so delicate and powerful an apparatus as the shark's jaw always in order. The voracity of the shark forms an endless resource for the writers on the marvellous whose bent lies toward natural history. Whole ships' crews have been devoured by sharks ere now, while their omnivorousness is extraordinary. This is well exemplified by the observation once made to me by an old tar, who was dilating on the variety of objects he had found at one time or another inside the bellies of sundry sharks. "Lord love ye, sir," quo' Ben, "there bain't nothin' as you mightn't expec' to find in the insides o' a shirk, from a street pianny to a milestone!" [1]

Continuing the description of the variety of weapons exemplified in fishes, we have a rival of that terrible scourge the knout in the tail of the Thresher, or Fox-shark (*Alopias vulpes*). The upper lobe is tremendously elongated, being nearly as long as the body of the fish, and amazingly muscular. It is curved like the blade of a scythe in shape, and the blows which it can and does inflict with this living flail can be

[1] Witness the story of the Magpie schooner, very well told in the "Shipwreck" series of the "Percy Anecdotes." This vessel was capsized in a squall, and most of the crew took refuge in a boat, which was upset by overcrowding. They were surrounded by sharks at the time, and every man, save two, who managed to right the boat and escape, was devoured by the sharks.

heard at a great distance; a herd of dolphins are scattered as though they were mere sprats, by one stroke of the thresher's tail, and stories of the combats between the whale on the one side and a combination of threshers and sword-fish on the other are too common to need more than a reference here. The form of battle usually consists in the sword-fish stabbing the whale from beneath, and so driving him up to the surface, when the fox-sharks spring upon him, and with resonant blows from their fearful knouts drive him below again upon the weapons of their allies.

The lasso is a weapon of some efficacy among various people; a form of lasso was even used by the Hungarians, and with great effect, in the War of Independence. It consisted of a kind of long-lashed whip, with a bullet slung at the end of the lash. And we have a sort of living lasso in the foot of the Cephalopod. The cephalopods are the polypes of Aristotle, and belong to the mollusks. They are of the first order of invertebrate, or spineless animals. *Mollusca cephalopoda* is the style and titles of the family Cephalopoda, in English meaning "foot-headed"—that is, its organs of locomotion, or the greater part of them, are attached to its head, whence they radiate for the most part in long, tough, and pliant tentacles or arms, of great muscular powers. On these tentacles are placed rows of suckers of very singular construction, which singly or simultaneously adhere with great tenacity to any object they come in contact with. The arms are extended in all directions when seeking prey. In the centre of them, in the middle of the stomach as it were, is the mouth of the creature, which is fully as curious as the rest of its anatomy, and consists of a large and strong-hooked beak, similar to a hawk's or parrot's. A fish or other creature comes within reach, and is instantly lassoed by one of the tentacles, the others winding around it also, to secure it in their folds. It is compressed tightly and drawn down to the beak, which rends and devours it at leisure, escape from these terrible folds being almost impossible.

The arms are also the means of propulsion, and are used as oars, by the aid of which the Octopus manages to progress through the water with considerable rapidity. Mr. Wood, in his popular natural history, treats on this point as follows: "All the Squids are very active, and some species, called 'flying squids' by sailors, and *ommastrephes* by naturalists, are able to dash out of the sea and to dart to considerable distances;" and he quotes Mr. Beale to show that they sometimes manage to propel themselves through the air for a distance of 80 or 100 yards, the action being likened to a something which might be achieved by a live corkscrew with eight prongs. In the account given in Bennett's "Whaling Voyage" they are often spoken of as leaping on board the ship, and even clear over it into the water on the other side. Nature has also furnished the cephalopod with another curious weapon of offence, or defence rather, in the shape of a bag of black fluid, or sepia, commonly termed by fishermen the ink-bag; and what a dreadful weapon of offence or defence ink may be, in many cases, there are few of us unaware. The cuttle when closely pursued sends out a cloud of it to hide him from view, and escapes under cover of it.

Some of the cephalopods possess extraordinary powers of muscular contraction, as the common squid, for example, which is spread out at one moment in a body and volume larger round than a large man's fist, and the next moment will contract itself so that it can easily pass through the cork-hole in a boat or the neck of a wine-bottle. Great sensational attraction has been directed to the octopus by the tremendous description of the combat in Victor Hugo's "Toilers of the Sea." No doubt a large octopus, such as are found in the Pacific and elsewhere, and which sometimes have arms of eight or nine feet in length, could drown a man with the greatest ease, if he had no weapon, and were caught by one under water. From remote ages the deeds of the polypus have been chronicled by poets and writers of strong imaginative powers; and thus we have, probably, the partially fabulous story of the Lernæan hydra, which, if it ever existed at all, had its origin no doubt in the impossible deeds of some improbable octopus. Then there is the story of the king's daughter and the noble diver, who dived for a gold cup and the love of his princess, but profited by neither, since he never came up again, being supposed to have been lassoed by some monster octopus at the bottom of the whirlpool, and many other well-known stories. The beast forms a very great attraction at the Crystal Palace aquarium, where the ladies, of course, insist on calling him "the Devil-Fish" (but that distinguished title belongs to another fish); and where he is poked up daily for their inspection, it being one of his diabolical tendencies to dwell "under ebon shades and low-browed rocks." What a life for a poor devil who wants nothing but solitude and retirement, to be a show-devil and at the beck and call of the ladies!

Among other offensive powers commanded by fish and men alike is the very remarkable one of electricity; it is slightly used in warlike as well as useful purposes. But the possible uses to which we may put electricity ourselves hereafter as an offensive weapon we cannot at present even guess at. It is a powerful agent to several kinds of fish, and yet ichthyologists are greatly at fault to settle the exact purpose for which it is given to them—whether it be for the purpose of killing the animals they prey on, or of facilitating their capture, or whether it be intended to render them more easy of digestion.

Mr. Couch, in speaking of the properties of electricity and the digestive capability of the Torpedo, has the following: "One well-known effect of the electric shock is to deprive animals killed by it of their organic irritability, and consequently to render them more easily disposed to pass into a state of decomposition, in which condition the digestive powers more speedily and effectively act upon them. If any creature more than others might seem to require such preparation of its food, it is the cramp ray, the whole canal of whose intestine is not more than half as long as the stomach." This is certainly very curious, and, if it should be found that the same deficiency in point of digestive accommodation exists in the gymnotus and the other fishes of electric powers, the hypothesis would be converted almost into a certainty. In hunting up authorities to verify this curious fact, we find, in the article on the gymnotus in *Chambers's Encyclopædia*, that "all the gymnotidæ are remarkable for the position of the *anus*, which is so very far forward as, *in the electrical eel, to be before the gill-openings*," which would certainly seem to confirm Mr. Couch's supposition.

Of the tremendous powers which can be given off in one shock, it may be stated that Faraday, having made experiments with the specimen which was shown several years ago at the Adelaide Gallery, estimated that an average shock emitted as great a force as the highest force of a Leyden battery of fifteen jars, exposing 3,500 inches of coated surface.

There are five different fish endued with electrical powers. Of the torpedo there are two species—the old and new British torpedo; one of the *Gymnotus electricus*, or electric eel, as it is called; and two of the *Malapterurus*—viz., *M. electricus* of the Nile, called Raash, or thunder-fish, by the Arabs, and the *Malapterurus Beninensis*—the smallest of the electrical fishes, found in the Old Calabar River, which falls into the Bight of Benin, on the coast of Africa. The latter fish is a comparatively recent discovery, having been known to us only some fifteen or sixteen years. We have no very good account of either of these latter fish. A specimen of the last was sent to me three or four years ago. It is a curious little fish, about five or six inches in length, and very much resembles the *Siluridæ* in general appearance, about the head especially. It has long barbules, three on each side of the mouth, and has a very bloated, puffy appearance, caused, it is to be presumed, by the electric apparatus which is deposited between the skin and the frame of the fish. In the torpedo the electric battery is placed in two holes, one on either side of the eyes. Here a number of prismatic cells are arranged in the fashion of a honey-comb, the number being regulated by the age of the fish. These represent the jars in the battery, and they are capable of giving out a terrible shock, as many an incautious fisherman has experienced to his cost. We may trust also that the torpedoes with which our coasts and harbors are likely to be thronged will be capable of giving off even a severer shock; and though gunpowder and gun-cotton will be the shocking agents in these cases, yet electricity will play no unimportant part in their process. Formerly quacks galvanized their patients by the application of the natural torpedo, applying it to the joints and limbs for gout, rheumatism, etc. That the electricity is true electricity has been proved by a host of experiments. The electrometer has shown it, and needles have been magnetized just as if a battery had been employed.

There are many other points of similarity which might be enlarged upon; but, if one were to attempt to set down all the strange and various considerations which come under cognizance in this subject, they would soon swell the matter much beyond the limits of a magazine article.—*Fraser's Magazine.*

MOTIONS OF THE STARS.

AT the last meeting of the Royal Astronomical Society, Dr. Huggins, the eminent spectroscopist, made an extraordinary statement respecting the motions taking place among the stars. The results he announces are so wonderful that it will be well briefly to explain how they have been obtained, as well as their relation to what had formerly been known upon the subject.

Our readers are doubtless aware that the stars are not really fixed, but are known to be travelling swiftly through space. To ordinary observation the stars seem unmoving; nor indeed can the astronomer recognize any signs of motion save by prolonged observation. But, if the exact place of a star be carefully determined at any time, and again many years later, a measurable displacement can be recognized; year after year, and century after century, the motion thus determined proceeds, until at length the star may be removed by a considerable arc (or what is so regarded by astronomers accustomed to deal with the minutest displacements) from the position it had formerly occupied.

But, in general, these movements afford no means of estimating the real rate at which the stars are travelling through space. In the first place, a star might be moving with enormous rapidity toward or from the earth, and yet seem to be quite fixed on the star-vault—just as the light of a rapidly approaching or receding train seems to occupy an unchanging position if the train's course is at the moment in the direction of the line of sight. It is only what may be called the thwart-motion of the star that the astronomer can recognize by noting stellar displacements. But even this motion he cannot estimate—in miles per second, say—unless he knows how far off the sun is; and astronomers know in truth very little about stellar distances.

Now, it seems, at first sight, altogether hopeless to attempt to measure the rate at which a star is approaching or receding. No change of brightness could be looked for, nor indeed could any observed change be trusted as an evidence of changed distance, since stars are liable to real changes of brilliancy, much as our own sun is liable to be more or less spot-marked. But the distances of the stars are so enormous that no conceivable rate of approach or recession could affect their brilliancy discernibly. Only the most rapid thwart-motions yet recognized would carry a star over a space equal to the moon's seeming diameter in 500 years, so that a corresponding motion of recess or approach would only change a star's distance to about the same relative extent, and it is obvious that such a change could not make a star, even in that long period, change appreciably in brightness.

It will seem, then, utterly incredible that astronomers have learned not merely whether certain stars are receding or approaching, but have actually been enabled to determine respecting this kind of motion what they cannot determine respecting the more obvious thwart-motion, viz., the rate at which the motion takes place.

This is rendered possible by what is known of the nature of light. Light travels through space in waves, not as a direct emanation. Now, let us compare a star's action in emitting such waves with some known kind of wave-action, and we shall at once recognize the effects of very rapid motion on the star's part. Conceive a fixed paddle-wheel turning at a uniform rate in water, and that every blade as it reaches the water raises one wave, that wave being transmitted in a given direction. Then there would be a succession of waves separated from each other by a constant distance. But, suppose the paddle-wheel itself to be carried in the given direction. It is clear that, after one blade has raised its wave, the next blade, descending in the same time as before, will reach the water closer to the preceding wave than if the paddle-wheel had been at rest; for the moving wheel will have *carried* the blade closer, so that now a succession of waves will result as before, but they will have their crests closer together. And obviously, if the wheel were carried in the contrary direction, the wave-crests would be farther apart than if the wheel had been at rest.

Thus, reverting to the stars, we infer that if a star is approaching, the light which comes to us from it will have its waves closer together than if the star were at rest, and *vice versa*. Now, the distance between the wave-crests of light signifies a difference of color, the longer waves producing red and orange light; waves of medium length, yellow and green light; and the shorter waves producing blue, indigo, and violet light. So that, if a star were shining with pure red light, it might by approaching very rapidly be caused to appear yellow, or even blue or indigo, according to the rate of approach; while, if a star were shining with pure indigo light, it might by receding very rapidly be caused to appear green or yellow, or even orange or red.

But stars do not shine with pure-colored light, but with a mixture of all the colors of the rainbow; so that the attempt to estimate a star's rate of approach or recession by its color would fail, even though we knew the star's real color, and even though stars moved fast enough to produce color-changes. The spectroscopist has, however, a much more delicate means of dealing with the matter. The rainbow-tinted streak forming a star's spectrum is crossed by known dark lines; and these serve as veritable mile-marks for the spectroscopist. If one of these lines in the spectrum of any star is seen to be shifted toward the red end, the observer knows that the star is receding, and that swiftly; if the shift is toward the violet end, he knows that the star is swiftly approaching

Now, Dr. Huggins had been able nearly four years ago to apply this method to the case of the bright star Sirius, though his instrumental means were not then sufficient to render him quite certain as to the result. Still he was able to announce with some degree of confidence that Sirius is receding at a rate exceeding 20 miles per second. In order that he might extend the method to other stars, the Royal Society placed at his disposal a fine telescope, 15 inches in aperture, and specially adapted to gather as much light as possible with that aperture. Suitable spectroscopic appliances were also provided for the delicate work Dr. Huggins was to undertake. It was but last winter that the instrument was ready for work; but already Dr. Huggins has obtained the most wonderful news from the stars with its aid. He finds that many of the stars are travelling far more swiftly than had been supposed. Arcturus, for example, is travelling toward us at the rate of some 50 miles per second, and, as his thwart-motion is fully as great (for this star's distance has been estimated), the actual velocity with which he is speeding through space cannot be less than 70 miles per second. Other stars are moving with corresponding velocities.

But, amid the motions thus detected, Dr. Huggins has traced the signs of law. First he can trace a tendency among the stars in one part of the heavens to approach the earth, while the stars in the opposite part of the heavens are receding from us; and the stars which are approaching lie on that side of the heavens toward which Herschel long since taught us that the sun is travelling. But there are stars not obeying this simple law; and among these Dr. Huggins recognizes instances of that community of motion to which a modern student of the stars has given the name of star-drift. It happens, indeed, that one of the most remarkable of these instances relates to five well-known stars, which had been particularly pointed to as forming a drifting set. It had been asserted more than two years ago that certain five stars of the Plough or Charles's Wain—the stars known to astronomers as Beta, Gamma, Delta, Epsilon, and Zeta, of the Great Bear—are drifting bodily through space. The announcement seemed to many very daring, yet its author (trusting in the mathematical analysis of the evidence) expressed unquestioning confidence; he asserted, moreover, that whenever Dr. Huggins applied the new method of research, he would find that those five stars are either all approaching or all receding, and at the same rate, from the earth. The result has justified his confidence as well in his theory as in Dr. Huggins's mastery of the new method. Those five stars are found to be all receding from the earth at the rate of about 30 miles per second.

This result at once illustrates the interesting nature of Dr. Huggins's discoveries, and affords promise of future relevations even more interesting. The theories hitherto accepted respecting the constitution of the stellar universe have been tried against the views recently propounded, with a result decidedly in favor of the latter. We may feel assured that the matter will not rest here. A simple and decisive piece of evidence, such as that we have described, will invite many to examine afresh the theories respecting the stellar heavens which have so long been received unquestioningly. The theory of star-drift is associated with others equally novel, and which admit equally well of being put to test. We venture to predict that, before many years have passed, there will be recognized in the star-depths a variety of constitution and a complexity of arrangement startlingly contrasted with the general uniformity of structure recognized in the teachings at present accepted.—*Spectator.*

THE UNCONSCIOUS ACTION OF THE BRAIN.

By WM. B. CARPENTER, M.D., LL.D., F.R.S.

MANY of you, I doubt not, will remember that I had the pleasure of addressing you in this hall some months ago, with reference to researches which I had a share in carrying on into the Depths of the Ocean, when I endeavored to give you some insight into the conditions of the sea-bottom as regards temperature, pressure, animal life, and the deposits now in process of formation upon it.

Now, I am going this evening to carry you into quite a different field of inquiry—an inquiry which I venture to think I have had some share in myself promoting, into what goes on in the Depths of our own Minds. And I think I shall be able to show you that some practical results of great value in our own mental culture, as training and as discipline, may be deduced from this inquiry. I shall begin with an anecdote that was related to me after a lecture which I gave upon this subject about five years ago, at the Royal Institution, in London. As I was coming out from the lecture-room, a gentleman stopped me and said, "A circumstance occurred recently in the north of England, which I think will interest you, from its affording an exact illustration of the doctrine which you have been setting forth to-night." The illustration was so apposite, and leads us so directly into the very heart of the inquiry, that I shall make it, as it were, the text for the commencement of this evening's lecture. The manager of a bank in a certain

[1] A lecture, delivered in the Hulme Town Hall, Manchester.

large town in Yorkshire could not find a key which gave access to all the safes and desks in the bank. This key was a duplicate key, and ought to have been found in a place accessible only to himself and to the assistant-manager. The assistant-manager was absent on a holiday in Wales, and the manager's first impression was, that the key had probably been taken away by this assistant in mistake. He wrote to him, and learned to his own great surprise and distress that he had not got the key, and knew nothing of it. Of course, the idea that the key, which gave access to every valuable in the bank, was in the hands of any wrong person, having been taken with a felonious intention, was to him most distressing. He made search everywhere, thought of every place in which the key might possibly be, and could not find it. The assistant-manager was recalled, both he and every person in the bank were questioned, but no one could give any idea of where the key could be. Of course, although no robbery had taken place up this point, there was the apprehension that a robbery might be committed after the storm, so to speak, had blown over, when a better opportunity would be afforded by the absence of the same degree of watchfulness. A first-class detective was then brought down from London, and this man had every opportunity given him of making inquiries; every person in the bank was brought up before him; he applied all those means of investigation which a very able man of this class knows how to employ; and at last he came to the manager and said: "I am perfectly satisfied that no one in the bank knows any thing about this lost key. You may rest assured that you have put it somewhere yourself, and you have been worrying yourself so much about it that you have forgotten where you put it away. As long as you worry yourself in this manner, you will not remember it; but go to bed to-night with the assurance that it will be all right; get a good night's sleep; and in the morning I think it is very likely you will remember where you have put the key." This turned out exactly as it was predicted. The key was found the next morning in some extraordinarily secure place which the manager had not previously thought of, but in which he then felt sure he must have put it himself.

Now, then, ladies and gentlemen, this you may say is merely a remarkable case of that which we all of us are continually experiencing; and so I say it is. Who is there among you who has not had occasion some time or other to try to recall something to his (or her) mind which he has not been able to bring to it? He has seen some one in the street, for instance, whose face he recognizes, and says, "I ought to know that person;" and thinks who it can be, going over (it may be) his whole list of friends and acquaintances in his mind, without being able to recall who it is; and yet, some hours afterward, or it may be the next day, it flashes into his mind who this unknown person is. Or you may want to remember some particular and recent event; or it may be, as I have heard classical scholars say, to recall the source of a classical quotation. They "cudgel their brains," to use a common expression, and are unsuccessful; they give their minds to something entirely different; and some hours afterward, when their thoughts are far away from the subject on which they had been concentrating them with the idea of recovering this lost clew, the thing flashes into the mind. Now, this is so common an occurrence, that we pass it by without taking particular note of it; and yet I believe that the inquiry into the real nature of this occurrence may lead us to understand something of the inner mechanism of our own minds which we shall find to be very useful to us.

There is another point, however, arising out of the story which I have just told you, upon which again I would fix your attention: Why and how did the detective arrive at this assurance from the result of his inquiries? It was a matter of judgment based upon long practice and experience, which had given him that kind of insight into the characters, dispositions, and nature of the persons who were brought before him, which only those who have got this faculty as an original gift, or have acquired it by very long experience, can possess with any thing like that degree of assurance which he was able to entertain. I believe that this particular power of the detective is, so to speak, an exaltation in a particular direction of what we call "common-sense." We are continually bringing to the test of this common-sense a great number of matters which we cannot decide by reason; a number of matters as to which, if we were to begin to argue, there may be so much to be said on both sides, that we may be unable to come to a conclusion. And yet, with regard to a great many of these subjects—some of which I shall have to discuss in my next lecture—we consider that common-sense gives us a much better result than any elaborate discussion. Now, I will give you an illustration of this which you will all readily comprehend: Why do we believe in an external world? Why do I believe that I have at present before me many hundreds of intelligent auditors, looking up and listening to every word that I say? Why do you believe that you are hearing me lecture? You will say at once that your common-sense tells you. I see you; you see and hear me; and I know that I am addressing you. But if once this subject is logically discussed, if once we go into it on the basis of a pure reasoning process, it is found really impossible to construct such a proof as shall satisfy every logician. As far as my knowledge extends, every logician is able to pick a hole in every other logician's proof. Now, here we have, then, a case obvious to you all, in which common-sense decides for us without any doubt or hesitation at all. And I venture to use an expression upon this point which has been quoted with approval by one of the best logicians and metaphysicians of our time, Archbishop Manning, who cited the words that I have used, and entirely concurred in them, namely, that "in regard to the existence of the external world the common-sense decision of mankind is practically worth more than all the arguments of all the logicians who have discussed the basis of our belief in it." And so, again, with regard to another point which more nearly touches our subject to-night—the fact that we have a Will which dominates over our actions; that we are not merely the slaves of automatic impulse which some philosophers would make us—"the decision of mankind" (as Archbishop Manning, applying my words, has most truly said), "derived from consciousness of the existence of our living self or personality, whereby we think, will, or act, is practically worth more than all the arguments of all the logicians who have discussed the basis of our belief in it."

Now, then, my two points are these: What is the nature of this process which evolves, as it were, this result unconsciously to ourselves, when we have been either asleep, as in the case of the banker, or, as in the other familiar case I have cited, when we have been giving our minds to some other train of thought in the interval? What is it that brings up spontaneously to our consciousness a fact which we endeavored to recall with all the force of our will, and yet could not succeed?

And then again: What is the nature of this common-sense, to which we defer so implicitly and immediately in all the ordinary judgments of our lives?

Now, in order that we may have a really scientific conception of the doctrine I would present to you, I must take you into an inquiry with regard to some of the simpler functions of our bodies, from which we shall rise to the simpler actions of our minds. You all know that the Brain, using the term in its general sense, is the organ of our Mind. That every one will admit. We shall not go into any of the disputed questions as to the relations of Mind and Matter; for the fact is, that these are now coming to take quite a new aspect, from Physical philosophers dwelling so much more upon Force than they do upon Matter, and on the relations of Mind and Force, which every one is coming to recognize. Thus, when we speak of nerve-force and mind as having a most intimate relation, no one is found to dispute it; whereas, when we talk about Brain and Mind having this intimate relation, and Mind being the function of the brain, there are a great many who will rise up against us and charge us with materialism, and atheism, and all the other deadly sins of that kind. I merely speak of the relation of the brain to the mind, as the instrument through which the mind operates and expresses itself. We all know that it is in virtue of the impressions carried to the brain, through the nerves proceeding from the different sensory organs in various parts of the body, that we become conscious of what is taking place around us. And, again, that it is through the nerves proceeding from the brain that we are able to execute those movements which the Will prompts and dictates, or which arise from the play of the Emotions. But I have first to speak of a set of lower centres, those which the Will can to a certain extent control, but which are not in such immediate relation to it as is the brain. You all know that there passes down our backbone a cord which is commonly called the "Spinal Marrow." Now, this spinal marrow gives off a pair of nerves at every division of the backbone; and these nerves are double in function—one set of fibres conveying impressions from the surface to the spinal cord, the other motor impulses from the spinal cord to the muscles. Now, it used to be considered that this Spinal Cord (I use the term spinal cord, which is the same as spinal marrow, because it is just as intelligible and more correct) was a mere bundle of nerves proceeding from the brain; but we have long known that this is not the case, that the spinal cord is really a nervous centre in itself, and that if there were no brain at all the spinal cord would still do a great deal. For example, there have been infants born without a brain, yet these infants have breathed, have cried, have sucked, and this in virtue of the separate existence and the independent action of this spinal cord. Let us analyze one or two of these actions. We will take the act of Sucking as the best example, because experiments have been made upon young puppies, by taking out the brain, and then trying whether they would suck; and it was found that putting between the lips the finger moistened with milk or with sugar and water, produced a distinct act of suction, just as when an infant is nursed. Now, how is this? It is what we call a "reflex action." I shall have a good deal to say of reflex action higher up in the nervous system, and therefore I must explain precisely what we mean by that term. It is just this: There is a certain part of the spinal cord, at the top of the neck, which is what we call a ganglion, that is, a centre of nervous power: in fact, the whole of the spinal cord is a series of such ganglia; but this ganglion at the top of the neck is the one which is the centre of the actions which are concerned in the act of sucking. Now, this act of sucking is rather a complicated one, it involves the action of a great many muscles put into conjoint and harmonious contraction. We will say, then, that here is a nervous centre. [Dr. Carpenter made a sketch upon the black-board.] These are nerves coming to it, branches from the lips; and these another set going to the muscles concerned in the movement of sucking from it. Thus, by the conveyance to the ganglionic centre of the impression made on the lips, a complicated action is excited, requiring the combination of a number of separate muscular movements. We will take another example—the act of Coughing. You feel a tickling in your throat, and you feel an impulse to cough which you cannot resist; and this may take place not only when you are awake and feel the impulse, but when you are asleep and do not feel it. You will often find persons coughing violently in sleep, without waking or showing any sign of consciousness. Here, again, the stimulus, as we call it, produced by some irritation in the throat, gives rise to a change in the nerves going toward the ganglionic centre, which produces the excitement of an action in that centre that issues the mandate, so to speak, through the motor nerves to the muscles concerned in coughing, which actions have to be united in a very remarkable manner, which I cannot stop to analyze; but the whole action of coughing has for its effect the driving out a violent blast of air, which tends to expel the offending substance. Thus, when any thing "goes the wrong way," as we term it—a crumb of bread, or a drop of water finding its way into the windpipe, then this sudden and violent blast of air tends to expel it.

Now, these are examples of what we call "reflex action;" and this is the character of most of the movements that are immediately concerned with the maintenance of the vital functions. I might analyze other cases. The act of breathing is a purely reflex action, and goes on when we are perfectly unconscious of exerting any effort, and when our attention is entirely given up to some act or thought; and even when asleep the act of breathing goes on with perfect regularity, and, if it were to stop, of course the stoppage would have a fatal effect upon our lives. But most of these reflex actions are to a certain degree placed under the control of our Will. If it were not for this controlling power of will, I could not be addressing you at this moment. I am able so to regulate my breath as to make it subservient to the act of speech; but that is the case only to a certain point. I could not go on through a long sentence without taking my breath. I am obliged to renew the breath frequently, in order to be able to sustain the circulation and other functions of life. But still I have that degree of control over the act of respiration, that I can regulate this drawing in and expulsion of the breath for the purposes of speech. This may give you an idea of the way in which Mental operations may be independent of the Will, and yet be under its direction. To this we shall presently come.

Now, those reflex actions of the spinal cord, which are immediately and essentially necessary to the maintenance of our lives, take place from the commencement without any training, without any education; they are what we call "instinctive actions;" the tendency to them is part of our nature; it is born with us. But, on the other hand, there are a great many actions which we learn, to which we are trained in the process of bodily education, so to speak, and which, when we have learned them, come to be performed as frequently, regularly, methodically, and unconsciously, as those of which I have spoken. This is the case particularly with the act of walking. You all know with how much difficulty a child is trained to that action. It has to be learned by a long and painful experience, for the child usually gets a good many tumbles in the course of that part of its education; but, when once acquired, it is as natural as the act of breathing, only it is more directly under the control of the will; yet so completely automatic does it become, that we frequently execute a long series of these movements without any consciousness whatever. You start in the morning, for instance, to go from your home to your place of employment; your mind is occupied by a train of thought, something has happened which has interested you, or you are walking with a friend, and in earnest conversation with him; and your legs carry you on without any consciousness on your part that you are moving them. You stop at a certain point, the point at which you are accustomed to stop, and very often you will be surprised to find that you are there. While your mind has been intent upon something else, either the train of thought which you were following out in your own mind, or upon what your friend has been saying, your legs move on of themselves, just as your heart beats, or as your muscles of breathing continue to act. But this is an acquired habit; this is what we call a "secondarily automatic" action. Now, that phrase is not very difficult when you understand it. By automatic we mean an action taking place of itself. I dare say most of you have seen automata of one kind or another, such as children's toys and more elaborate pieces of mechanism, which, being wound up with a spring, and containing a complicated series of wheels and levers, execute a variety of movements. In each of the Great Exhibitions there have been very curious automata of this kind. We speak, then, of the actions being "automatic," when we mean that they take place of themselves, without any direction on our own parts; such as the act of sucking in the infant, the acts of respiration and swallowing, and others which are entirely involuntary, and are of this purely reflex character. Now, those are "primarily automatic," that is, originally automatic; we are born with a tendency to execute them; but the actions of the class I am now speaking of are executed by the same portion of the nervous system—the spinal cord—and are "secondarily automatic," that is to say, we have to learn them, but, when once learned, they come very much into the condition of the others, only we have some power of will over them. We start ourselves in the morning by an act of the will; we are determined to go to a particular place; and it may be that we are conscious of these movements over the whole of our walk; but, on the other hand, we may be utterly unconscious of them, and continue to be so until either we have arrived at our journey's end or begin to feel fatigued. Now, when we begin to feel fatigued, we are obliged to maintain the action by an effort of the will; we are no longer unconscious, and we are obliged to struggle against the feeling of fatigue, to exert our muscles in order to continue the action.

Now, having set before you this reflex action of the Spinal Cord, you will ask me perhaps what is the exciting cause of this succession of actions in walking. I believe it is the contact of the ground with the foot at each movement. We put down the foot, that suggests as it were to the spinal cord the next movement of the leg in advance, and that foot comes down in its turn; and so we follow with this regular rhythmical succession of movements.

We next pass to a set of centres somewhat higher, those which form the summit, as it were, of this spinal cord, which are really embedded in the brain, but which do not form a part of that higher organ, which is in fact the organ of the higher part of our mental nature, yet which are commonly included in that which we designate the brain. In fact, the anatomist who only studies the human brain is very liable to be misled in regard to the character of these different parts, by the fact that the higher part—that which we call the Cerebrum—is so immensely developed in Man, in proportion to the rest of the animal creation, that it envelops, as it were, the portion of which I am about to speak, concealing it, and reducing it apparently to the condition of a very subordinate part; and yet that subordinate part is, as I shall show you, the foundation or basis of the higher portion—the Cerebrum itself. The brain of a Fish consists of very little else than a series of these ganglia, these little knots—the word "ganglion" means "knot," and the ganglia in many instances, when separated, are little knots, as it were, upon the nerves. The brain of a fish consists of a series of these ganglia, one pair belonging to each principal organ of sense. Thus we have in front the ganglia of smell, then the ganglia of sight, the ganglia of hearing, and ganglia of general sensation. These constitute almost entirely the brain of the fish. There is scarcely any thing in the brain of the fish which answers to the Cerebrum or higher part of the brain of man. I will give you an idea of the relative development of these parts. [Dr. Carpenter made other sketches on the black-board, to represent these ganglia of sense in man and the lower animals.] Now, the Cerebrum in most fishes is a mere little film, overlying the sensory tract, but in the higher fish we have it larger; in the reptiles we have it larger still; and in birds we have it still larger; in the lower mammalia it is larger still; and then as we ascend to man this part becomes so large in proportion that my board will not take it in. This Cerebrum, this great mass of the brain, at the bottom of which these Ganglia of Sense are buried, as it were, so overlies and conceals them that their essential functions for a long time remained unknown. Now, in the Cerebrum, the position of the active portion, what we call the ganglionic matter, that which gives activity and power to these nervous centres, is peculiar. In all ganglia this "gray" matter, as it is called, is distinct from the white matter. In ordinary ganglia, this gray matter lies in the interior as a sort of little kernel; but in the Cerebrum it is spread out over the surface, and forms a film or layer. If any of you have the curiosity to see what it is like, you have only to get a sheep's brain and examine it, and you will see this film of a reddish substance covering the surface of the Cerebrum. In the higher animals, and in man, this film is deeply folded upon itself, with the effect of giving it a very much more extended surface, and in this manner the blood-vessels come into relation with it; and it is by the changes which take place between this nervous matter and the blood that all our nervous power is produced. You might liken it roughly to the galvanic battery by which the electric telegraph acts, the white or fibrous portion of the brain and nerves being like the conducting wires of the telegraph. Just as the fibres of the nerves establish a communication between the organs of sensation and the ganglionic centres, and again between the ganglionic centres and the muscles, so do the white fibres, which form a great part of the brain, establish a communication between the gray matter of the convoluted or folded surface of the Cerebrum and the Sensory Ganglia at its base. Now, I believe that this sensory tract which lies at the base of the skull is the real *Sensorium*, that is, the centre of sensation; that the brain at large, the cerebrum, the great mass of which I have been speaking, is not in itself the centre of sensation; that, in fact, the changes which take place in this gray matter only rise to our consciousness—only call forth our conscious mental activity—when the effect of those changes is transmitted downward to this Sensorium. Now, this Sensorium receives the nerves from the organs of sense. Here, for instance, is the nerve from the organ of smell, here from the eye, and here from the body generally (the nerves of touch), and here the nerves of hearing—every one of these has its own particular function. Now, these Sensory ganglia have in like matter reflex actions. I will give you a very curious illustration of one of these reflex actions: You all know the start we make at a loud sound or a flash of light; the stimulus conveyed through our eyes from the optic nerve to the central ganglion causing it to send through the motor nerves a mandate that calls our muscles into action. Now, this may act sometimes in a very important manner for our protection, or for the protection of some of our delicate organs. A very eminent chemist a few years ago was making an experiment upon some extremely explosive compound which he had discovered. He had a small quantity of this compound in a bottle, and was holding it up to the light, looking at it intently; and whether it was a shake of the bottle or the warmth of his hand, I do not know, but it exploded in his hand, the bottle was shivered into a million of minute fragments, and those fragments were driven in every direction. His first impression was, that they had penetrated his eyes, but to his intense relief he found presently that they had only penetrated the outside of his eyelids. You may conceive how infinitesimally short the interval was between the explosion of the bottle and the particles reaching his eyes; and yet in that interval the impression had been made upon his sight, the mandate of the reflex action, so to speak, had gone forth, the muscles of his eyelids had been called into action, and he had closed his eyelids before the particles reached them, and in this manner his eyes were saved. You see what a wonderful proof this is of the way in which the automatic action of our nervous apparatus enters into the sustenance of our lives, and the protection of our most important organs from injury.

Now I have to speak of the way in which this Automatic action of the Sensory nerves, and of the motor nerves which answer to them, grows up, as it were, in ourselves. We will take this illustration: Certain things are originally instinctive, the tendency to them is born with us; but in a very large number of things we educate ourselves, or we are educated. Take, for instance, the guidance of the class of movements I was speaking of just now—our movements of locomotion. We find that when we set off in the morning with the intention of going to our place of employment, not only do our legs move without our consciousness, if we are attending to something entirely different, but we guide ourselves in our walk through the streets; we do not run up against anybody we meet; we do not strike ourselves against the lamp-posts; and we take the appropriate turns which are habitual to us. It has often happened to myself, and I dare say it has happened to every one of you, that you have intended, to go somewhere else—that when you started you intended instead of going in the direct line to which you were daily accustomed, to go a little out of your way to perform some little commission; but you have got into a train of thought and forgotten yourself, and you find that you are half-way along your accustomed track before you become aware of it. Now, there, you see, is the same automatic action of these sensory ganglia—we see, we hear—for instance, we hear the rumbling of the carriages, and we avoid them without thinking of it—our muscles act in respondence to these sights and sounds—and yet all this is done without our intentional direction—they do it for us. Here again, then, we have the "secondarily automatic" action of this power, that of a higher nervous apparatus which has grown, so to speak, to the mode in which it is habitually exercised. Now, that is a most important consideration. It has grown to the mode in which it is habitually exercised; and that principle, as we shall see, we shall carry into the higher class of Mental operations.

But there is one particular kind of this action of the Sensory nerves to which I would direct your attention, because it leads us to another very important principle. You are all, I suppose, acquainted with the action of the stereoscope; though you may not all know that its peculiar action, the perception of solidity it conveys to us, depends upon the combination of two dissimilar pictures—the two dissimilar pictures which we should receive by our two eyes of an object if it were actually placed before us. If I hold up this jug, for instance, before my eyes, straight before the centre of my face, my two eyes receive pictures which are really dissimilar. If I made two drawings of the jug, first as I see it with one eye, and then with the other, I should represent this object differently. For instance, as seen with the right eye, I see no space between the handle and the body of the jug; as I see it with the left eye, I see a space there. If I were to make two drawings of that jug as I now see it with my two eyes, and put them into a stereoscope, they would bring out, even if only in outline, the conception of the solid figure of that jug in a way that no single drawing could do. Now, that conception is the result of our early-acquired habit of combining with that which we *see* that which we *feel*. That habit is acquired during the first twelve or eighteen months of infancy. When your little children are lying in their cradles and are handling a solid object, a block of wood, or a simple toy, and are holding it at a distance from their eyes, bringing it to their mouth and then carrying it to arm's length, they are going through a most important part of their education—that part of their education which consists in the harmonization of the mental impressions derived from sight and those derived from the touch; and it is by that harmonization that we get that conception of solidity or projection which, when we have once acquired it, we receive from the combination of these two dissimilar pictures alone, or even, in the case of objects familiar to us, without two dissimilar pictures at all—the sight of the object suggesting to us the conception of its solidity and of its projection.

Now, this is a thing so familiar to you, that few of you have probably ever thought of reasoning it out; and in fact it has only been by the occurrence of cases in which persons have grown to adult age without having acquired this power, from having been born blind and having only received sight by a surgical operation at a comparatively late period, when they could describe things as they saw them—I say it is only by such cases that we have come to know how completely dissimilar and separate these two classes of impressions really are, and how important is this process of early infantile education of which I have spoken. A case occurred a few years ago in London where a friend of my own performed an operation upon a young woman who had been born blind, and, though an attempt had been made in early years to cure her, that attempt had failed. She was able just to distinguish large objects, the general shadow, as it were, of large objects without any distinct perception of form, and to distinguish light from darkness. She could work well with her needle by the touch, and could use her scissors and bodkin and other implements by the training of her hand, so to speak, alone. Well, my friend happened to see her, and he examined her eyes, and told her that he thought he could get her sight restored; at any rate, it was worth a trial. The operation succeeded; and, being a man of intelligence and quite aware of the interest of such a case, he carefully studied and observed it; and he completely confirmed all that had been previously laid down by the experience of similar cases. There was one little incident which will give you an idea of the education which is required for what you would suppose is a thing perfectly simple and obvious. She could not distinguish by sight the things that she was perfectly familiar with by the touch, at least when they were first presented to her eyes. She could not recognize even a pair of scissors. Now, you would have supposed that a pair of scissors, of all things in the world, having been continually used by her, and their form having become perfectly familiar to her hands, would have been most readily recognized by her sight; and yet she did not know what they were; she had not an idea until she was told, and then she laughed, as she said, at her own stupidity. No stupidity at all; she had never learned it, and it was one of those things which she could not know without learning. One of the earliest cases of this kind was related by the celebrated Cheselden, a surgeon of the early part of last century. Cheselden relates how a youth just in this condition had been accustomed to play with a cat and a dog; but for some time after he attained his sight he never could tell which was which, and used to be continually making mistakes. One day being rather ashamed of himself for having called the cat the dog, he took up the cat in his arms and looked at her very attentively for some time, stroking her all the while; and in this way he associated the impression derived from the sight of the cat with the impression derived from the touch, and made himself master (so to speak) of the whole idea of the animal. He then put the cat down, saying, "Now, puss, I shall know you another time."

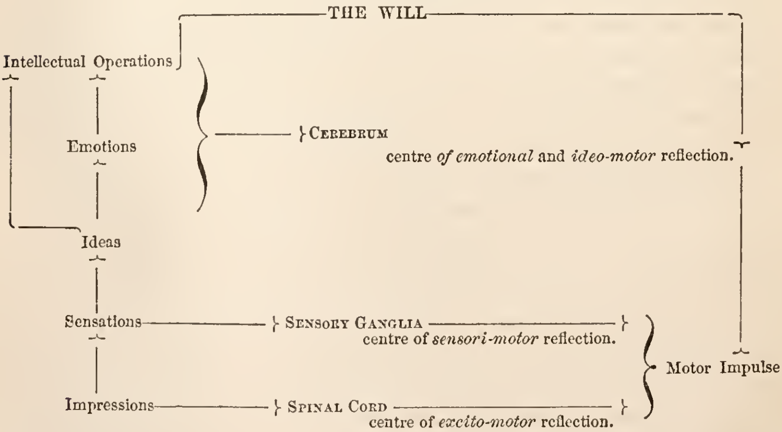
Now, the reason why I have specially directed your attention to this is because it leads to one of the most important principles that I desire to expound to you this evening—what I call in Mental Physiology the doctrine of *resultants*. All of you who have studied mechanics know very well what a "resultant" means. You know that when a body is acted on by two forces at the same time, one force carrying it in this direction, and another force in that direction, we want to know in what direction it will go, and how far it will go. To arrive at this we simply complete what is called the parallelogram of forces. In fact, it is just as if a body were acted on at two different times, by a force driving it in one direction, and then by a force driving it in the other direction. [Dr. Carpenter illustrated this point by the aid of the black-board.] We draw two lines parallel to this, and we draw a diagonal—that diagonal is what is called the resultant; that is, it expresses the direction, and it expresses the distance—the length of the motion which that body will go when acted upon by these two forces. Now, I use this term as a very convenient one to express this—that when we have once got the conception that is derived from the harmonization of these two distinct sets of impressions on our nerves of sense, we do not fall back on the original impressions, but we fall back on the resultant, so to speak. The thing has been done for us; it is settled for us; we have got the resultant; and the combination giving that resultant is that which governs the impression made upon our minds by all similar and future operations of the same kind. We do not need to go over the processes of judgment by which the two sets of impressions are combined in every individual case; but we fall back, as it were, upon the resultant. Now, what is the case in the harmonization of the two classes of impressions of sight and touch, I believe to be true of the far more complicated operations of the mind of which the higher portion of the brain, the Cerebrum, is the instrument. Now, this Cerebrum we regard as furnishing, so to speak, the mechanism of our thoughts. I do not say that the Cerebrum is that which does the whole work of thinking, but it furnishes the mechanism of our thought. It is not the steam-engine that does the work; the steam-engine is the mere mechanism; the work is done, as my friend Prof. Roscoe would tell you, by the heat supplied; and if we go back to the source of that heat, we find it originally in the heat and light of the sun that made the trees grow by which the coal was produced, in which the heat of the sun is stored up, as it were, and which we are now using, I am afraid, in rather wasteful profusion. The steam-engine furnishes the mechanism; the work is done by the force. Now, in the same manner the brain serves as the mechanism of our thought; and it is only in that sense that I speak of the work of the brain. But there can be no question at all that it works of itself, as it were,—that it has an automatic power, just in the same manner as the sensory centres and the spinal cord have automatic power of their own. And that a very large part of our mental activity consists of this automatic action of the brain, according to the mode in which we have trained it to action, I think there can be no doubt whatever. And the illustration with which I started in this lecture gives you, I believe, a very good example of it. However, there are other examples which are in some respects still better illustrations of the automatic work that is done by the brain, in the state which is sometimes called Second Consciousness or Somnambulism—to which some persons are peculiarly subject. I heard only a few weeks ago of an extremely remarkable example of a young man who had overworked himself in studying for an examination, and who had two distinct lives, as it were, in each of which his mind worked quite separately and distinct from the other. One of these states, however—the ordinary one—is under the control of the will to a much greater extent than the other; while the secondary state is purely, I suppose, automatic. There are a great many instances on record on very curious mental work, so to speak, done in this automatic condition—a state of active dreaming, in fact. For instance, Dr. Abercrombie mentions, in his very useful work on "The Intellectual Powers," an example of a lawyer who had been excessively perplexed about a very complicated question. An opinion was required from him, but the question was one of such difficulty that he felt very uncertain how his opinion should be given. The opinion had to be given on a certain day, and he awoke in the morning of that day with a feeling of great distress. He said to his wife, "I had a dream, and the whole thing in that dream has been clear before my mind, and I would give any thing to recover that train of thought." His wife said to him, "Go and look on your table." She had seen him get up in the night and go to his table and sit down and write. He went to his table, and found there the very opinion which he had been most earnestly endeavoring to recover, lying in his own handwriting. There was no doubt about it whatever, and this opinion he at once saw was the very thing which he had been anxious to be able to give. A case was put on record of a very similar kind only a few years ago by a gentleman well known in London, the Rev. John De Liefde, a Dutch clergyman. This gentleman mentioned it on the authority of a fellow-student who had been at the college at which he studied in early life. He had been attending a class in mathematics, and the professor said to his class one day: "A question of great difficulty has been referred to me by a banker, a very complicated question of accounts, which they have not themselves been able to bring to a satisfactory issue, and they have asked my assistance. I have been trying, and I cannot resolve it. I have covered whole sheets of paper with calculations, and have not been able to make it out. Will you try?" He gave it as a sort of problem to his class, and said he should be extremely obliged to any one who would bring him the solution by a certain day. This gentleman tried it over and over again; he covered many slates with figures, but could not succeed in resolving it. He was a little put on his mettle, and very much desired to attain the solution; but he went to bed on the night before the solution, if attained, was to be given in, without having succeeded. In the morning, when he went to his desk, he found the whole problem worked out in his own hand. He was perfectly satisfied that it was his own hand; and this was a very curious part of it—that the result was correctly obtained by a process very much shorter than any he had tried. He had covered three or four sheets of paper in his attempts, and this was all worked out upon one page, and correctly worked, as the result proved. He inquired of his "hospita," as she was called—I believe our English equivalent is bedmaker, the woman who attended to his rooms—and she said she was certain that no one had entered his room during the night. It was perfectly clear that this had been worked out by himself.

Now, there are many cases of this kind, in which the mind has obviously worked more clearly and more successfully in this automatic condition, when left entirely to itself, than when we have been cudgelling our brains, so to speak, to get the solution. I have paid a good deal of attention to this subject, in this way: I have taken every opportunity that occurred to me of asking inventors and artists—creators in various departments of art—musicians, poets, and painters, what their experience has been in regard to difficulties which they have felt, and which they have after a time overcome. And the experience has been almost always the same, that they have set the result which they have wished to obtain strongly before their minds, just as we do when we try to recollect something we have forgotten; they think of every thing that can lead to it; but, if they do not succeed, they put it by for a time, and give their minds to something else, and endeavor to obtain as complete a repose or refreshment of the mind upon some other occupation as they can; and they find that either after sleep, or after some period of recreation by a variety of employment, just what they want comes into their heads. A very curious example of this was mentioned to me a few years ago by Mr. Wenham, a gentleman who has devoted a great deal of time and attention to the improvement of the microscope, and who is the inventor of that form of binocular microscope (by which we look with two eyes and obtain a stereoscopic picture) which is in general use in this country. The original binocular microscope was made upon a plan which would suggest itself to any optician. I shall not attempt to describe it to you, but it involved the use of three prisms, giving a number of reflections; and every one of these reflections was attended with a certain loss of light and a certain liability to error. And, besides that, the instrument could only be used as a binocular microscope. Now, Mr. Wenham thought it might be possible to construct an instrument which would work with only one prism, and that this prism could be withdrawn, and then we could use the microscope for purposes to which the binocular microscope could not be applied. He thought of this a great deal, but he could not think of the form of prism which would do what was required. He was going into business as an engineer, and he put his microscopic studies aside for more than a fortnight, attending only to his other work, and thinking nothing of his microscope. One evening after his day's work was done, and while he was reading a stupid novel, as he assured me, and was thinking nothing whatever of his microscope, the form of the prism that should do this work flashed into his mind. He fetched his mathematical instruments, drew a diagram of it, worked out the angles which would be required, and the next morning he made his prism, and found it answered perfectly well; and upon that invention nearly all the binocular microscopes made in this country have since been constructed.

I could tell you a number of anecdotes of this kind which would show you how very important is this automatic working of our minds—this work which goes on without any more control or direction of the Will, than when we are walking and engaged in a train of thought which makes us unconscious of the movements of our legs. And I believe that in all these instances—such as those I have named, and a long series of others—the result is owing to the mind being left to itself without the disturbance of any emotion. It was the worry which the bank-manager had been going through, that really prevented the mind from working with the steadiness and evenness that produced the result. So in the case of the lawyer; so in the case of the mathematician; they were all worrying themselves, and did not let their minds have fair play. You have heard, I dare say, and those of you who are horsemen may have had experience, that it is a very good thing sometimes, if you lose your way on horseback, to drop the reins on the horse's back and let him find his way home. You have been guiding the horse into one path and into another, and following this and that path, and you find that it does not lead you in the right direction; just let the horse go by himself, and he will find his way better than you can. In the same manner, I believe that our minds, under the circumstances I have mentioned, really do the work better than our wills can direct. The will gives the impulse in the first instance, just as when you start on your walk; and not only this, but the will keeps before the mind all the thoughts which it can immediately lay hold of, or which association suggests, that bear upon the subject. But then these thoughts do not conduct immediately to an issue, they require to work themselves out; and I believe that they work themselves out very often a great deal better by being left to themselves. But then we must recollect that such results as these are only produced in the mind which has been trained and disciplined; and that training and discipline are the result of the control of the Will over the mental processes, just as in the early part of the lecture I spoke to you of the act of speech as made possible by the control which the will has over the muscles of breathing. We cannot stop these movements—we must breathe—but we can regulate them, and modify them, and intensify them, or we can check them for a moment, in accordance with the necessities of speech. Well, so it is, I think, with regard to the action of our will upon our mental processes. I believe that this control, this discipline of the will, should be learned very early; and I will give to the mothers among you, especially, one hint in regard to a most valuable mode of training it even in early childhood. I learned this, I may say, from a nurse whom I was fortunate enough to have, and whose training of my own sons in early childhood I regard as one of the most valuable parts of their education. She was a sensible country girl, who could not have told her reasons, but whose instincts guided her in the right direction. I studied her mode of dealing with the children, and learned from that the principle. Now, the principle is this: A child falls down and hurts itself. (I take the most common of nursery incidents. You know that Sir Robert Peel used to say that there were three ways of looking at this question; and there are three modes of dealing with this commonest of nursery incidents.) One nurse will scold the child for crying. The child feels the injustice of this; it feels the hurt, and it feels the injustice of being scolded. I believe that is the most pernicious of all the modes of dealing with it. Another coddles the child, takes it up and rubs its head, and says, "O naughty chair, for hurting my dear child!" I remember learning that one of the royal children fell against a table in the queen's presence, and the nurse said, "O naughty table," when the queen very sensibly said: "I will not have that expression used; it was not the table that was naughty; it was the child's fault that he fell against the table." I believe that this method is extremely injurious; the result of it being that it fixes the child's attention upon its hurt, and causes it to attain that habit of self-consciousness which is in after-life found to have most pernicious effects. Now, what does the sensible and judicious nurse do? She distracts the child's attention, holding it up to the window to look at the pretty horses, or gets it a toy to look at. This excites the child's attention, and the child forgets its hurt, and in a few moments is itself again, unless the hurt has been severe. When I speak of coddling, I mean about a trifling hurt such as is forgotten in a few moments; a severe injury is a different matter. But I believe that the coddling is only next in its evil results (when followed out as a system) to the evil effects of the system of scolding; the distraction of the attention is the object to be aimed at. Well, after a time the child comes to be able to distract its own attention. It feels that it can withdraw its own mind from the sense of its pain, and can give its mind to some other object, to a picture-book or to some toy, or whatever the child feels an interest in; and that is the great secret of self-government in later life. We should not say, "I won't think of this"—some temptation, for instance; *that* simply fixes the attention upon the very thought that we wish to escape from; but the true method is, "I will think of something else;" *that*, I believe, is the great secret of self-government, the knowledge of which is laid in the earliest periods of nursery-life.

Now, just direct your attention to this diagram, as a sort of summary of the whole:

[DIAGRAM.]



You see I put at the top the Will. The will dominates every thing else. I do not pretend to explain it, but I simply say, as Archbishop Manning said, in applying my own language to this case, that our common-sense teaches us that we have a will, that we have the power of self-government and self-direction, and that we have the power of regulating and dominating all these lower tendencies to a certain extent, not to an unlimited extent. We cannot prevent those thoughts and feelings rising in our minds that we know to be undesirable; but we can escape from them, we can repress them; but, as I said, the effort to escape from them is much more effectual than the effort to repress them, excepting when they arise with great power, and then we have immediately, as it were, to crush them out; but when they tend to return over and over again, the real mode of subduing them is to determine to give our attention to something else. It is by this exercise of the will, therefore, in training and disciplining the mind, that it acquires that method by which it will work of itself. The mathematician could never have worked out that difficult problem, nor the lawyer have given his opinion, nor the artist have developed those conceptions of beauty which he endeavors to shape either in music, or poetry, or painting, but for the training and disciplining which his mind has undergone. The most wonderfully creative of all musicians, Mozart, whose music flowed from him with a spontaneousness that no musician, I think, has ever equalled—Mozart went through, in early life, a most elaborate course of study, imposed upon him, in the first instance, by his father, and afterward maintained by himself. When his contemporaries remarked how easily his compositions flowed from him, he replied, "I gained the power by nothing but hard work." Mozart had the most extraordinary combination of this intuitive musical power, with a knowledge derived from patient and careful study, that probably any man ever attained. Now, in the same manner we have persons of extraordinary natural gifts, and see these gifts frequently running to waste, as it were, because they have not received this culture and discipline. And it is this discipline which gives us the power of performing, unconsciously to ourselves, these elaborate mental operations; because I hold that a very large part of our mental life thus goes on, not only automatically, but even below the sphere of our consciousness. And you may easily understand this if you refer to the diagram which I drew just now on the black-board. You saw that the Cerebrum, the part that does the work, what is called the convoluted surface of the brain, lies just immediately under the skull-cap; that it is connected with the sensorium at the base of the brain by a series of fibres which are merely, I believe, conducting fibres. Now, I think that it is just as possible that the Cerebrum should work by itself when the sensorium is otherwise engaged or in a state of unconsciousness, as that impressions should be made on the eye of which we are unconscious. A person may be sleeping profoundly, and you may go and raise the lid and bring a candle near, and you will see the pupil contract; and yet that individual shall see nothing, for he is in a state of perfect unconsciousness. His eye sees it, so to speak, but his mind does not; and you know that his eye sees it by the contraction of the pupil, which is a reflex action; but his mind does not see it, because the sensorium is in a state of inaction. In the same manner during sleep the Cerebrum may be awake and working, and yet the Sensorium shall be asleep, and we may know nothing of what the cerebrum is doing except by the results. And it is in this manner, I believe, that, having been once set going, and the cerebrum having been shaped, so to speak, in accordance with our ordinary processes of mental activity, having grown to the kind of work we are accustomed to set it to execute, the cerebrum can go on and do its work for itself. The work of invention, I am certain, is so mainly produced, from concurrent testimony I have received from a great number of inventors, or what the old English called "makers"—what the Greeks called poets, because the word poet means a maker. Every inventor must have a certain amount of imagination, which may be exercised in mechanical contrivance or in the creations of art; these are *inventions*—they are made, they are produced, we don't know how; the conception comes into the mind we cannot tell whence; but these inventions are the result of the original capacity for that particular kind of work, trained and disciplined by the culture we have gone through. It is not given to every one of us to be an inventor. We may love art thoroughly, and yet we may never be able to evolve it for ourselves. So in regard to humor. For instance, there are some men who throw out flashes of wit and humor in their conversation, who cannot help it—it flows from them spontaneously. There are other men who enjoy this amazingly, whose nature it is to relish such expressions keenly, but who cannot make them themselves. The power of invention is something quite distinct from the intellectual capacity or the emotional capacity for enjoying and appreciating; but although we may not have these powers of invention, we can all train and discipline our minds to utilize that which we do possess to its utmost extent. And here is the conclusion to which I would lead you in regard to Common-Sense. We fall back upon this, that common-sense is, so to speak, the *general resultant of the whole previous action of our minds.* We submit to common-sense any questions—such questions as I shall have to bring before you in my next lecture; and the judgment of that common-sense is the judgment elaborated as it were by the whole of our mental life. It is just according as our mental life has been good and true and pure, that the value of this acquired and this higher common-sense is reached. We may in proportion I believe to our honesty in the search for truth—in proportion as we discard all selfish considerations and look merely at this grand image of truth, so to speak, set before us, with the purpose of steadily pursuing our way toward it—in proportion as we discard all low and sensual feelings in our love of beauty, and especially in proportion to the earnestness of the desire by which our minds are pervaded always to keep the right before us in all our judgments—so I believe will our minds be cleared in their perception of what are merely prudential considerations. It has on several occasions occurred to me to form a decision as to some important change either in my own life, or in the life of members of my family, which involved a great many of what we are accustomed to call *pros* and *cons*—that is, there was a great deal to be said on both sides. I heard the expression once used by a naturalist, with regard to difficulties in classification—"It is very easy to deal with the white and the black; but the difficulty is to deal with the gray." And so it is in life. It is perfectly easy to deal with the white and the black—there are things which are clearly right, and things which are clearly wrong; there are things which are clearly prudent, and things which are clearly imprudent; but a great many cases arise in which even right and wrong may seem balanced, or the motives may be so balanced that it is difficult to say what is right; and again, there are cases in which it is difficult to say what is prudent; and I believe, in these cases where we are not hurried and pressed for a decision, the best plan is to do exactly that which I spoke of in the earlier part of the lecture—to set before us as much as possible every thing that is to be said on both sides. Let us consider this well; let us go to our friends; let us ask what they think about it. They will suggest considerations which may not occur to ourselves. It has happened to me within the last three or four months to have to make a very important decision of this kind for myself; and I took this method—I heard every thing that was to be said on both sides, I considered it well, and then I determined to put it aside as completely as possible for a month, or longer, if time should be given, and then to take it up again, and simply just to see how my mind gravitated—how the balance then turned. And I assure you that I believe that in those who have disciplined their minds in the manner I have mentioned, that act of "Unconscious Cerebration," for so I call it, this unconscious operation of the brain in balancing for itself all these considerations, in putting all in order, so to speak, in working out the result—I believe that that process is far more likely to lead us to good and true results than any continual discussion and argumentation, in which one thing is pressed with undue force, and then that leads us to bring up something on the other side, so that we are just driven into antagonism, so to speak, by the undue pressure of the force which we think is being exerted. I believe that to hear every thing that is to be said, and then not to ruminate upon it too long, not to be continually thinking about it, but to put it aside entirely from our minds as far as we possibly can, is the very best mode of arriving at a correct conclusion. And this conclusion will be the *resultant* of the whole previous training and discipline of our minds. If that training and discipline has all been in the direction of the true and the good, I believe that we are more likely to obtain a valuable result from such a process than from any conscious discussion of it in our minds, any thing like continually bringing it up and thinking of it, and going over the whole subject again in our thought. The unconscious settling down, as it were, of all these respective motives will, I think, incline the mind ultimately to that which is the just and true decision.

There is just one other point I could mention in connection with this subject: the manner in which the *conscious* direction and discipline of the mind will tend to remove those *unconscious* prejudices that we all have more or less from education, from the circumstances in which we were brought up; and from which it is excessively difficult for us to free ourselves entirely. I have known a great many instances, in public and in private life, in which the most right-minded men have every now and then shown the trammelling, as it were, of their early education and early associations, and were not able to think clearly upon the subject in consequence of this. These early prejudices and associations cling around us and influence the thoughts and feelings of the honestest men in the world unconsciously; and it is sometimes surprising, to those who do not know the force of these early associations, to see how differently matters which are to them perfectly plain and obvious are viewed by men whom we feel we must respect and esteem. Now, I believe that it is the earnest habit of looking at a subject from first principles, and, as I have said over and over again, looking honestly and steadily at the true and the right, which gives the mind that direction that ultimately overcomes the force of these early prejudices and these early associations, and brings us into that condition which approaches the nearest of any thing that I think we have the opportunity of witnessing in our earthly life, to that *direct insight*, which many of us believe will be the condition of our minds in that future state in which they are released from all the trammels of our corporeal existence.

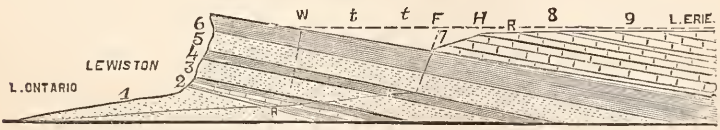
THE PAST AND FUTURE OF NIAGARA.

By Prof. W. D. GUNNING.

IN October, 1842, the Falls of Niagara were made the subject of careful study by the New York State Geologists. Under their direction a trigonometrical survey was made, and the river-banks—ancient and recent—the contours of Goat and Luna and Bath Islands, and the periphery of the Falls, were mapped with the utmost precision. The map is preserved in the archives of the State, at Albany, and the copper bolts and little stone monuments, which were placed to mark the trigonometrical points, remain—all, except those which fell with Table Rock. The American Association for the Advancement of Science, at its session last summer, petitioned the New York Legislature to provide for another survey. The expense would have been a mere trifle, but gentlemen of "the Reform Legislature" would not even consider the proposition. It is to be lamented, for another survey would give data by which we could translate into time nearly half a mile of the channel. Until the Falls shall be examined again by instrumentation, in estimating the rate of recession we must depend on the eye alone.

In 1840 old citizens told Lyell that the Falls recede about a yard in a year. I hear the same estimate from citizens now. They see a notch in the Horseshoe which was not there thirty years ago, and they see it growing deeper year by year; they see the American Fall more indented than it was when they used to observe it, and from such changes they construct a scale and apply it to the entire periphery. They deceive themselves. A careful study of the Falls from the trigonometrical points, even without instruments, and a comparison of what you see, with the map of 1842, would convince you that the recession during the past 30 years would fall inside of 15 feet. Let us take six inches a year as an approximation to the rate at which the Falls are eating back through the ledges of shale and limestone. The scale which answers to the last 30 years will apply to the channel from the Horseshoe to Ferry Landing, nearly half a mile. Through this part of the channel the Falls have cut through the same rocks they are cutting now. When they were at the site of Ferry Landing, a hard limestone, a member of the Clinton group, No. 4 of our section (Fig. 1), lay at their base, and the recession must have been arrested. Again, when they were at the site of the Whirlpool, a very hard, quartzose sandstone, marked 2 in the section, a member of the Medina system, lay at their base and checked their recession. Here the great cataract must have stood for ages almost stationary. With these two exceptions, the Falls, in every stage of their retreat, have cut through shale below, and the Niagara limestone above.

Fig. 1.



Section of Strata along the River from Lake to Lake.

Numbers 1, 2, 3, belong to the Medina group; 4, to the Clinton group; 5, 6, 7, to the Niagara group; and 8 and 9 to the Onondaga group. Numbers 1 and 3 are red shaly sandstone; 2 is quartzose limestone; 4 green shale and limestone; 5 dark shale; and 6 gray limestone. W, site of the Whirlpool, where the Falls were 120 feet higher than now, and where their recession was checked by the quartzose sandstone, No. 2. The dotted line *t*, *t*, represents the highest terrace (or oldest river-bank) from the Whirlpool to the head of the Rapids, H. F represents the present site of the Falls, and R, R, the surface of the river from lake to lake.

Another element in the problem of Niagara's age is the flow of water. To construct a scale from the present and apply it to the past, we should know that the amount of water in past ages has been essentially the same as now.

About 9,800 cubic miles of water—nearly half the fresh water on the globe—are in the upper lakes, and 18,000,000 cubic feet of this plunge over Niagara Falls every minute, all the water of the lakes making the circuit of the Falls, the St. Lawrence, the ocean, vapor, rain, and lakes again, in 152 years. Through the Illinois Canal about 8,000 cubic feet of water are taken every minute from Lake Michigan to the Illinois River; through the Welland Canal 14,000 cubic feet flow every minute from Lake Erie into Lake Ontario, and through the Erie Canal 30,000 cubic feet pass every minute from the same lake into the Hudson. Thus, 52,000 cubic feet of water, which Nature would give to Niagara, are diverted every minute by artificial channels, some into the Mexican Gulf and some into the Bay of New York. Add this to 18,000,000, it is as a drop in the bucket, and would make no appreciable difference in the character of the Falls or their rate of recession. Was there *ever* a time when the Niagara was appreciably a greater river than now?

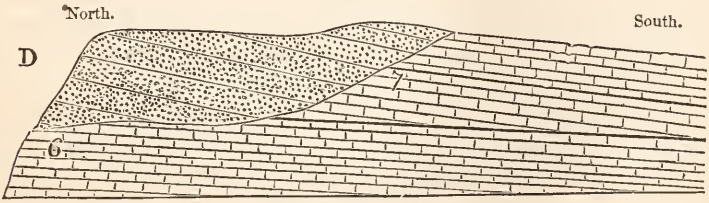
Below the Falls, on the Canada side, is a terrace, extending along the river-bank, and attaining a height of 46 feet. It contains river-shells, and is an old river-bank. A corresponding bank is found on the New York side, although much broken and eroded. If a tourist will stand on the New Suspension Bridge and cast his eye along these ancient banks, his first impression will be that the Niagara which flowed against them was vastly greater than the river which flows now nearly 200 feet below him. But, if his eye will follow the Canadian terrace above the Horseshoe, he will see it falling lower and lower, till, at the head of the Rapids, it merges into the present bank. From this point upward the river is contained within low banks, and bounded by a plain whose monotony is not broken by a hill or terrace. A glance at the section (Fig. 1) will make this clear to the eye of the reader. The surface of the river from Buffalo to Lake Ontario is represented by the line R, R; the banks, from Buffalo to the Rapids, by the dotted line *t*, *t*; and the *old* banks, from the Rapids to the Whirlpool, by a continuation of the same line. It will be seen that this line rises as the surface of the river falls. The slope from the head of the Rapids to the Falls is nearly 50 feet, and the terrace opposite the Falls attains a height of 46 feet.

We turn now to Goat Island. A walk around the island, by the margin of the river, will show us what immense denudation its limestones have suffered. The extent of this denudation can be seen in our section of the island (Fig. 2). To wear away such beds of limestone, the river, for many ages, must have flowed over the island. And as the upper beds of fluviatile drift, marked D in our section, are a little below the level of the highest terrace, we must infer that the river, when contained in these ancient banks, covered the island, and was eroding its beds of limestone.

By all this we see that the Niagara itself has made the Rapids, and that, as it cut its way downward, its forsaken banks have assumed the character of terraces. And we see, by the low banks and absence of old banks above the Rapids, that even the highest of these ancient banks did not contain a greater river than this which flows through the narrow gorge to-day.

We assume, then, from all the monuments the river has left of its own history, that the present rate of recession would be a fair measure of the past, except at the Whirlpool and Ferry Landing. Six inches a year, measured on the channel, would place the Falls at Lewiston 74,000 years ago. We have no means of knowing how long the quartzose sandstone, which forms the lowest part of the bank at the Whirlpool, would have arrested the cataract. This stratum is 25 feet thick, and, as its southward dip is 20 feet a mile, and the slope of the river-channel 15 feet a mile, the Falls would have to cut back through this rock more than half a mile. The halt may have been many thousand years. Add another period for the halt at the landing,

Fig. 2.



Section of Goat Island.

No. 6, the Niagara limestone (6 also of Fig. 1); No. 7, the shaly limestone (marked 7 in Fig. 1). The Rapids have been formed by the erosion of this limestone. D, alluvial drift covering the eroded limestone. The section will show how great had been the denudation of the limestone by the river before the drift D accumulated, and before the river had found its present level.

and the age of the channel, from Lewiston to the Horseshoe, may not fall below 200,000 years. Unquestionably the channel has been excavated since the close of the glacial epoch, which science has well-nigh demonstrated occurred about 200,000 years ago. But this channel is only the last chapter in the history of Niagara.

Standing by the Whirlpool on the east, and looking over the river, we see a break in the ledges of rock which everywhere else form the bank. On the western side, around the bend of the Whirlpool, for a distance of 500 feet, bowlders and gravel take the place of ledges of rock. Many of these bowlders are granite and greenstone and gneiss, which have travelled hundreds of miles from the northeast. This mass of northern drift fills an old river-channel, which we can trace from the Whirlpool to the foot of the escarpment at St. David's—about two miles and a half. The reader will see by the map (Fig. 4) that this old channel marked 13 lies in a line with the present channel above the Whirlpool. The opening at St. David's is two miles wide. Here the Falls stood "in the beginning," wide, but not deep. They had cut back two miles and a half when the glacial period came, and lakes and rivers, and the great cataract, were buried under a colossal sheet of ice. If we can trust astronomical data (Stone's Tables of the Eccentricity of the Earth's Orbit), the glacial epoch lasted about 50,000 years. Add this to the age of the present channel, and 25,000 years for the preglacial channel, and we have 275,000 years as an approximation to the age of Niagara River.

Of course these figures are given merely as an approximation to the truth. To the general reader the time seems immense. But to the geologist it seems short, and his concern is to account for the æons in which the lakes and their water-shed must have stood above the ocean, but which the Niagara has not registered. Let us attend for a little while to the earlier history of this Niagara region.

From the Old Suspension Bridge three geologic systems can be seen on the river-banks. The lowest is a red, mottled, shaly sandstone, the *Medina sandstone*. It is marked 3 on the section (Fig. 1). Above this, and having the same dip, is a thin group of green shale and gray limestone, the *Clinton group*, No. 4 of the section. Overlying the Clinton is dark shale, and over the shale a thick band of gray limestone, the two forming the *Niagara group*, designated on the section by Nos. 5 and 6.

Below the escarpment at Lewiston, as the diagram will show, the lowest member of the Medina sandstone (No. 1, Fig. 1) appears as the surface rock. We find it ripple-marked and carrying the *Lingula cuneata* and *Fucoides Harlani*, its characteristic shell and sea-weed. It underlies a good part of Western New York and Canada, and extends southward into Pennsylvania and Virginia, with everywhere the same characters, indicating a quiet, shallow sea, fed by rivers which for ages brought down the same sediments. It is eighth in the series of palæozoic rocks which form the first volume of the world's history after the beginnings of life, and is the oldest rock which shows itself about the Falls.

Up the river, about two miles from Lewiston, the railroad, which descends the river-bank, takes us to the junction of the Medina sandstone with the Clinton group. The green shale is barren here, but at Lockport we have found it full of *Agnostus lotus*, a little ill-defined crustacean. The overlying limestone is exceedingly rich in fossils, *Atrypa neglecta* being the characteristic shell. The sea had changed both its life and the rock material on its bottom.

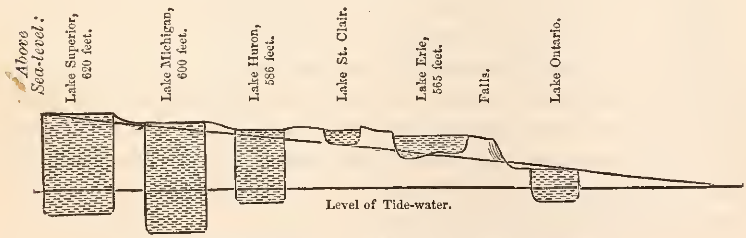
Another change, and to the Clinton succeeded the Niagara period. The change was not abrupt, for many species, common in the Clinton sea, lived in the Niagara as well.

In the Niagara shale we have found *Conularia Niagarensis*, a shell which must be referred to a Pteropod mollusk. Pteropods of the living world are seen only on mid-ocean. They flap themselves over the water by wing-like appendages from the side to the head. Their shells do not drift ashore, but the dredge has brought them up from the ooze of the deep-sea bottom. Now, this Niagara shale is only the hardened ooze of an ancient sea-bottom, and the *Conularia* tells us that here the sea was open and deep.

A time came when mud-sediments were no longer brought down, and the bottom of an ocean, clear, warm, placid, over an area which extended from the Hudson far beyond the Mississippi, was a vast grove of coral. In sheltered nooks of the coral-grove were gardens of waving crinoids, and three-lobed, many-jointed, many-eyed trilobites were crawling over the coral sand, and mollusks in richly-sculptured shells were everywhere on sand and coral. The Niagara limestone is a monument of that ancient life. With the formation of this rock and its uplift from the sea, the geologic record here about Niagara closed, until the coming of the Ice.

We turn now to the geology of the lake-region. The area of the lakes is estimated at 90,000 square miles; and the area whose streams flow into the lakes, at 400,000 square miles. This immense area is one of the oldest on the globe. On the north shore of Lake Huron and Lake Superior we find the azoic rocks, and on the borders of Lake Erie and Lake Michigan we find no rock newer than the lowest members of the Devonian. The whole water-shed of the St. Lawrence was reclaimed from the ocean before the close of the Devonian epoch. If the drainage has always been through the gulf of St. Lawrence, the Niagara should be one of the oldest rivers on the globe. And yet, as we have seen, in the geological calendar it is very young. How shall we account for this gap between ocean-history and river-history? A little more of geology and something of topography will help us to understand why the Niagara has recorded such a small segment of the time which lies between us and the Devonian seas.

Fig. 3.



Hypothenuse of the Triangle, 1,600 Miles long.

Ideal Section of the St. Lawrence and its Lakes.

Borings made a few years ago at La Salle, on the Illinois, revealed the fact that the valley had been eroded forty feet below the present river-bed. Pot-holes and water-worn ledges at Athens mark the course of an ancient river. Other evidences of the ancient river are found in the valley of the Des Plaines and along the Calumet feeder of the Illinois Canal.

The topography of the lake-basins and the Niagara plateau will explain that old river-bed.

Lake Erie, as everybody knows, and as we have indicated in the ideal section of the St. Lawrence and its lakes (Fig. 3), fills a shallow basin eroded in a plateau 333 feet above the level of Lake Ontario, and 565 feet above the ocean. The surface of Lake Michigan is 600 feet above tide-level, and, as the lake is 1,000 feet deep, its bottom is 400 feet below the level of tide-water. Lake Superior is 900 feet deep, and its surface about 20 feet above that of Lake Michigan. The Niagara, from Buffalo to the head of the Rapids, has a fall of 15 feet. The fall from Lake Michigan to Goat Island is 50 feet—just equal to the slope of the Rapids. A barrier 15 feet high, stretching across the plateau at the head of the Rapids, would throw the river back on Lake Erie, and such a barrier, 50 feet high, would hold back the waters of Lake Michigan.

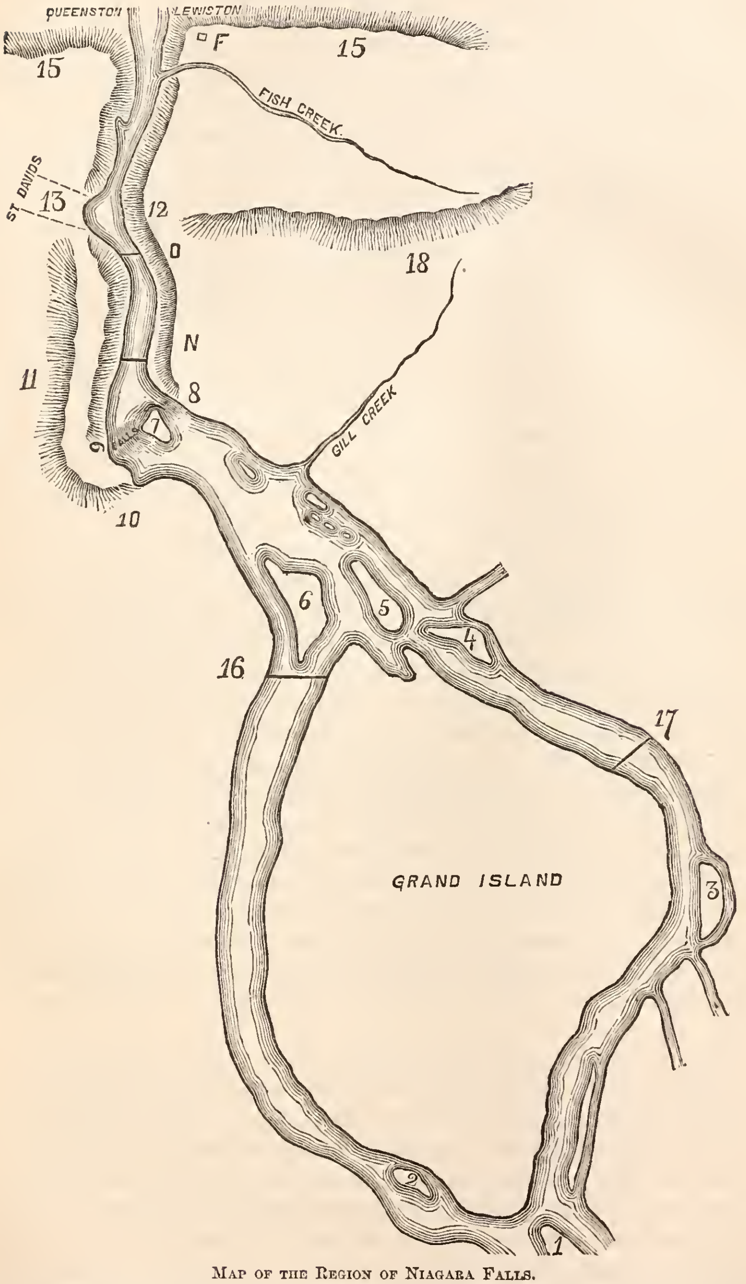
We can see the significance, now, of a few features of topography about the Falls.

The reader will turn to the map of Niagara River, which we have drawn, with some modifications, from the official maps of the Boundary Commission. He will see that, from the foot of Grand Island to the Falls, the course of the river is almost due west. At the Falls it makes an elbow, and extends thence, with no abrupt winding except at the Whirlpool, northward to Lake Ontario. At Schlosser Landing, about a mile above the Rapids, a stream called Gill Creek empties into the river. It is not more than six miles long, and its course is parallel to that of Niagara below the Falls. Its source is a swamp about two miles east of the river, and nearly the same distance north of Old Fort Gray. We have the anomaly of two streams flowing side by side, within two miles of each other, in opposite directions, and through an apparently level country. Gill Creek, flowing southward, has a fall in six miles, of 60 feet. Its source is 60 feet higher than the surface of Niagara at Schlosser Landing. This high land is not a hill, but a ridge—an anticlinal axis extending from northeast to southwest across the Niagara channels. Before it was broken through and eroded, it formed a barrier a few feet higher than the surface of Lake Michigan. Then Niagara was not, and the upper lakes sought the ocean through a great river, sections of whose channel, as we have seen, can still be traced from Chicago to the Illinois.

We have lingered long in the past. What of the future? The intelligent tourist who stands by the great cataract cannot allow the beauty, the grandeur, the vast magnificence of the scene, to bear down his imagination and bind up all his powers in the present. He looks and listens, and, while he stands overpowered by the falling torrent and rising spray, and thunderous pounding of torrent on fallen torrent, his imagination breaks the spell, and his thoughts wander away into the past and the yet to be. Are future ages to see this wonder, and find it as great as our eyes see it?

Mr. Hall, in his report on the Fourth District, and Sir Charles

FIG. 4.



MAP OF THE REGION OF NIAGARA FALLS.

1. Strawberry Island; 2. Beaver Island; 3. Tonawanda Island; 4. Cayuga Island; 5. Brockton Island; 6. Navy Island; 7. Goat Island; 8. American Fall; 9. Horseshoe Fall; 10. Gas Spring; 11. Oldest Terrace; 12. Whirlpool; 13. Preglacial Channel; 15, 15. Line of the Escarpment; N. New Suspension Bridge; O. Old Suspension Bridge; F. Fast Ground; 16, 17. Position of the Falls when the shale shall dip below the river-bed, and the limestone shall form the entire precipice. After receding so far, the Falls will then wear away into cascades and rapids. 18. The Old Barrier.

Lyell, in his "First Travels in the United States," have told us what they thought the Falls are coming to.

The reader will remember that the dip of the strata here is 20 feet a mile *southward.* He will remember, too, that the current below the Falls is 15 feet a mile northward. If he will turn to the section it may help him to see that a stratum which, a mile below the Falls, crops out along the bank 35 feet above the river, would be brought down, at the Falls, to the level of the river; and he will see that, for every mile the Falls have cut their way southward, they have lost 35 feet in height—the dip of the strata and slope of the channel. Let them cut back two miles farther (this is the reasoning of Hall and Lyell), and they will have passed the head of the Rapids. The shale which now lies at their base and forms the lower part of the precipice will have disappeared beneath the river-bed, and the limestone which has always been at the top of the precipice will have reached the bottom. As the Falls have receded by the action of the spray on the shale below, and the breaking and falling down of the undermined limestone above, now that the entire precipice is limestone, the features of the cataract will begin to change. The rock will wear away faster at the top than at the bottom, and the great Niagara—only a hundred feet high now—will dwindle away into a succession of cascades and rapids. This is the future as shaped in the minds of Hall and Lyell. They have overlooked an important fact—the change in the course of the river.

A reference to the map will show that the American Fall (8) is cutting eastward, and the Horseshoe (9) southward. But, after a few hundred feet have been cut away, the direction of the Horseshoe will change, and both Falls will move *eastward.* Above Goat Island they will unite and move on, one Fall, of immense width, till Navy Island cuts it in two. The greater Fall will then be on the American side, and its recession will still be eastward. A little Fall on the Canada side will retreat southward around Navy Island and then Grand Island. About a mile above the northern point of Grand Island this Fall will have moved southward far enough to leave the shale and have the precipice all of limestone. The water will then wear away the rim faster than the base, and the Fall will become a series of cascades and rapids.

But the main Fall will have to cut back to within a mile of Tonawanda Island—by the course of the river, nearly eight miles from the Horseshoe—before it makes the same southing. The Fall will have cut back, not *with* the dip, but nearly at right angles *across* it. And by the present rate of recession it must continue its work of excavation for 80,000 years before the shale will disappear under the bed of the river and the limestone form the entire precipice. Then the same fate will overtake this greater Fall which, ages before, awaited the other. All this on the assumption that Nature is to go on selecting her own channels and seeking her own ends.

But man is, here, greater as a mere dynamic than any other force acting on the globe. Already Niagara has felt his power. Fifty-two thousand cubic feet of water which belong to her, every summer minute he diverts to his own uses. Another century will see him on every acre along the borders of the upper lakes. Every forest he fells, every acre he ploughs, will affect, though inappreciably, the flow of water over the Falls. Time may come when his hand, laid on the earth in gigantic enterprise, will cause the Falls to shrink into insignificance. He will make these lakes furnish him highways to the ocean, east and south. A canal from Lake Michigan to the Illinois, great enough to float ships laden for the marts of Europe, and another from Lake Erie to Lake Ontario, are achievements in the near future.

YEAST.

By THOMAS H. HUXLEY, LL.D., F.R.S.

IT has been known, from time immemorial, that the sweet liquids which may be obtained by expressing the juices of the fruits and stems of various plants, or by steeping malted barley in hot water, or by mixing honey with water, are liable to undergo a series of very singular changes, if freely exposed to the air and left to themselves, in warm weather. However clear and pellucid the liquid may have been, when first prepared, however carefully it may have been freed from even the finest visible impurities, by straining and filtration, it will not remain clear. After a time it will become cloudy and turbid; little bubbles will be seen rising to the surface, and their abundance will increase until the liquid hisses as if it were simmering on the fire. By degrees, some of the solid particles which produce the turbidity of the liquid collect at its surface into a scum, which is blown up by the emerging air-bubbles into a thick, foamy froth. Another moiety sinks to the bottom, and accumulates as a muddy sediment, or "lees."

When this action has continued for a certain time, with more or less violence, it gradually moderates. The evolution of bubbles slackens, and finally comes to an end; scum and lees alike settle at the bottom, and the fluid is once more clear and transparent. But it has acquired properties of which no trace existed in the original liquid. Instead of being a mere sweet fluid, mainly composed of sugar and water, the sugar has more or less completely disappeared, and it has acquired that peculiar smell and taste which we call "spirituous." Instead of being devoid of any obvious effect upon the animal economy, it has become possessed of a very wonderful influence on the nervous system; so that in small doses it exhilarates, while in larger it stupefies, and may even destroy life.

Moreover, if the original fluid is put into a still, and heated for a while, the first and last product of its distillation is simple water; while, when the altered fluid is subjected to the same process, the matter which is first condensed in the receiver is found to be a clear, volatile substance, which is lighter than water, has a pungent taste and smell, possesses the intoxicating powers of the fluid in an eminent degree, and takes fire the moment it is brought in contact with a flame. The alchemists called this volatile liquid, which they obtained from wine, "spirits of wine," just as they called hydrochloric acid "spirits of salt," and as we, to this day, call refined turpentine "spirits of turpentine." As the "spiritus," or breath, of a man was thought to be the most refined and subtle part of him, the intelligent essence of man was also conceived as a sort of breath, or spirit; and, by analogy, the most refined essence of any thing was called its "spirit." And then it has come about that we use the same word for the soul of man and for a glass of gin.

At the present day, however, we even more commonly use another name for this peculiar liquid—namely, "alcohol," and its origin is not less singular. The Dutch physician, Van Helmont, lived in the latter part of the sixteenth and the beginning of the seventeenth century—in the transition period between alchemy and chemistry—and was rather more alchemist than chemist. Appended to his "Opera Omnia," published in 1707, there is a very needful "Clavis ad obscuriorum sensum referandum," in which the following passage occurs:

> Alcohol—In chemistry, a liquid or powder of extreme subtilty, from an Eastern word, *cohol* (or, better, *kohl*), used familiarly chiefly at Habessus, to denote an impalpable powder of antimony for painting the eyebrows. Alcohol is now used, by analogy, to express any very fine powder, such as powder for the eyebrows highly subtilized; and well-rectified spirits are said to be *alcoholized*.

Robert Boyle similarly speaks of a fine powder as "alcohol;" and so late as the middle of the last century the English lexicographer, Nathan Bailey, defines "alcohol" as "the pure substance of any thing separated from the more gross, a very fine and impalpable powder, or a very pure, well-rectified spirit." But, by the time of the publication of Lavoisier's "Traité Élémentaire de Chimie," in 1789, the term "alcohol," "alkohol," or "alkool" (for it is spelt in all three ways), which Van Helmont had applied primarily to a fine powder, and only secondarily to spirits of wine, had lost its primary meaning altogether; and, from the end of the last century until now, it has, I believe, been used exclusively as the denotation of spirits of wine, and bodies chemically allied to that substance.

The process which gives rise to alcohol in a saccharine fluid is known to us as "fermentation," a term based upon the apparent boiling up or "effervescence" of the fermenting liquid, and of Latin origin.

Our Teutonic cousins call the same process "gähren," "gäsen," "göschen," and "gischen;" but, oddly enough, we do not seem to have retained their verb or substantive denoting the action itself, though we do use names identical with, or plainly derived from, theirs for the scum and lees. These are called, in Low German, "gäscht" and "gischt;" in Anglo-Saxon, "gest," "gist," and "yst," whence our "yeast." Again, in Low German and in Anglo-Saxon, there is another name for yeast, having the form "barm," or "beorm;" and in the midland counties "barm" is the name by which yeast is still best known. In High German, there is a third name for yeast, "hefe," which is not represented in English, so far as I know.

All these words are said by philologers to be derived from roots expressive of the intestine motion of a fermenting substance. Thus "hefe" is derived from "heben," to raise; "barm" from "beren" or "bären," to bear up; "yeast," "yst," and "gist," have all to do with seething and foam, with "yeasty waves," and "gusty" breezes.

The same reference to the swelling up of the fermenting substance is seen in the Gallo-Latin terms "levure" and "leaven."

It is highly creditable to the ingenuity of our ancestors, that the peculiar property of fermented liquids, in virtue of which they "make glad the heart of man," seems to have been known in the remotest periods of which we have any record. All savages take to alcoholic fluids as if they were to the manner born. Our Vedic forefathers intoxicated themselves with the juice of the "soma;" Noah, by a not unnatural reaction against a superfluity of water, appears to have taken the earliest practicable opportunity of qualifying that which he was obliged to drink; and the ghosts of the ancient Egyptians were solaced by pictures of banquets in which the wine-cup passes around, graven on the walls of their tombs. A knowledge of the process of fermentation, therefore, was in all probability possessed by the prehistoric populations of the globe; and it must have become a matter of great interest even to primæval wine-bibbers to study the methods by which fermented liquids could be surely manufactured. No doubt, therefore, it was soon discovered that the most certain, as well as the most expeditious, way of making a sweet juice ferment was to add to it a little of the scum, or lees, of another fermenting juice. And it can hardly be questioned that this singular excitation of fermentation in one fluid, by a sort of infection, or inoculation, of a little ferment taken from some other fluid, together with the strange swelling, foaming, and hissing of the fermented substance, must have always attracted attention from the more thoughtful. Nevertheless, the commencement of the scientific analysis of the phenomena dates from a period not earlier than the first half of the seventeenth century.

At this time, Van Helmont made a first step, by pointing out that the peculiar hissing and bubbling of a fermented liquid are due, not to the evolution of common air (which he, as the inventor of the term "gas," calls "gas ventosum"), but to that of a peculiar kind of air such as is occasionally met with in caves, mines, and wells, and which he calls "gas sylvestre."

But a century elapsed before the nature of this "gas sylvestre," or, as it was afterward called, "fixed air," was clearly determined, and it was found to be identical with that deadly "choke-damp" by which the lives of those who descend into old wells, or mines, or brewers' vats, are sometimes suddenly ended; and with the poisonous aëriform fluid which is produced by the combustion of charcoal, and now goes by the name of carbonic-acid gas.

During the same time it gradually became clear that the presence of sugar was essential to the production of alcohol and the evolution of carbonic-acid gas, which are the two great and conspicuous products of fermentation. And finally, in 1787, the Italian chemist, Fabroni, made the capital discovery that the yeast-ferment, the presence of which is necessary to fermentation, is what he termed a "vegeto-animal" substance—or is a body which gives off ammoniacal salts when it is burned, and is, in other ways, similar to the gluten of plants and the albumen and casein of animals.

These discoveries prepared the way for the illustrious Frenchman, Lavoisier, who first approached the problem of fermentation with a complete conception of the nature of the work to be done. The words in which he expresses this conception, in the treatise on elementary chemistry, to which reference has already been made, mark the year 1789 as the commencement of a revolution of not less moment in the world of science than that which simultaneously burst over the political world, and soon engulfed Lavoisier himself in one of its mad eddies:

> We may lay it down as an incontestable axiom that, in all the operations of art and nature, nothing is created; an equal quantity of matter exists both before and after the experiment: the quality and quantity of the elements remain precisely the same, and nothing takes place beyond changes and modifications in the combinations of these elements. Upon this principle, the whole art of performing chemical experiments depends; we must always suppose an exact equality between the elements of the body examined and those of the product of its analyses.
>
> Hence, since from must of grapes we procure alcohol and carbonic acid, I have an undoubted right to suppose that must consists of carbonic acid and alcohol. From these premises we have two modes of ascertaining what passes during vinous fermentation: either by determining the nature of, and the elements which compose, the fermentable substances; or by accurately examining the products resulting from fermentation; and it is evident that the knowledge of either of these must lead to accurate conclusions concerning the nature and composition of the other. From these considerations, it became necessary accurately to determine the constituent elements of the fermentable substances;

and, for this purpose, I did not make use of the compound juices of fruits, the rigorous analysis of which is perhaps impossible, but made choice of sugar, which is easily analyzed, and the nature of which I have already explained. This substance is a true vegetable oxide, with two bases, composed of hydrogen and carbon, brought to the state of an oxide by means of a certain proportion of oxygen; and these three elements are combined in such a way that a very slight force is sufficient to destroy the equilibrium of their connection.

After giving the details of his analysis of sugar and of the products of fermentation, Lavoisier continues:

The effect of the vinous fermentation upon sugar is thus reduced to the mere separation of its elements into two portions: one part is oxygenated at the expense of the other, so as to form carbonic acid; while the other part, being disoxygenated in favor of the latter, is converted into the combustible substance called alkohol; therefore, if it were possible to reunite alkohol and carbonic acid together, we ought to form sugar.[1]

Thus Lavoisier thought he had demonstrated that the carbonic acid and the alcohol which are produced by the process of fermentation, are equal in weight to the sugar which disappears; but the application of the more refined methods of modern chemistry to the investigation of the products of fermentation by Pasteur, in 1860, proved that this is not exactly true, and that there is a deficit of from 5 to 7 per cent. of the sugar which is not covered by the alcohol and carbonic acid evolved. The greater part of this deficit is accounted for by the discovery of two substances, glycerine and succinic acid, of the existence of which Lavoisier was unaware, in the fermented liquid. But about 1½ per cent. still remains to be made good. According to Pasteur, it has been appropriated by the yeast, but the fact that such appropriation takes place cannot be said to be actually proved.

However this may be, there can be no doubt that the constituent elements of fully 98 per cent. of the sugar which has vanished during fermentation have simply undergone rearrangement; like the soldiers of a brigade, who at the word of command divide themselves into the independent regiments to which they belong. The brigade is sugar, the regiments are carbonic acid, succinic acid, alcohol, and glycerine.

From the time of Fabroni, onward, it has been admitted that the agent by which this surprising rearrangement of the particles of the sugar is effected is the yeast. But the first thoroughly conclusive evidence of the necessity of yeast for the fermentation of sugar was furnished by Appert, whose method of preserving perishable articles of food excited so much attention in France at the beginning of this century. Gay-Lussac, in his "Mémoire sur la Fermentation,"[2] alludes to Appert's method of preserving beer-wort unfermented for an indefinite

[1] "Elements of Chemistry." By M. Lavoisier. Translated by Robert Kerr. Second edition, 1793 (pp. 186–196).

[2] "Annales de Chimie," 1810.

time, by simply boiling the wort and closing the vessel in which the boiling fluid is contained, in such a way as thoroughly to exclude air; and he shows that, if a little yeast be introduced into such wort, after it is cooled, the wort at once begins to ferment, even though every precaution be taken to exclude air. And this statement has since received full confirmation from Pasteur.

On the other hand, Schwann, Schroeder and Dusch, and Pasteur, have amply proved that air may be allowed to have free access to beer-wort, without exciting fermentation, if only efficient precautions are taken to prevent the entry of particles of yeast along with the air.

Thus, the truth, that the fermentation of a simple solution of sugar in water depends upon the presence of yeast, rests upon an unassailable foundation; and the inquiry into the exact nature of the substance which possesses such a wonderful chemical influence becomes profoundly interesting.

The first step toward the solution of this problem was made two centuries ago by the patient and painstaking Dutch naturalist, Leeuwenhoek, who in the year 1680 wrote thus:

I have frequently examined the ferment of beer, and always observed globules floating through the pellucid liquor; I also noticed very clearly that each single globule of the ferment gave origin to six other distinct globules, which, in size and form, I found, on careful observation, to correspond to the globules of our blood. But I conceived these globules to be due to and formed from the starchy particles of the wheat, barley, oats, etc., dissolved in and mixed with hot water; and in this water, which as it cools may be called beer, numerous minute particles joined together, and formed a globule, the sixth part of the compound globule, and thus the globules formed continuously in sixes."[1]

Thus Leeuwenhoek discovered that yeast consists of globules floating in a fluid; but he thought that they were merely the starchy particles of the grain from which the wort was made, rearranged. He discovered the fact that yeast has a definite structure, but not the meaning of the fact. A century and a half elapsed, and the investigation of yeast was recommenced almost simultaneously by Cagniard de la Tour, in France, and by Schwann and Kützing, in Germany. The French observer was the first to publish his results; and the subject received at his hands and at those of his colleague, the botanist Turpin, full and satisfactory investigation.

The main conclusions at which they arrived are these: The globular, or oval, corpuscles which float so thickly in the yeast as to make it muddy, though the largest are not more than $\frac{1}{2000}$ of an inch in diameter, and the smallest may measure less than $\frac{1}{7000}$ of an inch, are living organisms. They multiply with great rapidity, by giving off minute buds, which soon attain the size of their parent, and then either become detached or remain united, forming the compound glob-

[1] Leeuwenhoek, "Arcana Naturæ Detecta." Ed. Nov., 1721.

ules of which Leeuwenhoek speaks, though the constancy of their arrangement in sixes existed only in the worthy Dutchman's imagination.

It was very soon made out that these yeast organisms, to which Turpin gave the name of *Torula cerevisiæ*, were more nearly allied to the lower Fungi than to any thing else. Indeed, Turpin, and subsequently Berkeley and Hoffmann, believed that they had traced the development of the *Torula* into the well-known and very common mould —the *Penicillium glaucum.* Other observers have not succeeded in verifying these statements; and my own observations lead me to believe that, while the connection between *Torula* and the moulds is a very close one, it is of a different nature from that which has been supposed. I have never been able to trace the development of *Torula* into a true mould; but it is quite easy to prove that species of true mould, such as *Penicillium*, when sown in an appropriate nidus, such as a solution of tartrate of ammonia and yeast-ash, in water, with or without sugar, give rise to *Torulæ*, similar in all respects to *T. cerevisiæ*, except that they are, on the average, smaller. Moreover, Bail has observed the development of a *Torula* larger than *T. cerevisiæ*, from a *Mucor*, a mould allied to *Penicillium.*

It follows, therefore, that the *Torulæ*, or organisms of yeast, are veritable plants; and conclusive experiments have proved that the power which causes the rearrangement of the molecules of the sugar is intimately connected with the life and growth of the plant. In fact, whatever arrests the vital activity of the plant also prevents it from exciting fermentation.

Such being the facts with regard to the nature of yeast, and of the changes which it effects on sugar, how are they to be accounted for? Before modern chemistry had come into existence, Stahl, stumbling, with the stride of genius, upon the conception which lies at the bottom of all modern views of the process, put forward the notion that the ferment, being in a state of internal motion, communicated that motion to the sugar, and thus caused its resolution into new substances. And Lavoisier, as we have seen, adopts substantially the same view. But Fabroni, full of the then novel conception of acids and bases and double decompositions, propounded the hypothesis that sugar is an oxide with two bases and the ferment a carbonate with two bases; that the carbon of the ferment unites with the oxygen of the sugar, and gives rise to carbonic acid; while the sugar, uniting with the nitrogen of the ferment, produces a new substance analogous to opium. This is decomposed by distillation, and gives rise to alcohol. Next, in 1803, Thénard propounded an hypothesis which partakes somewhat of the nature of both Stahl's and Fabroni's views. "I do not believe with Lavoisier," he says, "that all the carbonic acid formed proceeds from the sugar. How, in that case, could we conceive the action of the ferment on it? I think that the first portions of the acid are due to a combination of the carbon of the ferment with the oxygen of the sugar, and that it is by carrying off a portion of oxygen from the last that the ferment causes the fermentation to commence — the equilibrium between the principles of the sugar being disturbed, they combine afresh to form carbonic acid and alcohol."

The three views here before us may be familiarly exemplified by supposing the sugar to be a card-house. According to Stahl, the ferment is somebody who knocks the table, and shakes the card-house down; according to Fabroni, the ferment takes out some cards, but puts others in their places; according to Thénard, the ferment simply takes a card out of the bottom story, the result of which is that all the others fall.

As chemistry advanced, facts came to light which put a new face upon Stahl's hypothesis, and gave it a safer foundation than it previously possessed. The general nature of these phenomena may be thus stated: A body, A, without giving to or taking from another body, B, any material particles, causes B to decompose into other substances, C, D, E, the sum of the weights of which is equal to the weight of B, which decomposes.

Thus, bitter almonds contain two substances, amygdaline and synaptase, which can be extracted in a separate state, from the bitter almonds. The amygdaline thus obtained, if dissolved in water, undergoes no change; but, if a little synaptase is added to the solution, the amygdaline splits up into bitter-almond oil, prussic acid, and a kind of sugar.

A short time after Cagniard de la Tour discovered the yeast-plant, Liebig, struck with the similarity between this and other such processes and the fermentation of sugar, put forward the hypothesis that yeast contains a substance which acts upon sugar, as synaptase acts upon amygdaline; and as the synaptase is certainly neither organized nor alive, but a mere chemical substance, Liebig treated Cagniard de la Tour's discovery with no small contempt, and, from that time to the present, has steadily repudiated the notion that the decomposition of the sugar is in any sense the result of the vital activity of the *Torula*. But, though the notion that the *Torula* is a creature which eats sugar and excretes carbonic acid and alcohol, which is not unjustly ridiculed in the most surprising paper that ever made its appearance in a grave scientific journal,[1] may be untenable, the fact that the *Torulæ* are alive,

[1] "Das enträthselte Geheimniss der Geistigen Gährung (Vorläufige briefliche Mittheilung)" is the title of an anonymous contribution to Wöhler and Liebig's "Annalen der Pharmacie," for 1839, in which a somewhat Rabelaisian imaginary description of the organization of the "yeast animals," and of the manner in which their functions are performed, is given with a circumstantiality worthy of the author of "Gulliver's Travels." As a specimen of the writer's humor, his account of what happens when fermentation comes to an end may suffice: "When the animals find no longer any sugar, they devour one another; and this they do in a peculiar manner. They digest the entire animal, excepting only the eggs, which pass through the intestinal canal unchanged, and so the residuum is still a fermentable substance, viz., the sperm of the animals, which remains over."

and that yeast does not excite fermentation unless it contains living *Torulæ*, stands fast. Moreover, of late years, the essential participation of living organisms in fermentation other than the alcoholic, has been clearly made out by Pasteur and other chemists.

However, it may be asked, Is there any necessary opposition between the so-called "vital" and the strictly physico-chemical views of fermentation? It is quite possible that the living *Torula* may excite fermentation in sugar, because it constantly produces, as an essential part of its vital manifestations, some substance which acts upon the sugar, just as the synaptase acts upon the amygdaline. Or it may be that, without the formation of any such special substance, the physical condition of the living tissue of the yeast-plant is sufficient to effect that small disturbance of the equilibrium of the particles of the sugar which Lavoisier thought sufficient to effect its decomposition.

Platinum in a very fine state of division—known as platinum black, or *noir de platine*—has the very singular property of causing alcohol to change into acetic acid with great rapidity. The vinegar-plant, which is closely allied to the yeast-plant, has a similar effect upon dilute alcohol, causing it to absorb the oxygen of the air, and become converted into vinegar; and Liebig's eminent opponent, Pasteur, who has done so much for the theory and the practice of vinegar-making, himself suggests that, in this case—

> The cause of the physical phenomenon which accompanies the plant's life is to be attributed to a peculiar physical state, analogous to that of platinum black. It must, however, be observed that this physical state of the plant is closely connected with the plant's life.[1]

Now, if the vinegar-plant gives rise to the oxidation of alcohol, on account of its merely physical constitution, it is, at any rate, possible that the physical constitution of the yeast-plant may exert a decomposing influence on sugar.

But, without presuming to discuss a question which leads us into the very arcana of chemistry, the present state of speculation upon the *modus operandi* of the yeast-plant in producing fermentation is represented, on the one hand, by the Stahlian doctrine, supported by Liebig, according to which the atoms of the sugar are shaken into new combinations, either directly, by the *Torulæ*, or indirectly, by some substance formed by them; and, on the other hand, by the Thénardian doctrine, supported by Pasteur, according to which the yeast-plant assimilates part of the sugar, and, in so doing, disturbs the rest, and determines its resolution into the products of fermentation. Perhaps the two views are not so much opposed as they seem at first sight to be.

But the interest which attaches to the influence of the yeast-plants upon the medium in which they live and grow does not arise solely from its bearing upon the theory of fermentation. So long ago as

[1] "Études sur les Mycodermes," Comptes Rendus, liv., 1862.

1838, Turpin compared the *Torulæ* to the ultimate elements of the tissues of animals and plants. The elementary organs of their tissues, which might be compared to the minute vegetable growths found in common yeast, are likewise decomposers of those substances which environ them.

Almost at the same time, and, probably, equally guided by his study of yeast, Schwann was engaged in those remarkable investigations into the form and development of the ultimate structural elements of the tissues of animals, which led him to recognize their fundamental identity with the ultimate structural elements of vegetable organisms.

The yeast-plant is a mere sac, or "cell," containing a semifluid matter, and Schwann's microscopic analysis resolved all living organisms, in the long-run, into an aggregation of such sacs or cells, variously modified; and tended to show that all, whatever their ultimate complication, begin their existence in the condition of such simple cells.

In his famous "Mikroskopische Untersuchungen" Schwann speaks of *Torula* as a "cell," and, in a remarkable note to the passage in which he refers to the yeast-plant, Schwann says:

> I have been unable to avoid mentioning fermentation, because it is the most fully and exactly known operation of cells, and represents, in the simplest fashion, the process which is repeated by every cell of the living body.

In other words, Schwann conceives that every cell of the living body exerts an influence on the matter which surrounds and permeates it, analogous to that which a *Torula* exerts on the saccharine solution by which it is bathed—a wonderfully suggestive thought, opening up views of the nature of the chemical processes of the living body, which have hardly yet received all the development of which they are capable.

Kant defined the special peculiarity of the living body to be that the parts exist for the sake of the whole, and the whole for the sake of the parts. But when Turpin and Schwann resolved the living body into an aggregation of quasi-independent cells, each like a *Torula*, leading its own life and having its own laws of growth and development, the aggregation being dominated and kept working toward a definite end only by certain harmony among these units, or by the superaddition of a controlling apparatus, such as a nervous system, this conception ceased to be tenable. The cell lives for its own sake, as well as for the sake of the whole organism; and the cells, which float in the blood, live at its expense, and profoundly modify it, are almost as much independent organisms as the *Torulæ* which float in beer-wort.

Schwann burdened his enunciation of the "cell-theory" with two false suppositions: the one, that the structures he called "nucleus" and "cell-wall" are essential to a cell; the other, that cells are usually formed independently of other cells; but, in 1839, it was a vast and clear gain to arrive at the conception that the vital functions of all the higher animals and plants are the resultant of the forces inherent in the innumerable minute cells of which they are composed, and that each of them is, itself, an equivalent of one of the lowest and simplest of independent living beings—the *Torula.*

From purely morphological investigations, Turpin and Schwann, as we have seen, arrived at the notion of the fundamental unity of structure of living beings. And, before long, the researches of the chemists gradually led up to the conception of the fundamental unity of their composition.

So far back as 1803, Thénard pointed out, in most distinct terms, the important fact that yeast contains a nitrogenous "animal" substance; and that such substance is contained in all ferments. Before him, Fabroni and Fourcroy speak of the "vegeto-animal" matter of yeast. In 1844, Mulder endeavored to demonstrate that a peculiar substance, which he called "proteine," was essentially characteristic of living matter.

In 1846, Payen writes:

I recognize, in the numerous facts which have come under my observation, a law which has no exception, and which will lead us to regard vegetal life under a new aspect. If I am not mistaken, whatever we can discern under the form of cellules and vessels represents nothing but protective envelopes, reservoirs, and conduits, wherein the animated bodies which secrete and construct them find a home, food, and the means of transporting it, and where they throw off and reject excretory matter.

And again:

To state fully the general fact, I repeat that bodies which discharge the functions performed by the tissues of plants, are formed of elements which, in slightly different proportion, make up animal organisms. Hence we are led to recognize a wonderful unity of elementary composition in all living bodies.[1]

In the year (1846) in which these remarkable passages were published, the eminent German botanist, Von Mohl, invented the word "protoplasm," as a name for one portion of those nitrogenous contents of the cells of living plants, the close chemical resemblance of which to the essential constituents of living animals is so strongly indicated by Payen. And through the twenty-five years that have passed, since the matter of life was first called protoplasm, a host of investigators, among whom Cohn, Max Schulze, and Kühe, must be named as leaders, have accumulated evidence, morphological, physiological, and chemical, in favor of that "wonderful unity of elementary composition in all living bodies," into which Payen had, so early, a clear insight.

[1] "Mém. sur les Développements des Végétaux," etc.—"Mém. Présentées," ix., 1846.

As far back as 1850, Cohn wrote, apparently without any knowledge of what Payen had said before him:

The protoplasm of the botanist, and the contractile substance and sarcode of the zoologist must be, if not identical, yet in a high degree analogous substances. Hence, from this point of view, the difference between animals and plants consists in this, that, in the latter, the contractile substance, as a primordial utricle, is enclosed within an inert cellulose membrane, which permits it only to exhibit an internal motion, expressed by the phenomena of rotation and circulation, while in the former it is not so enclosed. The protoplasm in the form of the primordial utricle is, as it were, the animal element in the plant, but which is imprisoned and only becomes free in the animal; or, to strip off the metaphor which obscures the simple thought, the energy of organic vitality which is manifested in movement is especially exhibited by a nitrogenous contractile substance, which in plants is limited and fettered by an inert membrane, in animals not so.[1]

In 1868, thinking that an untechnical statement of the views current among the leaders of biological science might be interesting to the general public, I gave a lecture embodying them in Edinburgh. Those who have not made the mistake of attempting to approach biology, either by the high *a priori* road of mere philosophical speculation, or by the mere low *a posteriori* lane offered by the tube of a microscope, but have taken the trouble to become acquainted with well-ascertained facts, and with their history, will not need to be told that in what I had to say "as regards protoplasm," in my lecture "On the Physical Basis of Life," there was nothing new; and, as I hope, nothing that the present state of knowledge does not justify us in believing to be true. Under these circumstances, my surprise may be imagined, when I found that the mere statement of facts, and of views, long familiar to me as part of the common scientific property of Continental workers, raised a sort of storm in this country, not only by exciting the wrath of unscientific persons whose pet prejudices they seemed to touch, but by giving rise to quite superfluous explosions on the part of some who should have been better informed.

Dr. Stirling, for example, made my essay the subject of a special critical lecture,[2] which I have read with much interest, though, I confess, the meaning of much of it remains as dark to me as does the "Secret of Hegel" after Dr. Stirling's elaborate revelation of it. Dr. Stirling's method of dealing with the subject is peculiar. "Protoplasm" is a question of history, so far as it is a name; of fact, so far as it is a thing. Dr. Stirling has not taken the trouble to refer to the original authorities for his history, which is consequently a travesty; and still less has he concerned himself with looking at the facts, but contents himself with taking them also at second-hand. A most amusing example of this fashion of dealing with scientific statements is furnished by Dr. Stirling's remarks upon my account of the proto-

[1] Cohn, "Ueber Protococcus pluvialis," in the "Nova Acta" for 1850.

[2] Subsequently published under the title of "As regards Protoplasm."

plasm of the nettle-hair. That account was drawn up from careful and often-repeated observation of the facts. Dr. Stirling thinks he is offering a valid criticism, when he says that my valued friend Prof. Stricker gives a somewhat different statement about protoplasm. But why in the world did not this distinguished Hegelian look at a nettle-hair for himself, before venturing to speak about the matter at all? Why trouble himself about what either Stricker or I say, when any tyro can see the facts for himself, if he is provided with those not rare articles, a nettle and a microscope? But I suppose this would have been "*Aufklärung*"—a recurrence to the base, common-sense philosophy of the eighteenth century, which liked to see before it believed, and to understand before it criticised. Dr. Stirling winds up his paper with the following paragraph:

> In short, the whole position of Mr. Huxley, (1) that all organisms consist alike of the same life-matter, (2) which life-matter is, for its part, due only to chemistry, must be pronounced untenable—nor less untenable (3) the materialism he would found on it.

The paragraph contains three distinct assertions concerning my views, and just the same number of utter misrepresentations of them. That which I have numbered (1) turns on the ambiguity of the word "same," for a discussion of which I would refer Dr. Stirling to a great hero of "*Aufklärung*," Archbishop Whately; statement number (2) is, in my judgment, absurd; and certainly I have never said any thing resembling it; while, as to number (3), one great object of my essay was to show that what is called "materialism" has no sound philosophical basis!

As we have seen, the study of yeast has led investigators face to face with problems of immense interest in pure chemistry, and in animal and vegetable morphology. Its physiology is not less rich in subjects for inquiry. Take, for example, the singular fact that yeast will increase indefinitely when grown in the dark, in water containing only tartrate of ammonia, a small percentage of mineral salts, and sugar. Out of these materials the *Torulæ* will manufacture nitrogenous protoplasm, cellulose, and fatty matters, in any quantity, although they are wholly deprived of those rays of the sun, the influence of which is essential to the growth of ordinary plants. There has been a great deal of speculation lately, as to how the living organisms buried beneath two or three thousand fathoms of water, and therefore in all probability almost deprived of light, live. If any of them possess the same powers as yeast (and the same capacity for living without light is exhibited by some other fungi), there would seem to be no difficulty about the matter.

Of the pathological bearings of the study of yeast, and other such organisms, I have spoken elsewhere. It is certain that, in some animals, devastating epidemics are caused by fungi of low order—similar to those of which *Torula* is a sort of offshoot. It is certain that such diseases are propagated by contagion and infection, in just the same way as ordinary contagious and infectious diseases are propagated. Of course, it does not follow from this, that all contagious and infectious diseases are caused by organisms of as definite and independent a character as the *Torula;* but, I think, it does follow that it is prudent and wise to satisfy one's self in each particular case, that the "germ-theory" cannot and will not explain the facts, before having recourse to hypotheses which have no equal support from analogy.—*Contemporary Review.*

MEASUREMENT OF EARTHQUAKE-WAVES.

By GEORGE FORBES.

WHILE the scientific world and his own countrymen are rivals in doing honor to Prof. Palmieri for his zeal in remaining at his post in spite of all danger, it may be interesting to examine in some detail the work done at the Observatory of Mount Vesuvius. We know wonderfully little about the origin and mutual dependence of volcanic phenomena. This is due to a want of accurate observations. For the complete investigation we require first to know at what dates earthquakes and eruptions occur at different parts of the earth. Next we must have observations of the direction and exact hour at which a wave of disturbance passes different places whose positions are known. This gives us the velocity of the wave, and helps to determine the position, under the earth's surface, of the centre of disturbance; or, if a wave be propagated over the sea, we obtain a means of estimating the average depth of the intervening ocean; for the velocity of a wave increases with the depth of the sea. This method gives one of the best determinations we possess of the depth of the Pacific Ocean. But beyond this we must have observations made systematically at some place subject to earthquakes and volcanic eruptions. No place in Europe is more suitable for this than the neighborhood of Mount Vesuvius; and it was for such observations that an observatory was established there.

Every one knows that Mount Vesuvius consists of a vast cone of lava and ashes, at the top of which is the great crater. On the northern side, separated from it by the deep valley called the Atrio del Cavallo, rises the precipitous and semicircular Monte Somma. This once formed the crater of the volcano, and the present cone seems to have been formed inside that great crater at the time when Pompeii was overwhelmed. On a spur of rock, a mile or two in length, running down from the Atrio del Cavallo, the Observatory is placed. It is close to the well-known "Hermitage," or half-way house, in the ascent of the mountain. Being raised on this ridge above the surrounding country, it is comparatively safe from the molten lava that flows at times on either side of it.

The building itself is handsome; in fact, it is to be regretted that so much money should have been devoted to the masonry instead of to additional instruments. On the ground-floor are the inhabited rooms, all scantily furnished; but the pursuers of science cannot always expect bodily comfort. On the first floor we find the Museum, with a fine collection of minerals found on the mountain. Perhaps it may be as well here to correct the common mistake as to the nature of the yellow substance found about the craters, whose brilliant colors remind one so much of the Solfatara. This substance is not sulphur, but copper. The most interesting objects in the Museum are the "fumerolles," or smoke-holes. Occasionally at the end of an eruption you may see at the bottom of the crater a small cone of lava, with a hole in its top, through which the steam pours with a hissing noise like a wave breaking on a pebbly beach, or like a blast-furnace, or, as Pliny has it, like the grinding of a saw; the intensity of the sound varying with your position. These small cones are the fumerolles; they are a foot or two high; and Palmieri has actually had several of these natural chimneys cut off and transported to the Museum.

We now pass on to the Observing-Room. There are solid piers carried up from the ground to support the instruments. First comes the elegant *seismograph*, an instrument for the automatic registration of earthquake-shocks. The object of the instrument is twofold: first, to measure the direction and intensity of a shock; and, second, to write down a history of the earthquake. The shock may be either vertical or horizontal, or partly vertical and partly horizontal. For the vertical shocks a fine metallic point is suspended by a coil of wire over a cup of mercury. The coil of wire acts as a spring, and the slightest upward motion of the earth is sufficient to cause the point to dip into the cup of mercury. This completes a galvanic circuit, which stops a clock at the exact half-second at which the shock occurred, and rings a bell to call the observer, and also does other work which we shall speak of again. There are three or four helices of wire of different strengths, which support small magnets above a cup of iron filings. When a vertical shock occurs, some of these magnets dip into the iron filings. To one of these a light index is attached, for measuring the intensity of the shock.

For horizontal shocks there are four glass tubes. Each of them is bent twice at right angles, so as to form a U-tube. One arm of this tube has more than double the diameter of the other, and is shorter. The four tubes point in the directions of the four cardinal points. Each tube has a certain quantity of mercury poured into it, and on the surface of the mercury, within the narrow arm of the tube, there rests a small weight attached to a silk fibre, which passes over a delicate ivory pulley, and has a counterpoise attached at the other end. Each pulley has an index and circular scale to mark the angle turned through. The extremity of a wire is fixed at a small distance above the surface of the mercury in each tube. If, then, a horizontal shock occur, the mercury rises in the corresponding tube; but it rises higher in that one which has its long arm to the north. The pulley is turned through a certain angle, which is measured by the index, and at the same time the mercury in rising comes in contact with the fixed wire, and so completes a galvanic circuit which rings a bell, and stops the clock at the exact half-second when the shock occurred. If the shock comes from some intermediate point, two of the indices will be moved, and the direction and intensity can be measured by observing both of them. We have seen up to this point that the instrument will measure the direction and intensity of a shock, will mark the time at which the shock occurred, and will ring a bell to attract the attention of the observer on duty, who may register succeeding shocks, or, if the earthquake has ceased, may reset the apparatus. But this is not all. The galvanic circuit, which is completed at the moment a shock occurs, releases at the same instant the pendulum of a second clock, which has been held out of the vertical by means of a detent. This clock allows a roll of paper to be unwound off a drum, as in any registering telegraph, at the rate of three metres an hour. A pencil rests nearly in contact with the strip of paper. It is connected with one arm of a lever, the other arm of which is slightly distant from an electro-magnet. As often as the current passes, this end of the lever is attracted to the magnet, and the pencil in consequence is made to press on the paper, to be released only when the current ceases. By this means, then, a continuous history of the earth's trembling is registered, a pencil-mark corresponding to a time of trembling, and a blank space to a period of cessation.

This instrument is extremely delicate, and registers motions of the earth which are too slight to be perceptible to the human frame. When we examined it, some one happened accidentally to touch the casing of the instrument. The alarm was immediately given by the bell, and the two clocks were respectively checked and put in motion by the galvanic current.

In the same room there is apparatus for detecting and measuring atmospheric electricity. A gold-leaf electroscope and a bifilar electrometer are observed regularly. These are successively put in connection with the conductor. This consists of a disk of metal above the roof of the house connected with an insulated metallic rod, supported vertically, and capable of being rapidly raised by means of a cord passing over a pulley. When not in use this rod is in connection with the ground. In making an observation, the rod with the disk attached is quickly raised, thereby disconnecting it from the ground. The electricity of the atmosphere at the point where the disk is fixed affects the electroscope and electrometer. Prof. Palmieri prefers the conductor above described, to a conducting point or a flame, because he considers that these do not give comparable results, an objection which is not supported by all observers. He considers the same to be true of the method of dropping water.

After having made careful observations on atmospheric electricity for about a quarter of a century in a country where meteorological changes are more regular and less capricious than in our own island, there is no one whose deductions are more deserving of our attention; the more so as he considers that he has combined his researches into a definite law. His first fact is this: *If within a distance of about fifty miles there is no shower of rain, hail, or snow, the electricity is always positive.* The single exception is during the projection of ashes from the crater of Vesuvius. During a shower he finds the following law universally to hold good: At the place of the shower there is a strong development of positive electricity; round this there is a zone of negative, and beyond this again positive. The nature of the electricity observed depends upon the position of the observer with respect to the shower, and the phenomena will change according to the direction in which the shower is moving. Sometimes negative electricity may be observed during a shower; but this is always due to a more powerful shower farther off. These conclusions have been supported by means of telegraphic communication with neighboring districts. It appears, then, that except when the moisture of the air is being condensed, there is no unusual development of electricity. These results are in accordance with the experiments of Palmieri and others, which show that aqueous vapor in condensing develops positive electricity. No unusual development of electricity has ever been detected by him in a cloud when no rain is falling.

The above results, though falling short of what has to be done to complete the theory, are yet definite, and hence valuable, the more so if supported by other observers placed in equally favorable situations. But of the variations *in intensity* of positive or negative electricity nothing has been said.

Besides the fixed instruments at the Observatory, others are used on the mountain. Gases are collected from cracks in the earth's crust, tubes being let down into them, and the gas sucked up by a kind of bellows, to be examined at leisure. A portable spectroscope is also used during eruptions, and there is a larger one by Hoffman in the Observatory. From this Observatory we have received valuable information, and it is much to be regretted that equally efficient observatories have not been established in different parts of the world. Many portable and cheap instruments have been invented, most of which are described by Mr. Mallet, in the "Admiralty Manual of Scientific Inquiry;" but there ought to be three or four as delicate as that on Mount Vesuvius. It is a pity that no observatory has ever replaced the ancient one of Empedocles, near the summit of Etna, or even at Nicolosi, where the valuable services of Dr. Gemellaro might have been obtained. This would have been the more interesting, as Palmieri can detect shocks caused by that volcano, though the distance is enormous. With a third observatory, say in the Philippine Islands, we could not fail to increase our knowledge enormously.

From long practice Palmieri is able to predict eruptions. We remember well, when we were enjoying his hospitality at the beginning of last year, how he said, "This is a small eruption, but there is going to be a great one; I do not say it will be soon, it may be a year, but it will come." In almost exactly a year the great eruption did come. —*Abstract from Nature.*

SCHOOL DIETARIES.

By M. D.

IN the neighborhood of one of our midland cities is a school for some fifty boys, varying in age from nine or ten to fourteen or fifteen years. During some recent visits to this school, the singular healthiness and heartiness of the boys made me curious to learn exactly how they were fed. The following I ascertained to be the dietary:

Breakfast (in summer at 8, in winter at 8.30) consists of tea or good strong coffee, with abundance of milk, bread-and-butter, and cold meat. By way of change, now and then, eggs for a few days together take the place of meat. Before the foregoing, boys who like it have a small basin of bread-and-milk, or of Scotch porridge made with milk. The milk is new, and comes straight from a farm adjoining the school-grounds.

Lunch at 11.—Each boy has a small fresh roll of bread, or a bun, or a captain's biscuit, and, if weakly, a tumbler of milk or small glass of wine or ale; but, as a rule, nothing is drunk at lunch, dinner, or supper, but pure water.

Dinner, at 1.30, always consists of two courses: 1. Two kinds of meat, viz., beef and mutton, with not less than two kinds of vegetables, and of these a liberal supply. 2. Pudding, usually of fruit, fresh or preserved according to the season, and always well sweetened. On four days of the week the meat is hot roast; on one day it is hot boiled; on one day steaks, cutlets, or made dishes, are substituted for joints; while the Sunday dinner always consists of cold beef, mashed potatoes or salad, and plum-pudding. After dinner some ripe fruit, as an orange or some kind of garden-fruit, according to the season.

Tea at 6 P. M.—Tea, bread-and-butter, varied almost daily either with home-made plum-cake, or marmalade or honey. Whenever procurable, some salad-herb, such as lettuce, radish, etc., is given at this meal, and always eaten with much relish.

Supper at 8 P. M. (for senior boys only).—Bread-and-butter, or bread-and-cheese, or biscuit, or, where it may seem needed, a tumbler of milk, or glass of beer and a meat sandwich.

No hampers of eatables are allowed to be sent to the boys from their friends, and no shop for the sale of sweets, etc., is allowed or accessible to the boys.

This dietary seems to me so exactly what growing boys or girls ought to have, and so often what they do not get, even at their own homes, that it may appropriately serve as the text for a few remarks on the usual dietaries of public and private schools. I will begin by at once stating my belief—as one who was himself at a private and a public school, and who still sees a good deal of school-boys—that either in quality, quantity, variety, or frequency of meals, the dietary of nearly every school I have known is more or less defective.

The usually unvaried breakfast of tea or coffee (and these fluids too often of a miserably thin description), with bread-and-butter, is a meagre meal for a boy who has to break a twelve-hours' fast. It is not enough for the robust, nor varied enough for the delicate. A good basin of bread-and-milk, or milk-porridge, should always be allowed as a substitute for tea or coffee; and the latter, when preferred, should always be accompanied with some little extra, such as a bit of cold meat, or bacon, or an egg—sometimes one, sometimes the other, so as to secure the utmost possible variety. Coffee, by-the-way, should be of good quality, strong enough to require copious dilution with milk, and not the sloppy decoction of brown paper which it too often resembles in taste, appearance, and nutritive value.

Nearly all boys want something between breakfast and dinner, about 11 o'clock; and if this something be not provided for them in a wholesome form by the school-master, they will seek to get it, probably in a much less wholesome form, at the school "shop," or in the contents of the "hamper from home." Concerning these two venerable institutions more shall be said presently.

Meat or other food of bad quality is hardly ever put on the table nowadays in any decent school. Equally rare is any stint in its allowance. The fault of most school dinners is roughness in the cooking and serving, insufficient variety in the form and kind of meat and vegetables, and the too frequent absence of puddings. It will be seen by the above dietary that, with very little strain of culinary arrangements, meat may be served up in half a dozen different forms each week, and, if two kinds of it always come to table, ample variety will have been attained. Variety in food is no mere luxury or pampering of appetite. In all cases desirable, in the case of growing boys it is highly so; while in the case of boys with delicate or capricious appetites it becomes an absolute necessity. A certain percentage of such boys will be found in every school—boys who, if denied considerable range of choice in their food, will at least fail to thrive in the midst of plenty.

A boy's chief meal should always consist of two courses, meat and pudding.[1] Many boys, being small meat-eaters, should at least have the chance of "making up" with something further, and good reason can be given why this something should be a well-sweetened pudding or tart; if containing fresh or preserved fruit, so much the better. All boys as a rule dislike meat fat and leave it on their plates, and it is a barbarous practice to try to make them eat it.[2] And yet the same fat in a different guise, embodied with flour in a *well-cooked* pudding, they as universally like. All boys, again, love sugar and the juices of fresh vegetables or fruits, and it is a grave mistake not to secure a fair proportion of these elements in their daily food. Now, a well-made fruit-pudding or tart combines these several elements in happy proportion and palatable form; and boys' universal liking for this article of diet is simply the practical expression of the physiological truth that fat and its chemical allies, starch and sugar, together with certain organic acids and salts, are indispensable to the healthy constitution of the blood; in other words, to the due building up and maintenance of the fabric of the body.

A boy who has dined at 1 or 1.30 is ready by 6 o'clock for something more than the eternal tea and bread-and-butter. He keenly relishes at this meal some little variety or addition, such as plain home-made cake, or some preserve, or a bit of whatever salad-herb may be in season. The dietetic value of salad-herbs (lettuce, water-cress, etc.) to growing boys is out of all proportion to their cost. Where there is a kitchen-garden (which every school should have), they practically cost nothing. Where they have to be bought, they need not cost much; and, even if they do, they will be worth the price.

Should boys have supper? Up to about twelve years of age they rarely need it, for boys of this age by 9 o'clock are ready for bed, and should be in bed; but from thirteen or fourteen onward boys much dislike being sent to bed so early, and if they do, say, one and a half or two hours' work after tea, they feel the want of, and ought to have, a light meal between 8 and 9 o'clock.

In the dietary above quoted it will probably excite surprise that no beer or other stimulant is allowed either at dinner or at any other meal or time in the day, except in special cases where a boy's health is

[1] Boys seldom care for *soup*.

[2] I was myself at a private school—an average good one in its day—where the rule was enforced that on "pudding-days" no boy who had left any fat on his plate should have any pudding. After a while meat rose in price, and, by way of "choking us off," we were made on these said days to eat the pudding before the meat. This was blundering strategy on the master's part, for he had now no hold upon us, and the meat was of course eaten without any fat at all.

thought to require such aid. If proof were needed that boys *may* grow up in the perfection of health and strength without any stimulants whatever, *provided they are liberally fed*, I might point to the splendid *physique* of the little inmates of this particular school, and invite any one to see how they work and how they play. Where the food is amply sufficient and varied, a boy does not want beer, nay, is better without it; where the food is not so, beer or wine will but imperfectly supplement its shortcomings. With delicate or sickly boys, of course the case is different; they have special needs in respect of stimulants which it would be foolish to ignore.

Another noteworthy point in the arrangements of this school is the veto on all "hampers from home," and the absence of any "shop" for the sale of sweets, etc. These are far from harmless institutions; they are time-honored abominations which cannot be too strongly condemned. The evil tendencies, at any rate of the latter, are so glaring that its authorized existence is, in my opinion, a blot upon any school. Setting aside the trash eaten, the sickness caused, the morbid appetite and habit of selfish gluttony acquired, and the facilities afforded for the introduction of contraband goods—the money boys often spend at these places is grievous to think of. I can vouch for many a boy, whose parents were weak enough to supply him with almost unlimited pocket-money, having often spent at his school "shop" a weekly sum quite sufficient to feed a poor family. Now, where school-meals are abundant enough, varied enough (especially in respect of sugar, starch, and vegetable juices), and frequent enough, there the inmates will have no further craving for cakes, sweets, fruits, etc. But if there be a shortcoming in one or other of these respects, then instinct drives the boys to seek elsewhere those elements of food in which their regular diet is deficient. An authorized "tuck-shop," therefore, in connection with a school, is *prima-facie* evidence to an outsider, and not uncommonly a tacit admission on the part of the school-proprietor, that the diet of the inmates by no means satisfies all their legitimate cravings.

That a scale of diet such as I have here advocated is just about what boys ought to have—*if they are to develop into strong, healthy men*—I am satisfied from personal experience and observation. That it is at all likely to meet with the acceptance of school-masters generally, I am not simple enough to suppose. It is too violent an innovation on old routine. Nay, even *paterfamilias* himself will probably pooh-pooh such new-fangled notions of feeding boys like grown men (especially when he finds they cost more money), forgetting that boys need more and more varied food than men. So-and-so was good enough for his (*pater's*) boyhood, why won't it do for his son's? But *paterfamilias* should speak only for himself. The diet of *his* school-days sufficed for *him*, thanks probably to his sound constitution, but was it enough for many of his less robust schoolmates? Did any of these in after-years fail to grow up strong and healthy men? and, if so, is *paterfamilias* sure that their "simple," i. e., monotonous and meagre mode of feeding during their years of most active growth had naught to do with their failure?

Just as any system of teaching is a real success in proportion as it adapts itself to the peculiar needs—not of those who are quick and willing, but of those who are slow or averse to learn—so any scale of diet approaches perfection in exact proportion to the provision made, not merely for the average standard of taste and appetite, but for all reasonable deviations therefrom. The daily meals of a school may be abundant and of good quality, still, if they be not more varied than to my certain knowledge they often are, many a boy and girl must fail day after day to get those particular elements of nutrition which they specially require. The result with such boys and girls is that even in the midst of plenty they remain permanently underfed and imperfectly nourished, thus retarding, if not arresting, the due growth and development of their bodies, and strongly favoring the development of any inherited or other constitutional unsoundness lurking within them. —*Food Journal.*

SCIENTIFIC DABBLERS.

By F. W. CLARKE.

THERE is, perhaps, no more amusing trait in human nature than that which leads people to criticise subjects about which they know nothing. And it seems to be a trait common to all minds, but differing much in intensity. Education roots it out to a considerable extent, but never quite obliterates it. The more ignorant the critic, the more confident are his assertions.

Four departments of knowledge are especially infested by these critical parasites, namely: physical science, metaphysics, politics, and theology. Persons wholly ignorant of political economy discuss taxation, capital, the rights of property, and similar questions, in the most solemn and owl-like manner; others, who know so little of natural history as to be almost unable to tell a grasshopper from a gorilla, will point out Darwin's errors most lucidly; and men who have the vaguest ideas as to the meanings of the polysyllables which they habitually use, expound, with wonderful clearness, the nature of infinity, and invent new theories of the universe for every day in the week.

At the present time, natural science is a favorite field for the gambols of these wiseacres. And, strange as it would seem, at first sight, their energies are usually directed to the highest and most difficult subjects. The sciolist rarely wastes his thoughts upon simple matters. And plainly, since he is ignorant of that which he expounds, it is better for him to leave common things to common minds, and, by discussing the loftier questions of the day, get greater credit for wisdom from those who are equally ignorant with himself. He is safer from overthrow in speculating upon unsettled theories than in attempting to explain that which has been well demonstrated.

Probably the majority of Americans get their ideas upon scientific questions from the newspaper and the pulpit. The meagre quantities of scientific lore picked up in the common schools, and in most of the colleges, are scarcely important enough to be worth noticing; and the knowledge doled out in the form of popular lectures is so often beaten up into froth, to suit the tastes of those who listen merely to kill time, that it may also be left out of question. But, week after week, the clergy hurl forth their anathemas against the profanities of science, and, day after day, the newspapers quote the sayings of the popular reviews. And but too frequently clergymen and journalists are both mere scientific dabblers. Not always, but wofully often. Quite naturally, then, much of the information given is practically worthless. The really important discoveries are rarely noticed until they are years old, for these retailers of scientific gossip scarcely ever know what is of value, and generally content themselves with giving remarkable theories, broached by intellectual quacks, or brilliant illustrations of principles, with the principles themselves left out. The surface is given, but the meanings lying beneath are neglected.

Now and then, however, a startling theory is put forward by some eminent scientist, or, after lying comparatively unnoticed for years, is lifted into sudden prominence. And, presto! down sweep the clergy upon it as opposed to religion; and the newspapers, roused by the noise, add their dubious ridicule to the forces of the Church. Only the press is generally less conservative than the pulpit. Its attacks are not nearly so virulent as those of the theologian.

And unquestionably these assaults do some good. They advertise the theory, set people to thinking, and, in some measure, stimulate the advance of the truth. Had it not been for Romish persecution, Galileo's views might have been much slower in gaining ground; and it is likely that, if the English pulpit had made less vigorous attack upon young Geology, there might still have been educated men believing in the literal six days' creation and the universal deluge. And yet it is worth noticing, in this connection, that a book has been published in England, within the past two years, which is meant to show that the earth is not a globe, and that the sun revolves around it. The author's chief arguments are that "water is level," and that his views are scriptural. He calls Newton a "lunatic" (these are the words of his prospectus), and the Astronomical Society a set of "professional liars." Equally ridiculous statements upon scientific matters may be heard from popular lecturers and writers nearly every day.

As I have already stated, the scientific dabbler prefers to disport himself in the field of theory. And, at present, there are several great questions up for discussion before the scientific world. The most prominent among them relate to the connection between vital and physical forces, the origin of life, the development of species, and the antiquity of man. In general, the pulpit has in the most Christian manner allied itself *with the weaker side.* In many instances, the press follows the lead of the priesthood. And on each question there seems to be popular misunderstanding.

The first of these questions is practically settled. Experiment has thrown much light upon it, and now the leaders in science are pretty well agreed that the ordinary forces of Nature are sufficient to produce all the physical phenomena of life. And yet, when a well-known chemist, a year or two ago, stated, before a New York audience, the simple fact that the animal heat is the result of purely physical actions in the system, an astute letter-writer took him roundly to task for his "absurdities," and actually found a newspaper to print the effusion. The lecturer stated an experimental fact, while the objector merely vented ignorant prejudice. If a man who had never learned to read should attempt to instruct an experienced printer in the art of setting type, he would hardly present a more ridiculous spectacle than this self-appointed critic.

In discussing the origin of life, we find the theory of spontaneous generation brought prominently forward. Certain experimenters have enclosed various substances in hermetically-sealed tubes, heated them, so as to apparently destroy all possibilities of life within, and, after allowing them to remain undisturbed for months, have found the contents swarming with animalcules. Other scientists have tried similar experiments under varied circumstances, and have failed to obtain living organisms. And no one but a man trained in scientific methods can judge of the relative values of the experiments. Yet many clergymen do not hesitate to decide at once in favor of the negative experiments, in spite of the fact that no thorough scientist regards the questions involved as in any degree settled. The leading opponents of spontaneous generation seem to oppose the doctrine only provisionally, on the ground that the evidence accumulated is not sufficient to warrant a final decision. The weight of evidence, however, seems to lend probability to the doctrine. The successes of Wyman, Bastian, and others, more than counterbalance all failures. Yet more exact experiments are needed. It is plain that the first life must have been developed from non-living matter, whatever methods the Creator may have employed. Why may not the same methods be acting to-day? The clerical opponents of the theory here fall into an obvious error. They impute to it tendencies which it cannot have. The question to-day is, not whether life arose by a Divine act, but, in what manner did it arise? If it should be proved that living beings may be produced by natural laws from non-living matter, it will merely be shown that they arose in accordance with the universal design. That is, looking from the standpoint of a belief in Deity, it would be demonstrated that here, as throughout all the domain of Nature, His work was done systematically, through the medium of law, and not in an arbitrary, mechanical, dust-moulding manner. And no one can find any thing atheistic, or even materialistic, in such a view. The question is one of visible order *versus* seeming disorder, the probabilities being in favor of the former.

Not long since, Darwin's "Descent of Man" was published. And shortly afterward, I stumbled upon a newspaper review, which was made up of unreasoning ridicule. The writer was evidently no specialist in science, and yet he ventured to discuss a theory propounded by one of the most thorough naturalists living, who is supported in his views by probably a large majority of scientific men. And the most astonishing portion of this astonishing review was, where the writer asserted that the book did not contain a single argument which would convince any one but a scientific man! As if any one but a scientific man was able to judge fully of the merits of the arguments.

Now, space forbids my entering into discussion of the development-theory (which, by-the-way, did not originate with Darwin, his being merely one of several development-theories), and yet a word or two is necessary. The naturalist, looking about him, sees many facts which require to be classified and explained. He sees that all mammals resemble each other anatomically; he finds evidences of development from lower to higher stages in their embryos; he is confronted by the fact that species are modified by cultivation; and he meets with hosts of observations chiming in with these. The development-theory is naturally suggested to his mind. Flinging prejudices to one side, he finds that the theory classifies many of these facts, and renders them mutually intelligible. To be sure, the doctrine is not absolutely proved, but then there are all these things in its favor, and little more than negative evidence against it. He has learned to beware of negative evidence, however, as often leading to fallacies; and, looking at all the difficulties in the way, accepts the theory, provisionally at least, as superior to any other which has been suggested. It may not be true, or it may; at all events it classifies his knowledge for him, and is useful for the time being. And he finds that, instead of giving him degraded views of man, it enables him to see both God and humanity in clearer light. The progress indicated in the past hints at greater progress in the future, and encourages him to stronger and better efforts. Development is shown to be a part of man's duty, and the hope of success is strengthened.

The question of the actual antiquity of man will probably never be settled. If man, as the development-theory holds, arose by the slow modification of lower species, then it is plain that no precise moment can be pointed out in which he ceased to be brute and became human. But in some senses the question of antiquity may be answered. It may be proved that man, as we now recognize him, has existed on earth *more* than a certain number of years. That period may be of six, ten, twenty, or a hundred thousand years; how *much* more we may never know. And the quarrels upon the subject to-day are over the accuracy of the Mosaic estimate of 6,000 years. The question has been discussed on both sides by clerical dabblers. On the one hand, I have heard an eminent "evangelical" divine assert most dogmatically that there was absolutely no evidence to overthrow the Mosaic chronology, and that all belief to the contrary was "utter delusion." On the other side, I have listened to a prominent "liberal" preacher who claimed that it was almost certain that man had dwelt on the earth for at least 4,000 centuries! And probably neither of those estimable men had a very clear conception of the subject they discussed so airily. Not only does space forbid my entering at length into this subject, but, if I should do so, I should lay myself open to the charge of being a scientific dabbler. Suffice it to say that the best scientific authorities appear to be well agreed that man has existed for much more than 6,000 years. Human bones have been found under circumstances which make it highly probable that they were buried at least 20,000 years ago. There was not, perhaps, absolute proof, but probability. And this probability, supported as it is by some evidence, is far more worthy of belief than the mere unfortified assertions of the Old Testament. Whatever value the latter work may have in its relations to morality and religion, it is an unsafe guide in matters of science. Geology and astronomy have both contended with it, and have come off victorious. Perhaps its errors may exist only in the interpretations of theologians; if so, the interpreters may be deceived even now.

I do not wish to be understood as attacking the clergy. I wish only to show that science will not bear to be used for partisan purposes. The truth must not be tampered with. And clergymen, in dealing with science, are often mere special pleaders, who wilfully ignore much evidence. There are some preachers who are controversially inclined, and batter away at science whenever it crosses their path. And they often stultify themselves. For instance, they attack the Darwinian theory, and reject it because it is not proved. But they accept the theory of individual creations, which is equally unproved. It would be wiser for them to hold judgment in suspense, and wait for the decisions of competent investigators. But here some reverend gentleman may say indignantly: "What! shall we not defend our faith against the attacks of science?" Certainly, my dear sir; only do not be careless. First make sure that your faith is attacked; then, that you understand the nature of the attack, and then give your opponent credit for honesty equal with your own. Do not hesitate to look squarely at all the evidence bearing upon the questions involved; defend yourself with arguments, not dogmatic assertions; and do not ask your adversaries for proofs stronger than those which you are ready to give. Above all, remember that you yourself are but mortal, and liable to err; and therefore that it is always within the bounds of possibility that your antagonist may be in the right, and you in the wrong. The man of science studies God's own handiwork; he approaches the truth reverently, yet fearlessly, seeking it for its own sake; and his conclusions cannot be lightly disregarded. Science may throw more light upon theology than theology can ever throw upon science. And the theologian who sincerely wishes to know and to spread the highest and clearest truths, will do well to take at least some lessons from the interpreters of Nature, and in all cases to treat the doctrines of science with the respect which is always due to honesty. Under all circumstances, whatever may be his private views and his desires, he will find it the part of wisdom not to commit himself publicly to either side of an unsettled question. Dogmatism on undecided points is worse than foolish.

Every now and then we meet with certain scientific dabblers who are silly through the medium of the newspapers. I refer to those unfortunate people who try to illustrate science with fanciful statistics. Of late, one of these statistical paragraphs has been going the rounds of the press. It treats of what the writer supposed to be physiological chemistry. First come some estimates as to the number of pairs of boots and the quantity of hats which might be made from the leather and felt imagined by the author to be formed by some obscure chemical process in the stomach. This is utilitarian science with a vengeance, but is eclipsed shortly when the brilliant popularizer of scientific knowledge asserts that a man of average size contains clay enough to make a dozen large bricks, and consumes carbonate of lime enough with his food to form a marble mantel-piece in a year! The estimates are really quite beautiful in their way, but are unfortunately like the French definition of a crab. Certain French lexicographers were one day hard at work, and had just defined a crab as "a little red fish which walks backward." Cuvier, entering just then, was asked what he thought of the definition. "Admirable!" said he, "only the crab is not a fish, it is not red, and it does not walk backward." I cannot vouch for the authenticity of this anecdote, yet it serves very well to illustrate the case in point. The newspaper scientist was about as accurate in his knowledge as were the lexicographers—especially in the brick-making item; for the two elements most characteristic of clay, namely, silicon and aluminum, are wholly wanting in the human system; or, if present, they are in such small quantities as to be undiscoverable by analysis.

This example is sufficient to illustrate this particular kind of dabbling. Some thorough scientific man makes a discovery, which is briefly alluded to in some foreign journal of popular science. The periodicals on this side of the ocean, catching up the allusion, dilute it still further, and presently it becomes a sort of intellectual goose-pond for these dabblers to disport themselves in. The clear fountains of knowledge from which it sprang are lost to sight, and only a mud-puddle remains in view.

Let me now sum up briefly my object in writing these pages. I have not written them to attack either clergymen or journalists, for I will not attempt to deny that much useful scientific knowledge finds its way to the popular mind through the pulpits and the newspapers. My purpose is twofold: First, to call attention to the silly character of much of what is called "popular science;" and, secondly, to urge upon true scientific men the importance of rendering real knowledge more accessible to the masses. There is a demand for science, or the trash which is written would not be read. It works into nearly all departments of common life, and is, in one way or another, of immediate interest to almost every one. Yet, as I have already said, the current popular lectures upon scientific topics are frothy and worthless: the theologian often misrepresents science for partisan purposes; and the newspapers, with all the good they may do, are too frequently conducted by those ignorant of all science. The people seek for knowledge, and unwittingly get much chaff with their wheat. In some respects the popular mind is filled with absurd superstitions. Strange psychological phenomena are attributed to "animal magnetism," and other natural wonders are apt to be fathered upon electricity. The latter innocent force is made responsible for almost every thing unusual. Therefore it seems to be time that true students of science should seek to popularize their learning. Faraday, Tyndall, Huxley, and others, have done an admirable work abroad, and their example should be more generally followed here. Our lyceums need more scientific lectures, and our best thinkers and observers should be ready to work in that direction. Men of science constantly lament that the government does not extend more aid to scientific research. The government is a popular one, and the people must be trained before its help can be expected. Therefore, it is for the interest of the teachers as well as for the good of the people, that scientific truths should be popularly put forward in simple, untechnical language, and made accessible to all.

TOWN AND COUNTRY AS PRODUCERS OF INTELLECT.

By G. M. B.

THE last number of the *Journal of the Statistical Society* had an interesting article, by Mr. Hyde Clarke, on the "Geographical Distribution of Intellectual Qualities in England."

The writer proves, by the use of a numerical test, that the towns contribute most of the intellectual laborers of note, and that the popular notion that genius is generally of low origin or derived from obscure districts is a mistake. Some "village Hampden," it is true, may adorn the region of politics, but this is an exceptional distinction. It is needless to premise that Mr. Clarke has considered the influence of population, and has not merely enumerated the clever men from given places. He has taken 2,000 names of men of genius or high intellectual powers, and sorted them out into districts, and this forms the basis of his calculations. He says:

> The more important matter is to ascertain how far the external influence of the community has affected the birth or production of men of ability, genius, or celebrity, exemplified in intellectual endowment. . . . On the whole, such men are rather born in towns than in the country, and examples to the contrary, as those of Newton, Dryden, etc., admit of explanations which neutralize their apparent antagonism.

Speaking of the preëminence of London in the production of such men, he says:

> If we test this for other countries, whether in ancient or modern times, we shall find the same thing. Rome and Athens will assert a metropolitan position, and so will Paris. A map of the geographical distribution of such elements will safely mark out the most famous cities of antiquity. A map of England, of France, of Germany, or Italy, will show the like modern results. The town population being the smaller portion in each country, yet the larger number of names will belong to the town population, and not to the rural population; and, on the whole, the names which can be marked as first and second class will belong in the larger proportion to the town population.

Of the 2,000 names, three-eighths belong to the country, and five-eighths to the town districts.

The following extracts give the main points in the interesting analysis:

> In regarding the distribution among the town population, again, the unequal distribution gives in most cases a larger *pro rata* proportion to the large towns over the small. The most striking case is, however, that of London (333), and, as that is supported by the example of other metropolitan cities, ancient and modern, it can be accepted as an authenticated fact that the larger the population the larger the proportion of distinguished men. Edinburgh gives 73, and Dublin 53. The proportion of those metropolitan cities to the whole number is about 22 per cent. Still, on examining the smaller towns among themselves, this by no means holds good. Many small towns furnish more names than those of larger population, and these will be found to be cathedral and university towns. What is to be marked is the low position of such great modern centres of industry and population as Manchester, Liverpool, Birmingham, Sheffield, Leeds, Hull, Bradford, etc. . . . The relation of names may, therefore, be considered to be, not to the population generally in gross, but rather to the classes engaged in the pursuit of learning, to the educated classes, and those in easy circumstances. This explains best the phenomena of London, and the preponderant towns, and likewise what may be called the intellectual

rise of the manufacturing cities in modern times. . . . It does not appear to be the case, on the whole, that men of distinction spring from the lowest classes, as some assert. It may be that such a man is the son of a poor man, or of one in an inferior trade, but the greater men are ascertained to spring from gentlemanly families or from families formerly in easy circumstances. The popular belief is the other way, because we have books giving the names of those who have risen from the lowest pursuits.

From a table given, it appears that out of the 2,000 English writers of celebrity, only 58 exercised a mechanical trade, and only 40 were sons of such, thus giving a total of only 3 per cent. connected with such occupations.

The conclusion to be drawn is, that intellectual exertion is not manifested in the lower classes, or in the children of such, to the same extent as in those where the means of instruction are more available.

This seems corroborated by a glance at the relative proportion of distinguished men in the several districts of England. The south and south midland districts contributed 60 per cent., the north and north midland 17, Wales 1, Scotland 12, and Ireland 4 per cent. The low figures for Wales and Ireland are accounted for by the Celtic language prevailing, the influence of this being further shown by the fact that Cornwall produced 21, and Devon 97 instances, though the two counties join.

London has produced, not only in number, but also in value, a larger portion of the celebrities of the country—Milton, Spenser, Pope, Byron, Chaucer, Cowley, Gray, Surrey, Herrick, Keats, Johnson, Fletcher, Gibbon, Mitford, C. Mill, Camden, Bacon, Canning, Fox, Blackstone, De Foe, Arnold, etc. . . . The facts appear to show that literary attainments are in relation to literary culture, or the culture of the educated classes, and not of the uneducated classes. . . . The development of intellectual improvement cannot be effected by sole exertion of the nervous system, but by the proper application of all the faculties dependent on the physical condition of men. It is, in fact, a creation of selection on the best principles.—*Journal of Mental Science.*

CIVILIZATION AS ACCUMULATED FORCE.

By L. DUMONT.[1]

THE word *civilization* is of somewhat indefinite meaning. It were easy to say which of the two is the more civilized, a European or a New-Caledonian savage. But, when we have to assign their respective ranks to two civilized nations, the case is more difficult. Each philosopher has his own definition of civilization. One will say that

[1] Translated from the *Revue Scientifique*, by J. Fitzgerald, A. M.

civilization is the social fact of the increase of wealth. But even though we take the word wealth in its widest sense, it will not include all the elements of civilization, and especially it will not include those which have their seat in man himself, such as moral and physical development. Then an accident, such as conquest, might enrich a nation, without advancing it in civilization.

Guizot makes civilization depend chiefly on political institutions. According to him, it is the perfectionment of civil life, the development of society, and of the relations of man with man. But he admits that we must also take into account individual life, the inner life of man and his development intellectually, socially, and morally. In his History, however, Guizot almost altogether disregards this element, so that we may consider his work as merely an excellent history of political progress under constitutional monarchy.

Buckle's History is the antithesis of Guizot's. Here the individual is every thing; institutions nothing, or even hinderances. The state, according to Buckle, is a resultant, not a principal. Buckle also denies that religion is a factor in working out the problem of civilization. These views, at first warmly opposed, are now more favorably received.

But since he deduced civilization neither from religion nor from political constitutions, how did he account for it? He defined it to consist in the supremacy of intellectual laws over physical laws. The history of Europe, as he read it, is simply a series of victories gained by man over Nature; whereas, the domination of Nature over man causes the irremedial decadence of Oriental nations.

We will not deny the justice and truth of this line of observation. The contest between man and the outer world, the conquests of science, the subjection of all the forces of Nature to man's will—these are truths as clear as day. And yet we do not believe that they constitute the sum total of civilization. Men are brought face to face, not alone with Nature, but also with one another. We have to adapt ourselves, not alone to physical forces, but we have also to adapt ourselves to one another; in a word, we find in civilization, in progress, a social as well as a physical element. Side by side with the conquests of humanity over the remainder of the universe, there is a progress in morals, and in the relations between man and man—between one society and another. Civilization is impossible without freedom and security, and these can exist only in virtue of social institutions.

All the theories we have been considering contain an admixture of truth and error; and they are all imperfect, being true in what they affirm, but erroneous in what they exclude from consideration. We have, therefore, to discover a formula which, while it applies equally to all these facts, and sums them up in a more general notion, shall show their intimate connection and their close association with one another.

I.

Civilization is *the result of previous progress.* Progress is a movement; it is, so to speak, *dynamical.* Civilization is a state, it is *static.* It is not the work of the present moment; it is rather that which the present inherits from the past, in the way of science, art, discovery, wealth, customs. In a society which is in process of civilization, each generation finds a certain store of the elements of civilization at hand. The scientific researches of the past have not to be commenced anew; its discoveries and industrial processes we have but to learn and to perpetuate. Agriculture has made progress, cities have been built, roads constructed, and society organized. Finally, we have language ready formed, and race instincts, and moral and intellectual qualities, more or less developed. So that we may regard civilization as the sum of human enjoyment at a given moment, which is at hand without the necessity of going in search of it. Or, in philosophical language, we say that civilization is an accumulation of force in the race, or for the race.

We have used the word *force*, and this calls for an explanation. Modern philosophy is inclined to see nothing but forces in the universe. Those things which we regard as *material* are but forces, or combinations of force. Light, heat, solidity, weight, and movement of every kind, are forces: life is an organization of force, and society an organization of living forces. The same is to be said of will, ideas, sensations, truth, right, science.

We may regard man as an aggregation of forces, physiological, intellectual, and moral. This aggregation is susceptible of perfectionment, its component parts becoming mutually better adjusted, or the combination becoming more complex. In either case the result will be an enlargement of the faculties and an increase of the individual's power.

But let us pursue this subject further. This system of forces which we call man is surrounded by forces which are unintelligent. He enters into competition with these, and turns them to his own advantage, appropriates them, and thus, as it were, projects his own personality outward. By the aid of science he makes Nature subject to him, and renders the most sterile soil productive. Mountains are tunnelled, and seas joined together. These and similar splendid achievements are not accomplished by the native forces of man, yet they bear the marks of man's handiwork; and the forces which did bring them about were in subjection to him. Though these forces, then, cannot be properly called *human* forces, still they are *humanized*, and it is the accumulation of both these kinds of force that makes up civilization.

It were inexact to say that this accumulation is a creation of force. Man does not *create*, he only transforms. Production implies only adapting things to our use. Therefore, when we speak of production, we imply only a new direction given to forces already active. But man is also a consumer of the wealth he acquires and of his own powers. In order, therefore, that he may accumulate, production must be in excess of consumption. Every act we perform involves an expenditure of muscular or intellectual energy; and the same is true with regard to the implements we employ for our work. If, however, by such expenditure we render available for human uses what before was unserviceable, and if this acquisition is of greater value than the outlay, there is a clear profit for humanity. Yet this gain has no value as a civilizing element, except in so far as it puts man in the way of making new products, whether by augmenting the power of his organs or faculties, by putting in his hands a new implement, by leading to some useful discovery, or by affecting favorably political relations, which in turn react upon production and upon progress in general.

This excess of production over consumption is not the only source of power. There is another which is of equal importance, and that is the perfecting of organization, whether among the forces which make up the individual, the society, or the race. Here, again, there is no creation, but only utilization of force. This organic adaptation diminishes friction, and permits the utilization of forces which else would be wasted. Organization, furthermore, brings together like capacities, and enables them to combine their strength, and thus forces which separately would be weak, being united, produce great results. In thus grouping together like forces, the first step is to detach them from those which are dissimilar, and consequently a perfect organization leads to the separation of faculties, the localization of functions, and the division of labor. We now proceed to confirm our inductions by particular applications of them to actual facts. And, first, we will consider those elements of civilization which are extrinsic to man. We can more easily understand the world around us than the interior phenomena of the mind, and the study of these external phenomena will furnish us with many analogies to guide us in the study of the more recondite internal phenomena.

II.

The word *capital* is employed to denote the sum of external forces accumulated by man, and which he can use for new productions. We do not, however, agree with certain contemporaneous economists who say that capital is only labor accumulated. This definition, though plausible, is inexact, and besides it involves a dangerous confusion of ideas, and has supplied the socialists with a portion of their arguments against capital, civilization, and political economy itself.

No doubt capital is an accumulation, but not an accumulation of labor; it is not even the product of labor. Though Proudhon ("Manuel du Spéculateur") defines capital to be "labor accumulated," he contradicts himself a few lines farther on, when he says, "The first capital is given gratis to man by Nature." Most of the precious metals possess a value in excess of the cost of production; the difference represents a portion of capital which does not come from labor, and the value of which is regulated simply by the law of demand and supply. Capital, then, is not always the product of labor, nor does labor, even when accumulated, always produce capital. There is such a thing as destructive labor, as, for instance, under the rule of the Commune in Paris. There is also such a thing as unproductive labor, as when thousands of working-men are employed for weeks together in preparations for *fêtes*, illuminations, and the like. An author may spend years in writing a work which no man will read or buy. He surely does not produce capital. Finally, if capital were in reality only labor accumulated, would not the complaint of the socialists be justified when they clamor against society for its iniquity in making the workers non-capitalists, while the capitalists are not workers?

It is better to regard capital as the *condition* of labor, and not its product. As for the origin of capital, to fix it precisely, we need only apply the general formula already given, according to which capital represents the excess of production over consumption. It means savings, therefore, or, if you wish, accumulated savings. One begins to acquire capital, not by labor, but rather by saving the products, whether of labor or of Nature. Hence it follows that a just distribution of capital must be based, not on the amount of labor, but on the amount of saving; and this is about the state of things existing in the present social order, allowance being made for some imperfections. The spendthrift wastes his capital; and he alone produces it, or increases it, who can save. Many persons, who are not at all socialists, discourage saving, and judge it better to expend capital than to consume it. It is true that expenditure in some measure benefits our contemporaries; yet only at the expense of society in the future; whereas, saving contributes to the future growth of civilization, though doing some little injury to the present generation. Now, shall we sacrifice the present for the future, or shall we compromise the future in order to alleviate the misery and suffering of the present? Let us put an hypothesis which, though impracticable, still may be supposed. Suppose France were to resolve to use up all her wealth in one day. During that one day all Frenchmen might have all sorts of enjoyment. But the morrow!

We must remember that the race is in process of development, and is never at any moment what it will be. The present is nothing. To insure progress, the first requisite is that capital should increase. Here is a quantity of grain which might subsist a family for one day: save it, turn it to account, and it will produce food for millions. Such is the benefit of saving, and this is the secret of material civilization, which is itself the result of foresight and of past privations. The nations which are at the head of material civilization are those whose institutions have most favored saving, by their respect for private property, and the safeguards they threw around capital. Unhappily, in modern European legislation, there are still to be found enactments which are nothing better than attacks upon the rights and liberties of capital. If a man has to save not alone for himself, but also for others, his economy will be more strict than if he had to save for himself alone. If you do away with the right of freely disposing of property, a man will take care to consume all his capital, rather than let it fall into the hands of those for whose benefit he has no mind to accumulate.

The accumulation of capital is often regarded with alarm, which, however, is baseless. We must not forget that capital is only the means of production, and that consequently it must always be profitably employed, else all its value is gone. Where capital is abundant, the capitalist is constrained to lend it at reasonable rates, and to go in search of labor, in order to find an advantageous investment. On the other hand, when there is but little capital, then labor must go in search of the capitalist, and pay him whatever interest he requires. Thus, individual property and the liberty of disposal are upheld by the very arguments that socialists bring to overturn them. The chief benefit of these institutions is to make accumulation of capital possible: this the socialists regard as an injury, for their aim is absolute equality, and they make small account of the interests of civilization. But we who regard civilization as the great aim of humanity find no more difficulty with inequality of capital than with inequality of wages. Some workmen get ten or twenty times as much pay as others, and some save ten or twenty times as much as others. If the capitalist has only to preserve what others have accumulated, or what has come to him by gift or inheritance, does not the workman in like manner profit by his capital of health and intellectual faculties, which he owes partly to inheritance and partly to his education, in order to demand higher pay?

In no country is the habit of saving so general as in France, and this is the securest basis of our prosperity and civilization. The French have been unjustly charged with prodigality; but the reproach should be confined to that *quartier* of Paris which lies between the Champs Elysées and the Faubourg Montmartre. Without these bounds, all France is steady and industrious. A very moderate estimate puts the annual increase of wealth in France at three milliards of francs. Unfortunately, however, we lose much of the benefit of this saving as a nation by embarking in ruinous adventures. The national debt, which will soon be twenty milliards, has doubled within twenty years. Though we make an annual increase of capital to the amount of three milliards, we annually burden posterity with a debt of a half milliard. Another and more serious defect of the French nation is, that this saving tends to check population; and this fact leads us to consider another element of civilization, viz., the value of the individual.

III.

As regards civilization, we may consider man from a threefold point of view: the numerical quantity of the population; the duration of human force, that is, longevity; and the intensity of this force, that is, the development of the organs and faculties.

Man being a combination of forces, does it follow that an increase of population is an accumulation of human forces, and so an element of civilization? As the increase of wealth favors the increase of population, so the latter reacts on the former by increasing the number of producers, and especially by favoring the division of labor. Consequently, a country's well-being requires a just equilibrium between the sum of the capital and the number of inhabitants. An increase of population ought not to lead to a loss in capital, nor ought the increase of capital, by saving, lead to diminished population. In the former case, the country would become impoverished; in the latter it would decay. The latter is the case with France, where the population is far less than the immense resources of the country would justify. While Saxony doubles its population in 45 years, England in 49, Prussia in 54, Russia in 56, Würtemberg and Switzerland in 114, France requires more than 198. There is reason to suppose that Great Britain, which now has 26,000,000, will, in 50 years, have 52,000,000; Germany, 60,000,000; and Russia, over 100,000,000; but France, unless there occur a change, will have no more than 45,000,000. At the beginning of this century, the annual increase of population in France was 175,000, now it is only 132,000 souls. Far from peopling our colonies, we find the very soil of France gradually encroached on by an immigration of the neighboring nations.

The reasons for this are numerous. The restrictions laid on the father of a family in France are greater than in most countries. Then the education Frenchwomen get has an influence. Marriages are not fewer than hitherto, but are contracted at a later period of life. In Catholic countries there is less moral freedom but more licentiousness than in Protestant countries. In the latter, marriage is rendered easy and spontaneous by the greater freedom of social relations between the sexes; but in France marriage is a matter of calculation, and marriages are generally contracted with the aid of go-betweens. Another cause is that habits of industry and especially individual enterprise are not at all in France in proportion with the national wealth. While in England a man generally acquires capital with a view to better his condition as a producer, a Frenchman's study is to retire from business, and leave to a very small family the means of living without work. We have also in France a large proportion of the poorer classes who flock into the great cities to live by public assistance. We have by no means exhausted all the resources of our soil, and there are 20,000,000 acres of waste land. Though in

France the population increases more slowly than in other European nations, the average duration of life is greater. The higher the average duration of life, the greater the accumulation of productive forces. The reason why war is so fatal to civilization, even among the conquerors, is that it destroys those who are at the age most favorable for production.

We have now to consider the third element of civilization, as found in man himself, and this is the most important of all, namely, the intensity of force. Two equal quantities of individuals will not in the same space of time produce equally, for each may not possess the same energy, the same intensity of life or force. Individual values are determined by the development of organs, functions, and faculties, which come in part from exercise and culture, and in part from inheritance. On the one hand, we have the habits acquired by the individual, which are modified by his surroundings; and, on the other hand, we have habits rooted in the family, nation, or race, and which become hereditary. The latter is called an instinct, and embraces all those sentiments which men have in common, their intensity being in proportion with the social progress which produced them. The influence of these inherited sentiments is very great, though it is frequently overlooked. If a man is what he is as distinct from all others in virtue of individual development and personal character, we are men having our specific and race character from inheritance. We are possessed of the apparatus of vision, hearing, language, circulation, digestion, because these functions are so many habits that have become essential to the human race.

These habits and instincts are not all good, for vices too are habits. This means only that the action of our organs and faculties sometimes takes a direction unfavorable to society or humanity. The body has its diseases, the understanding its errors, and the will its vices. Entire races have sometimes depraved instincts, which forbid their advancing beyond a certain degree of civilization, while others fail to attain that intellectual development which is the condition of all ulterior progress. Now, what is the criterion for determining what habits are good and favorable for civilization? We need only apply our general formula, and then we shall see that those habits have a civilizing influence which tends to increase man's forces, the power of his faculties, his value as an intellectual or material producer. On the contrary, those habits which have a tendency to deprave the individual, weaken his faculties, or efface his moral instincts, are vices which, when generalized and transmitted, whether by education or by inheritance, lead a people toward decay, decrepitude, and extinction. The ideas, instincts, and moral habits of the individual, are ever in competition, and, when this competition tends toward perfection, the element which wins in the struggle always gains power by selection.

It was the fashion during the eighteenth century to regard the faculties of the civilized man as inferior to those of the savage. Experience has not confirmed this. What certain organs have lost in one direction, they have got back in another. If our senses have a narrow range, they have gained in firmness of perception. The senses of touch and of taste are in the civilized man extremely subtile. Our power of vision has not a very great range, but we can peruse for many hours together the printed page, a thing which the eye of the savage could never do. If our ear cannot detect the stealthy approach of a wild beast, it can appreciate the nicest shades of difference in musical notes. We cannot climb trees, but a clerk seated at his desk does more work with his hand in one day than a savage in a twelvemonth. Finally, the muscular force of certain Indian tribes has been proved by the dynamometer to be very considerably less than that of English and French sailors.

There are faculties which appear to arise full grown, so to speak, when civilization has reached a certain stage, and which do not exist, even in germ, among savages. Such are the faculties of literary and artistic taste. The savage has no leisure for the pleasures of the imagination. A Molière, a Rembrandt, or a Mozart, would have to expend all his energy under such circumstances in procuring the bare necessaries of life. The fine arts are subordinated to the development of the other elements of civilization, but they may also be regarded as the best expression and the most exact measure of the state of a society. A few examples will explain our meaning:

How has architecture advanced? Men at first dwelt in hollow trees, in caves, or beneath any chance shelter. Next, they constructed rude houses of stones, branches, or sods. It was only at a later period that they could think of symmetry or regularity. Then came all kinds of ornamentation. At last they came to erect structures without direct utility, for æsthetic purposes merely, such as columns, porticoes, and the like. And so each increase of wealth in a society is followed by a corresponding progress in arts which are rather pleasing than useful. The same holds with respect to literature. At first, men would interchange only thoughts of immediate utility. Next they came imperceptibly to adorn their speech, and then arose history, religion, morality, philosophy, adorned with all the charms of versification, music, and poesy. It was only at a later period that poetry appeared in its own individual character, on the stage, or in the story, as the form in which pure fiction was to be cast, having as its aim to please the imagination, without reference to history, religion, or utility. In a word, art and poetry spring from a superabundance of intellectual energy, and from an exuberance of ideal force.

The culture of science, as viewed with reference to civilization, is the same thing as the development of the understanding. At first view, we might suppose that scientific truths, when once discovered, constitute a sort of capital, which may be stored up. But this is not the case, for science has no real value, except as it is present in the consciousness of the thinker, and it is inseparable from the exercise of the faculties. Science in books is of no importance for civilization. We will not speak of the immense importance of intellectual development, which Buckle regarded as the very essence of civilization. The mode of this development is a question for a theory of progress. It consists principally of an enlarging adaptation of ideas to external facts, and to one another; and the most natural explanation will be given when we apply Darwin's admirable inductions to the formation of ideas.

The French have boasted that they were the leaders of civilization in virtue of their intellectual superiority. But the Germans and English make the same pretensions. Yet the French mind appears to hold preëminent rank in certain respects, as for instance in taste for the beautiful, for grace, and for elegance. The country which produced Molière is now the only one that has a theatre worthy of the name; our painters are the first in the world; and in France alone are the refinements of an exquisite taste exhibited in the minor details of every-day life. We owe all this to the æsthetic influence of the capital.

The French mind also excels in all the lively and brilliant qualities of imagination. Still, it must be admitted that these qualities are blended with very grave defects. The philosophical faculties are in some degree weakened by the development of taste, and the refinement of the imagination often hinders the cultivation of the reason. We have, to be sure, some men of great distinction in all the sciences, but it cannot be gainsaid that instruction is not as wide-spread in France as in Germany; and moral science is far more backward here than in England. We have no taste for consecutiveness, method, long deduction, or patient analyses.

These defects expose us to grave dangers in political life especially, and this brings us to the consideration of social relations and institutions as they have a bearing upon civilization.

IV.

There are two things to be considered in the social order, viz., the rights of individuals, and the system of institutions guaranteeing them. As the definition of these rights depends on the development of the race in their ideas, morals, instincts, etc., we need but refer to what we have already said on the development of organs and faculties, to show how far these rights extend. But the case is different with governmental institutions which derive force not from the progress of individuals, but from the evolution of society, and the historic development of the nation. In times of order and tranquillity we are disposed to reduce governmental functions to the minimum. For this reason, prosperity sometimes leads to decadence. When the government is weakened, the nation compromises its civilization, and lies open either to anarchy or conquest, or both. Governmental progress is never made by radical destruction or suppression of established order, with a view to evolve a new organization, giving up historic advantages. Gradual modification is the condition of true progress, for no constitution or organization is of any value, unless it is the work of ages.

In order to guarantee security and respect for individual rights, the government derives a certain amount of force from the nation, and this force makes up the power of the state. The value of a government is to be estimated by the difference between what it costs and the benefits it secures. If we would know what is the value of French political institutions, for instance, we have only to estimate the value of our present capital, and compare it with what we should have were our institutions at an end. Hence, we see that political institutions are a true civilizing force, as yielding an excess of utility over expenditure.

A political society is an organism, and the individuals may be regarded as elementary cellules. Social progress consists in the increasing adaptation of individuals, which results from the separation of functions and the division of labor. Just as, in the lower grades of the physiological scale, one organ will discharge many very diverse functions, so, in the more imperfect forms of society, the government discharges every kind of office, as that of the soldier, priest, school-master, tutor, manufacturer, agriculturist, merchant, banker. The great problem is, to determine what is to be done by the state, what by other forces. The government will be more effective in proportion as it is freed from the embarrassment of diverse functions.

From this point of view we should say that France has departed from the path of progress in two directions: First, her revolutions have unduly weakened the government; second, public opinion has unduly favored the extension of governmental interference. The result of the first is, that no government in France is sufficiently strong; the result of the second, that government is entangled in affairs from which it were better freed, and every schemer and visionary is clamoring for government assistance to work out his plans.

Every ephemeral constitution we have had, has to-day a factious party ready to do battle for it. Thus, every administration finds itself surrounded with a coalition of minorities. Time alone can give authority to any constitution.

Not less serious are the consequences of Utopianism which would shape the state according to every fantastic notion. All forms of socialism strive to enlarge the action of society; and communism, its latest development, seeks to absorb the individual in the state. Governments have often unconsciously yielded to the influence of these dreams, as we see where they favor protection, state interference in religious matters, and in the direction of art and science, etc.

The university, too, is to blame for our disasters. Its metaphysics and worship of forms give rise to dreams of Utopia and all manner of illusions. We had little better than illusions to oppose to the sternly practical science of Germany. It is Utopian ideas that have produced, after a disastrous war, another crisis more serious still. Only solid, positive education can avert such disasters. England has opposed to fanciful dreams the serious study of political economy. Germany has profoundly studied the historical sciences, and has cultivated a searching criticism as well as the natural sciences. But France has followed an ideal, without regard to facts, and the result is, that every thing is in a state of disorder.

Present disaster may bring France to her senses, and induce her to start from different principles.

POPULAR GEOLOGY.[1]

By Rev. CHARLES KINGSLEY.

GEOLOGY is the science which explains to us the *rind* of the earth; of what it is made; how it has been made. It tells us nothing of the mass of the earth. That is, properly speaking, an astronomical question. If I may be allowed to liken this earth to a fruit, then astronomy will tell us—when it knows—how the fruit grew, and what is inside the fruit. Geology can only tell us at most how its rind, its outer covering, grew, and of what it is composed; a very small part, doubtless, of all that is to be known about this planet.

But, as it happens, the mere rind of this earth-fruit, which has, countless ages since, dropped, as it were, from the Bosom of God, the Eternal Fount of Life—the mere rind of this earth-fruit, I say, is so beautiful and so complex, that it is well worth our awful and reverent study. It has been well said, indeed, that the history of it, which we call geology, would be a magnificent epic poem, were there only any human interest in it; did it deal with creatures more like ourselves than stones, and bones, and the dead relics of plants and beasts. Whether there be no human interest in geology; whether man did not exist on the earth during ages which have seen enormous geological changes, is becoming more and more an open question.

But meanwhile all must agree that there is matter enough for interest—nay, room enough for the free use of the imagination, in a science which tells of the growth and decay of whole mountain-ranges, continents, oceans, whole tribes and worlds of plants and animals.

And yet it is not so much for the vastness and grandeur of those

[1] From advance sheets of Prof. Kingsley's excellent little book entitled "Town Geology."

scenes of the distant past, to which the science of geology introduces us, that I value it as a study, and wish earnestly to awaken you to its beauty and importance. It is because it is the science from which you will learn most easily a sound scientific habit of thought. I say most easily; and for these reasons. The most important facts of geology do not require, to discover them, any knowledge of mathematics or of chemical analysis; they may be studied in every bank, every grot, every quarry, every railway-cutting, by any one who has eyes and common-sense, and who chooses to copy the late illustrious Hugh Miller, who made himself a great geologist out of a poor stone-mason. Next, its most important theories are not, or need not be, wrapped up in obscure Latin and Greek terms. They may be expressed in the simplest English, because they are discovered by simple common-sense. And thus geology is (or ought to be), in popular parlance, the people's science—the science by studying which, the man ignorant of Latin, Greek, mathematics, scientific chemistry, can yet become—as far as his brain enables him—a truly scientific man.

But how shall we learn science by mere common-sense?

First, always try to explain the unknown by the known. If you meet something which you have not seen before, then think of the thing most like it which you have seen before; and try if that which you know explains the one will not explain the other also. Sometimes it will; sometimes it will not. But, if it will, no one has a right to ask you to try any other explanation.

Suppose, for instance, that you found a dead bird on the top of a cathedral-tower, and were asked how you thought it had got there. You would say, "Of course, it died up here." But if a friend said: "Not so; it dropped from a balloon, or from the clouds;" and told you the prettiest tale of how the bird came to so strange an end, you would answer: "No, no; I must reason from what I know. I know that birds haunt the cathedral-tower; I know that birds die; and therefore, let your story be as pretty as it may, my common-sense bids me take the simplest explanation, and say—it died here." In saying that, you would be talking scientifically. You would have made a fair and sufficient induction (as it is called) from the facts about birds' habits and birds' deaths which you knew.

But suppose that when you took the bird up you found that it was neither a jackdaw, nor a sparrow, nor a swallow, as you expected, but a humming-bird. Then you would be adrift again. The fact of it being a humming bird would be a new fact which you had not taken into account, and for which your old explanation was not sufficient: and you would have to try a new induction—to use your common-sense afresh—saying, "I have not to explain merely how a dead bird got here, but how a dead humming-bird."

And now, if your imaginative friend chimed in triumphantly with, "Do you not see that I was right after all? Do you not see that it fell from the clouds? That it was swept away hither, all the way from South America, by some southwesterly storm, and, wearied out at last, dropped here to find rest, as in a sacred place?" what would you answer? "My friend, that is a beautiful imagination: but I must treat it only as such, as long as I can explain the mystery more simply by facts which I do know. I do not know that humming-birds can be blown across the Atlantic alive. I do know that they are actually brought across the Atlantic dead; are stuck in ladies' hats. I know that ladies visit the cathedral: and, odd as the accident is, I prefer to believe, till I get a better explanation, that the humming-bird has simply dropped out of a lady's hat." There, again, you would be speaking common-sense; and using, too, sound inductive method; trying to explain what you do not know from what you do know already.

Now, I ask of you to employ the same common-sense when you read and think of geology.

It is very necessary to do so. For in past times men have tried to explain the making of the world around them, its oceans, rivers, mountains, and continents, by I know not what of fancied cataclysms and convulsions of Nature; explaining the unknown by the still more unknown, till some of their geological theories were no more rational, because no more founded on known facts, than that of the New Zealand Maories, who hold that some god, when fishing, fished up their islands out of the bottom of the ocean. But a sounder and wiser school of geologists now reigns; the father of whom, in England at least, is the venerable Sir Charles Lyell. He was almost the first of Englishmen who taught us to see—what common-sense tells us—that the laws which we see at work around us now have been most probably at work since the creation of the world; and that whatever changes may seem to have taken place in past ages, and in ancient rocks, should be explained, if possible, by the changes which are taking place now in the most recent deposits—in the soil of the field.

And in the last 40 years—since that great and sound idea has become rooted in the minds of students, and specially of English students—geology has thriven and developed, perhaps more than any other science; and has led men on to discoveries far more really astonishing and awful than all fancied convulsions and cataclysms.

I have planned this series of papers, therefore, on Sir Charles Lyell's method. I have begun by trying to teach a little about the part of the earth's crust which lies nearest us, which we see most often—namely, the soil; intending, if my readers do me the honor to read the papers which follow, to lead them downward, as it were, into the earth; deeper and deeper in each paper, to rocks and minerals which are probably less known to them than the soil in the fields. Thus you will find I shall lead you, or try to lead you on, throughout the series, from the known to the unknown, and show you how to explain the latter by the former. Sir Charles Lyell has, I see, in the new edition of his "Student's Elements of Geology," begun his book with the uppermost, that is, newest strata, or layers; and has gone regularly downward in the course of the book to the lowest or earliest strata; and I shall follow his plan.

I must ask you meanwhile to remember one law or rule, which seems to me founded on common-sense, namely, that the uppermost strata are really almost always the newest; that when two or more layers, whether of rock or earth—or indeed two stones in the street, or two sheets on a bed, or two books on a table—any two or more lifeless things, in fact, lie one on the other, then the lower one was most probably put there first, and the upper one laid down on the lower. Does that seem to you a truism? Do I seem almost impertinent in asking you to remember it? So much the better. I shall be saved unnecessary trouble hereafter.

But some one may say, and will have a right to say, "Stop—the lower thing may have been thrust under the upper one." Quite true: and therefore I said only that the lower one was most probably put there first. And I said "most probably," because it is most probable that in Nature we should find things done by the method which costs least force, just as you do them. I will warrant that, when you want to hide a thing, you lay something down on it ten times for once that you thrust it under something else. You may say: "What? When I want to hide a paper, say, under the sofa-cover, do I not thrust it under?" No, you lift up the cover, and slip the paper in, and let the cover fall on it again. And so, even in that case, the paper has got into its first place.

Now, why is this? Simply because in laying one thing on another you only move weight. In thrusting one thing under another, you have not only to move weight, but to overcome friction. That is why you do it, though you are hardly aware of it: simply because so you employ less force, and take less trouble.

And so do clays and sands and stones. They are laid down on each other, and not thrust under each other, because thus less force is expended in getting them into place.

There are exceptions. There are cases in which Nature does try to thrust one rock under another. But to do that she requires a force so enormous, compared with what is employed in laying one rock on another, that (so to speak) she continually fails; and, instead of producing a volcanic eruption, produces only an earthquake. Of that I may speak hereafter, and may tell you, in good time, how to distinguish rocks which have been thrust in from beneath, from rocks which have been laid down from above, as every rock between London and Birmingham or Exeter has been laid down. That I only assert now. But I do not wish you to take it on trust from me. I wish to prove it to you as I go on, or, to do what is far better for you, to put you in the way of proving it for yourselves, by using your common-sense.

At the risk of seeming prolix, I must say a few more words on this matter. I have special reasons for it. Until I can get you to "let your thoughts play freely" round this question of the superposition of soils and rocks, there will be no use in my going on with these papers.

Suppose, then (to argue from the known to the unknown), that you were watching men cleaning out a pond. Atop, perhaps, they would come to a layer of soft mud, and under that to a layer of sand. Would not common-sense tell you that the sand was there first, and that the water had laid down the mud on the top of it? Then, perhaps, they might come to a layer of dead leaves. Would not common-sense tell you that the leaves were there before the sand above them? Then, perhaps, to a layer of mud again. Would not common-sense tell you that the mud was there before the leaves? And so on down to the bottom of the pond, where, lastly, I think common-sense would tell you that the bottom of the pond was there already, before all the layers which were laid down on it. Is not that simple common-sense?

Then apply that reasoning to the soils and rocks in any spot on earth. If you made a deep boring, and found, as you would in many parts of this kingdom, that the boring, after passing through the soil of the field, entered clays or loose sands, you would say the clays were there before the soil. If it then went down into sandstone, you would say—would you not?—that sandstone must have been here before the clay; and however thick—even thousands of feet—it might be, that would make no difference to your judgment. If next the boring came into quite different rocks, into a different sort of sandstone and shales, and among them beds of coal, would you not say, "These coal-beds must have been here before the sandstones?" And, if you found in those coal-beds dead leaves and stems of plants, would you not say: "Those plants must have been laid down here before the layers above them, just as the dead leaves in the pond were?"

If you then came to a layer of limestone, would you not say the same? And if you found that limestone full of shells and corals, dead, but many of them quite perfect, some of the corals plainly in the very place in which they grew, would you not say, "These creatures must have lived down here before the coal was laid on top of them?" And if, lastly, below the limestone, you came to a bottom-rock quite different again, would you not say, "The bottom-rock must have been here before the rocks on the top of it?"

And if that bottom-rock rose up a few miles off, 2,000 feet, or any other height, into hills, what would you say then? Would you say: "Oh, but the rock is not bottom-rock; is not under the limestone here, but higher than it. So perhaps in this part it has made a shift, and the highlands are younger than the lowlands; for see, they rise so much higher?" Would not that be about as wise as to say that the bottom of the pond was not there before the pond-mud, because the banks round the pond rose higher than the mud?

ON MORAL CONTAGION.

By Dr. DESPINE.

IN his short pamphlet of twenty-four pages, the writer treats of a matter observed by all who read the newspapers—we mean the fact that crimes, particularly those of a graver description, generally occur in epidemics. To prove this point, Dr. Despine, in the first division of his paper, records a large number of murders, suicides, robberies, etc.; on these it is not necessary to dwell, but we shall pass on to his second division—the law which regulates Moral Contagion. The following is what is said on this matter:

Moral contagion, being a natural phenomenon, is consequently one of the laws to which God has subjected all created things. We succeed in the discovery of this law by analyzing moral facts and by studying the circumstances in which they occur, in the same manner as we succeed in discovering the laws which preside over the phenomena of the physical and organic worlds, by studying perseveringly the facts appertaining thereto as well as the conditions in which they are produced. Now, the conclusion to be drawn from the facts which we have related is forcibly this, which will represent the law that has directed the commission of these acts: *Every manifestation of the instincts of the mind, of the sentiments and passions of every kind, excites similar sentiments and passions in individuals who are capable of feeling them in a certain intensity.* This law explains how a certain act infects some and not others. One could not better compare man's moral nature than to a sounding-board (*table d'harmonie*). The sounding of one note causes vibrations in the same note in all the boards which, being susceptible of emitting it, are influenced by the sound emitted. In the same way, the manifestation of a sentiment, of a passion, excites the same instinctive element in every individual susceptible, by his moral constitution, of feeling more or less acutely this same instinctive element.

If this law acts beneficially in affording us the means of putting into activity, of exciting and strengthening by good example, the higher sentiments of man, it also becomes a source of evil in causing moral perversion by the influence of bad example, by the recounting of criminally immoral acts, which vivify, incite, strengthen the evil instincts, sentiments, passions, of the man whose natural *morale* is already below par. It is necessary, therefore, to take this law into serious consideration in order that it may operate as much as possible for good, and remove as far as possible those circumstances which tend to make it the source of evil. And these latter circumstances occur too frequently in our day, by the relation of hideous crimes with which all the newspapers are filled, and particularly those which, by their low price, are intended to be read by the lower classes. If the recital of immoral, criminal acts is not dangerous for individuals of good parts, who from their mental constitution reprobate these acts with horror, who have only an aversion to what is bad, it is incontestable that, for those morally deformed, in whom the tendencies to evil are very powerful, easily excited, or already developed, either by their inherent activity, or by the corrupting influence of immoral surroundings, and in whom the moral sentiments which are antagonistic to the depraved tendencies are feeble or absent—it is incontestable, I say, and I have brought forward numerous facts in evidence thereof, that the publication of criminal acts is very dangerous to public morality and security, because it stimulates in these individuals the same depraved tendencies which had occasioned these crimes, and awakens those sentiments, those *penchants*, those passions; and the desire to commit similar acts then appears. Now, in such morally-deformed individuals, who form the unfortunate dregs of society, a class which is constantly renewed, and of which the source is never exhausted, the recital of such acts becomes to them a cause of crime, and consequently a cause of danger to society. These individuals, abnormally constructed in the moral part of their nature, real moral idiots, though perhaps very intelligent, physically well developed, and in good bodily condition; these individuals whom the public describe as heartless, whom magistrates, before whom they appear on various charges, accuse of being destitute of human feelings; these individuals in whom criminal tendencies are not commanded by the sentiment of moral duty, by moral perception, by religious feelings, and by other noble instincts of humanity; these individuals who consider their immoral and hideous desires without abhorrence, and whom crime leaves unmoved and without remorse, who, in way of regret, feel only what injures the success of their undertakings at being captured and punished—these individuals, I say, will be tempted to commit crime if an evil desire excited by example becomes more powerful than their other better feelings which, while they predominated, restrained any criminal tendencies which these persons might have experienced. This miserable scum of humanity so dangerous to society, which produces exclusively all the greatest criminals, and to which we have directed too little attention up to the present time, ought to be explored to the bottom.—*Journal of Mental Science.*

THE ENEMIES WE IMPORT.

By Prof. SAMUEL LOCKWOOD, Ph. D.

IT would seem as if every grain brought its bane. The Agricultural Department at Washington has done a good deal for agriculture in the importation and distribution of foreign seeds, slips, and plants. In this way have been secured to the country many of the choicest improved plants from abroad, and many entirely new to our gardens. But it is to be feared that, in some instances unavoidably, and in others from want of care or skill, or both, the eggs and larvæ of foreign insect-pests have been introduced, and are to-day troublesome to the husbandman, and a source of mischief and loss to the interests of the nation at large. If that man, or that art, is a public blessing that makes a spear of wheat grow where the land was sterile before, or makes that bear twofold that before did little more than barely reproduce its kind, surely, then, that is a pest and misfortune that appears as a new destroyer of the anticipated harvest. So far as size is considered, the little fly introduced in the provender of the Hessian soldier, in 1776, is contemptible; yet it was destined to become an enemy more formidable than the troops that brought it. So diminutive, indeed, is this pest, that many a husbandman has never seen it to know it, and, in fact, only knows it from its sad depredations on his honest labor; which are such that all the combined whirlwinds and destructive storms that have ever swept over portions of our land have not robbed the national wealth so much as this almost invisible, tiny creature, that dances in the sunbeam; which science well names *Cecidomyia destructor*, and which tradition calls the *Hessian fly*.

In Freehold, N. J., in the autumn of 1870, I detected a new-comer making terrible havoc with the cabbage. This esculent was entered from without, and almost honey-combed by a small green caterpillar, that I had never seen before. It was soon determined to be the *Pieris rapae*, or cabbage-caterpillar of Europe. The parent was a pretty butterfly, mainly white, with black spots on the wings. It first appeared on this continent at Quebec, and made its noxious power felt in the destruction of the cabbages to the amount of many thousands of dollars in that neighborhood. It soon came into Northern New England, and in 1869 was found in the gardens within a few miles of New York. At Freehold, of course, it was stretching south. It soon reached Philadelphia. Last summer it was at home at Baltimore, and this June it has appeared at Washington. The terrible little beauty is thus belting the land with a scourge.

Among the insect pests that have become celebrated because of its fearful capacity of increase, the grasshopper deserves mention. It is well known that in Russia this insect appears in such prodigious numbers that the wheels of the vehicles roll crushingly through the masses. Mr. Glover, the entomologist of the Department of Agriculture, states that a new grasshopper has appeared. Besides several larvæ and part of an entire insect found when cleansing the pots in the greenhouse of the department, a pair of these strange creatures, a male and a female, has been obtained. They went lustily to work on the leaves of the coffee-plant, bananas, etc., in the greenhouse, "much in the same manner as is done by our native katydids, by eating holes in the leaves and gnawing away the edges. Their jaws were remarkably strong and sharp, and when the insects were incautiously handled they bit so severely as to draw blood. The male was about 1.75 inch in length from the tip of the cone, or horn on its forehead, to the end of its wing-covers when closed. The female measured 3.05 inches to the end of the ovipositor, which itself was at least 1.25 inch in length. The general color of both male and female was a light pea-green, and the wings were delicately veined with distinct nerves, resembling the venation of leaves. A very marked feature in this insect, when alive, is that the labrum and clypeus are bright yellow, contrasting strongly with the jet-black of the mandibles, which, together with the cone or horn on the top of its head, gives it a remarkable appearance. This cone or horn, which is placed obliquely upward on the top of the forehead, forming a line with the face, is yellow beneath, black at the tip, and ends in an acute point, which is somewhat bent downward at its summit. No insect resembling it having hitherto been found in this neighborhood, there is but little doubt that it has lately been imported with or on some foreign plants sent from South America, or the West Indies; and, as many exotic plants have been received from Balize, British Honduras, it is probable that this grasshopper came in the egg-state, on some of the plants from that locality, and was hatched out last summer in the greenhouse. This fact alone admonishes us how careful we should be when importing new and valuable plants from abroad, for, if a large insect, nearly two inches in length, and fully the size of a katydid, can be so easily introduced, how much more readily the small and inconspicuous noxious insects hidden under the bark would be likely to escape notice, until they had perpetuated their species, so as to become partially naturalized and injurious to our plants! There is no danger, however, that this grasshopper will spread, and, as it is apparently very tender and accustomed to a tropical climate, most probably it would not be able to withstand the rigors of our winters in the open air, and as all were killed or caught as soon as seen in the greenhouse, there is very little probability of any being left to perpetuate their race." Mr. Thomas has described this insect under the name of *Copiophora mucronata*, in the "Canadian Entomologist."

More curious and perhaps more interesting to scientific consideration is the appearance, in the hot-houses of the Agricultural Department, of a *new earth-worm.* The species is very large, and, compared with our common angle-worm, it is very curious. It has multiplied in the hot-houses of the department so as to have become a real pest. It is believed to have been introduced from Japan in the earth with the plants imported in the expedition under Commodore Perry. Mr. Glover seems to think it is the same as the worm now doing much damage to pot-plants in the hot-house conservatories of England, and quotes Mr. Fish in the *English Gardener's Chronicle*, who speaks of "the eel-worm" as "probably a tropical relation of the common earth-worm, as it cannot live out-of-doors in the climate of England, and scarcely subsists in a greenhouse, but revels in the temperature of a plant-store or orchideous house. It differs from the common worm in its mode of locomotion, and in several of its habits. It comes out at night on walls, stone floors, etc., and is as quick as an adder in its movements when disturbed. It seems impossible to eradicate it; it appears to breed with extraordinary rapidity, and is endowed with great muscular power, so much so that it is somewhat difficult to hold a large specimen between the thumb and finger. Lime-water, which is a sovereign remedy against the common earth-worm, appears to have little influence on it, and the only effective mode of destruction is to turn out the soil from the pot and catch and kill the intruder, taking care, however, not to knock or jar the plant, as this worm, instead of coming to the surface on being disturbed, like the common worm, will instantly recede to the centre of the ball of earth and remain there undisturbed. Mr. W. Baird speaks of a worm under the name of *Megascolex* (*Perichœta*) *diffringens*, found in three different gardens in England, in hot-stove houses, which is probably the same as the eel-worm referred to by Mr. Fish."

If, in the blatant ethics of the pot-house politician, "eternal vigilance is the price of liberty," in a sense certainly of equal importance it behooves that, even in disseminating these matters for the common good, science should dictate the method, and the economist practise the care that shall conserve the good while it separates the bad. But only of its best and noblest minds can the age exact the task of separating wisely and well its blessings and its bane.

EDITOR'S TABLE.

THE RECENT STRIKES.

THE eight-hour epidemic has at length subsided, and the working-men, having failed to accomplish their object, have generally returned to their labors under the old arrangements. The infection spread through all the leading industrial crafts: carpenters, bricklayers, cabinet-makers, upholsterers, carriage-makers, iron and metal workers, piano-makers, plumbers, sugar-refiners, gas-makers, car-drivers—one after another—were drawn into the movement. Laborers have had a trial of strength with capitalists, turning out some 80,000 strong, with much agitation and the best organization that could be rallied; yet the movement collapsed in less than three months from its outbreak. The details of the struggle it is unnecessary here to specify, as they have been extensively published by the newspaper press, but its leading results may be summed up as follows: 1. The loss of a couple of million of dollars to the mechanics concerned; 2. The consequent privation and suffering of many families; 3. The demoralization of the unemployed through idleness and exposure to vicious influences; 4. Extensive loss to capitalists and the public through the closure of manufactories, non-production, and business derangement; 5. An aggravation of hostile feeling between the employed and employers; 6. An organization of employers to resist future efforts of the same kind; 7 and lastly; the disclosure of the alarming prevalence of dangerous and destructive ideas among certain portions of the laboring-classes.

Of this last count it may be remarked that in the inflammatory harangues at public meetings it was constantly proclaimed that capitalists are the deadly enemies of the working-classes; that capital, of right, belongs to the producers who have created it; and the doctrine was avowed by some that, if the strikers could not get their own, the torch should prevent their robbers from enjoying it. Much of this intemperate talk should, no doubt, be credited to the excitement of the time, but it shows both the danger of such excitements and the sort of ideas that are simmering in the minds of many working-people.

As a partial compensation for all these mischiefs, it is hoped that something valuable has been learned from this experience. If it teaches laboring-men that this is not the way to promote their real interests, much will have been gained. The pathway to success is ever through failure, and to have tried a policy and proved its insufficiency is often the necessary preliminary to another and a better policy. That the relations of labor to capital are unsatisfactory, need not be denied; that the laboring-classes are often scantily and unjustly paid, and do not receive an equitable share of the profits resulting from the coöperation of operative and capitalist, is undoubtedly true. And the inequitable working of the present system is, in many cases, very hard to bear. There are evils to be overcome, and wrongs to be righted, but the great problem to be solved, in securing the remedy, is far from easy, and its solution is to be sought in quite another direction from that which has been lately taken. Laborers have a right to demand an advance of wages, to refuse to work if they do not get it, and to combine for the attainment of their end, but they have no right to resort to violence or measures of intimidation to carry their points. So long as strikes are peaceable, they are legitimate means of advancing the interests of labor; to what extent they are *wise*, means, time, and experience, will demonstrate. Yet we do not believe that it is by assuming and fostering enmities and widening the gulf between these two great classes, that the interests of the more numerous party are to be permanently subserved. It is not by measures of coercion or by the fiat of law that there is to be brought about a more equitable distribution of the products of capital and labor than now exists. Only as the laboring-classes become better informed in regard to the conditions of the question they have undertaken to settle—the principles it involves and the laws which govern a healthy social advancement—will they be enabled to cope with capitalists and secure a fairer division of the profits of industry. They must, first of all, accept the spirit of civilization, which is pacific, constructive, controlled by reason, and slowly ameliorating and progressive. Coercive and violent measures, which aim at great and sudden advantages, are sure to prove illusory.

The industrial classes must learn to organize more perfectly, to rely upon moral considerations, to demand only justice, and to wait patiently until by these means their ends can be accomplished. For these ends the resources of education must be invoked. There is a stir throughout all civilization for increased technical education, by which labor shall be made more intelligent and efficient. This is certainly important, but it is not enough. The elements of political economy and of social science ought to be introduced into general education, and until this is effectually done we cannot hope to be exempt from the consequences of the present ignorance upon these subjects.

THE PLACE OF SCIENCE IN THE HIGHER EDUCATION.

We return to this subject because of its extreme importance, and because it is an essential part of our legitimate work. It is not only inevitable that a periodical devoted to the popular interests of science must treat the question of its place in education and the causes which hinder its admission to that place, but this duty is made the more imperative by the fact that the newspaper press is predominantly in the interest of existing usages, and gives wide dissemination to crude and erroneous views upon the question.

The *Christian Union* takes ground upon this subject which we cannot think well considered, and which is certainly out of harmony with its character as an able expositor of the principles of sound reform. It says:

> By a singular confusion of ideas, the popular demand for "practical" education in colleges often specifies scientific studies as having peculiarly that character. In reality, while the natural sciences supply to certain classes of workers their main intellectual capital, to professional and business men they have no more of a "practical" value than Latin and Greek. We do not impugn their usefulness as part of a general education, but it does not lie in this direction. On the other hand, there is a class of studies of the highest practical utility to every American citizen, which have been greatly neglected in our higher education—those, namely, which relate to political and social science. We notice with great satisfaction the steps just taken in this direction at Yale. That university has appointed to lectureships on these branches Mr. E. L. Godkin of the *Nation*, and Mr. David A. Wells—both of them eminent examples of the application of thorough intellectual training to practical politics. A new professorship of political and social science has been filled by the appointment of the Rev. W. G. Sumner, one of the ablest among the younger graduates of the college. We trust that these gentlemen will have a space in the curriculum assigned to their de-

partments proportionate to the importance of the subject.

We fail to see the confusion alleged by the writer. There is a definite proposition which he explicitly denies. Educational reformers complain that the higher institutions in which the classical languages predominate give to our professional and business men an education that is not "practical," and they accordingly insist upon the retrenchment of these studies and the substitution of the sciences, that the higher education may become more truly "practical." This is certainly clear enough, and the antagonistic proposition of the writer is equally clear—that for the education of professional and business men the natural sciences are no more "practical" than Greek and Latin. The issue is thus sharply presented. Yet the ground taken by the writer has been long ago, and even ostentatiously, given up by the stanchest defenders of the classics. To the popular indictment that classical studies are not "practical" they have pleaded guilty, but have claimed that this alleged vice is in reality a virtue. The whole literature of that side of the question has been pervaded by a scorn of utility, and a contempt for the "practical." The dead languages have been advocated, not for their ulterior uses, but as mental gymnastics in which discipline of the faculties is the object to be obtained. It has not been denied that the sciences were "practical," but practical ends have themselves been repudiated as low, sordid, and unworthy.

Perhaps, however, the writer in the *Union* may not care what ground has been formerly taken. Is it *true*, then, that for the higher education of professional and business men the natural sciences are no more practical than Greek and Latin? By "practical" in this connection we understand that which bears upon practice, which fits for action. All are agreed that education is a calling out of human powers in preparation for something; and the term "practical," as employed by the friends of reform, is used to designate what the general character of this preparation should be. They maintain that it should have reference to the circumstances, duties, and work of life. Will it be claimed that the knowledge of two languages spoken by nations that have been extinct for many centuries, which were dead long before modern knowledge came into existence, and which have been emptied of their valuable thought over and over again by translation, confers an equal preparation for the responsibilities of practical life with that living knowledge of present things—that acquaintance with the forces and laws of the surrounding world which it is the office of science to impart? Even if the writer gives to the term "practical" as applied to education its narrowest meaning, that of a bare and specific preparation for professional and business pursuits (which is *not* the meaning given to it by educational reformers), his proposition is baseless, for there is not a profession or a business which does not involve scientific principles that must be known if they are to be "practised" intelligently. Merchant, manufacturer, agriculturist, and engineer; physician, lawyer, and clergyman—all deal with phenomena that are regulated by natural laws, and are intimately dependent upon them; and are we still to be told that a knowledge of these laws is of no more practical benefit than to be able to read a couple of antiquated languages?

With such an estimate of the educational value of scientific knowledge, it is not surprising that the writer in the *Union* throws no light upon its proper claim and place in the higher education. He admits that there are studies of the highest practical utility which have been greatly neglected—those, namely, which relate to political and social science—and is pleased that

Yale has taken steps to repair this deficiency. He says, that university has appointed two gentlemen to lectureships upon these subjects, with the following qualifications: they are "both of them eminent examples of the application of thorough intellectual training to practical politics;" and the hope is expressed that a space will be allowed in the curriculum proportionate to the importance of the subjects. We cordially concur with him in this desire, and cannot doubt that advantage will arise from the teachings of the able men selected to take the professorships; but we hold that merely to make a "place" for these studies or to engraft them on the classical stock, or to intrust their exposition to gentlemen whose qualifications are only the application of "thorough intellectual training to practical politics," is a quite inadequate preparation for the work to be done.

Social and political sciences are confessedly the most complex, obscure, and difficult of all the sciences; so much so that it is hardly yet understood what is meant by the terms, even by those who use them most freely. We have looked through the reports of the Social-Science Associations—English and American—for something like a clear definition of what social science is. This question was formally attacked, not long ago, at a convention in Boston, by men whose names are eminent in connection with the subject, but there was the most extraordinary disagreement, and a tacit confession of the impossibility of the task. The proceedings of these bodies abundantly attest this vagueness and conflict of opinion. They mainly consist of philanthropic projects and reformatory schemes for public improvement—plans for repairing the defects of society—which would be better described as social art than social science. With such loose and erroneous notions in regard to the subject itself, we are hardly to expect any clear views of its proper place in education. We have had centuries of that "thorough intellectual training," which it has been the boast of universities to give, applied to "practical politics" without so much as even discovering the existence of a social science. A higher education, which prides itself on the perfection of its mental discipline, and which sacrifices every thing else to this idea, has thrown its graduates by thousands, age after age, into political and public life to very little purpose, so far as the increase of our scientific knowledge of society is concerned; and for the obvious reason that the vaunted mental discipline has not been of a scientific character, and is therefore valueless for great scientific ends. This inquiry is, however, being worked out in a series of articles now appearing in the Popular Science Monthly. And it is well here to note that this difficult and important work is being first thoroughly done by a thinker whose intellectual training was not obtained at the university, who knows nothing of Greek and Latin, and has had very little to do with practical politics. His preparation, indeed, is such as the universities would not have afforded, and the chances are high that, if he had submitted himself to their guidance, and had his mind drilled in youth by their methods, and filled with their ideas, the great work that he is now doing would have been impossible for him. His preparation has consisted in the life-long study of science. He has mastered its various departments, and attested this mastery by original discoveries in its physical and biological branches; and, having given his whole life to these studies and obtained a knowledge of them which Mr. Mill has pronounced "encyclopædic," he has the indispensable preparation for the work of extending science in its higher and unexplored applications to social phenomena.

If there be a social science, it is because there are natural laws of society, laws of social condition, social action, and social change, and because human societies are parts of the general order of Nature; and that science must simply consist in the elucidation and exposition of these laws. So far from being of an isolated nature, which can be considered alone, social science is intimately and vitally dependent upon other sciences, and the proper preparation for it must consist in a knowledge of these, and a thorough discipline in scientific methods of thinking. The student must be steeped in science, as he is now steeped in classics. To thrust social science into the old traditional curriculum—to charge the minds of students with Latin and Greek literature, as a preparation for it—is, therefore, to say the least, irrational. Agreeing with the writer in the *Christian Union* as to the extreme importance of these studies, and the need of giving them a larger place in the collegiate scheme, we go yet further, and demand a reconstruction of the curriculum itself, and an adequate preliminary course of scientific study which shall be tributary to the end proposed.

LITERARY NOTICES.

Michael Faraday. By I. H. Gladstone, Ph. D., F. R. S. New York: Macmillan & Co.

Whatever is truly great has an interest that is inexhaustible. Again and again we return to the mountain, the cataract, the cathedral, the picture, the poem, with an ever-deepening appreciation of their influence over us. And so it is even in a more eminent degree with the grand in human character, for a human life of noble impulse and heroic achievement has also its perennial interest. We read the story as told by the skilful and sympathetic biographer, and then come back to it again fascinated by the majesty and the mystery of a powerful personality. Michael Faraday was a man of this heroic type, great among his countrymen, illustrious in humanity. Prof. Tyndall has given us a vivid portraiture of him as a man of science and a discoverer; Dr. Bence Jones, in two elaborate volumes, has displayed to us his inner life as illustrated in his private correspondence; and now Dr. Gladstone, in the neat little volume before us, has again told the wonderful story in a fresh and fascinating way. Drawing freely upon the works of Professors Tyndall and Jones, adding new information from various sources, among which are his own reminiscences, he has make a book that needed to be made and which is a model of its kind—clear, simple, discriminating, and appreciative. It first gives us the "Story of his Life," next the "Study of his Character," then the "Fruits of his Experience," again, his "Method of Working," and finally the "Value of his Discoveries."

We have no space here to give a sketch of Faraday's life—his humble birth and the little education he got in early boyhood at a common day-school—his first occupation as an errand-boy—his apprenticeship to a book-binder—his thirst for knowledge and how he commenced his scientific education by reading the books that were given him to bind—his passion for experimenting—his application to Sir Humphrey Davy for a chance to devote himself to science—his entrance to the Royal Institution, which was to be the theatre of his career—his rapid ascent to an eminent place among *savants* and philosophers—his rejection of wealth and titles, and his brilliant career as a discoverer, which was crowned by honors showered upon him by the learned societies of all nations—for the account of these things the reader is referred to the pages of Dr. Gladstone's book. But we cannot forbear quoting a few passages illustrative of Dr. Faraday's character. The author says:

> As a source of success there stands out also his enthusiasm. A new fact seemed to charge him with an energy that gleamed from his eyes and quivered through his limbs, and, as by induction, charged for the time those in his presence with the same vigor of interest. Plücker, of Bonn, was showing him one day, in the laboratory at Albermarle Street, his experiments on the action of a magnet on the electric discharge in vacuum-tubes. Faraday danced round them; and, as he saw the moving arches of light, he cried, "Oh! to live always in it!" Mr. James Heywood once met him in the thick of a tremendous storm at Eastbourne,

rubbing his hands with delight because he had been fortunate enough to see the lightning strike the church-tower.

This perseverance in a noble strife was another of the grand elements in his success. His tenacity of purpose showed itself equally in little and in great things. Arranging some apparatus one day with a philosophical-instrument maker, he let fall on the floor a small piece of glass: he made several ineffectual attempts to pick it up. "Never mind," said his companion, "it is not worth the trouble." "Well, but, Murray, I don't like to be beaten by any thing that I have once tried to do."

This faithful discharge of duty, this almost intuitive insight into natural phenomena, and this persevering enthusiasm in the pursuit of truth, might alone have secured a great position in the scientific world, but they alone could never have won for him that large inheritance of respect and love. His contemporaries might have gazed upon him with an interest and admiration akin to that with which he watched a thunder-storm; but who feels his affections drawn out toward a mere intellectual Jupiter? We must look deeper into his character to understand this. There is a law well recognized in the science of light and heat, that a body can absorb only the same sort of rays which it is capable of emitting. Just so it is in the moral world. The respect and love of his generation were given to Faraday because his own nature was full of love and respect for others.

Each of these qualities—his respect for and love to others, or, more generally, his reverence and kindliness—deserves careful examination.

Throughout his life, Michael Faraday appeared as though standing in a reverential attitude toward Nature, Man, and God—toward Nature, for he regarded the universe as a vast congeries of facts which would not bend to human theories. Speaking of his own early life, he says: "I was a very lively, imaginative person, and could believe in the 'Arabian Nights' as easily as in the 'Encyclopædia;' but facts were important to me, and saved me. I could trust a fact, and always cross-examined an assertion." He was, indeed, a true disciple of that philosophy which says: "Man, who is the servant and interpreter of Nature, can act and understand no further than he has, either in operation or contemplation, observed of the method and order of Nature." And, verily, Nature admitted her servant into her secret chambers, and showed him marvels to interpret to his fellow-men more wonderful and beautiful than the phantasmagoria of Eastern romance.

His reverence toward Man showed itself in the respect he uniformly paid to others and to himself. Thoroughly genuine and simple-hearted himself, he was wont to credit his fellow-men with high motives and good reasons. This was rather uncomfortable when one was conscious of no such merit, and I, at least, have felt ashamed, in his presence, of the poor, commonplace grounds of my words and actions. To be in his company was, in fact, a moral tonic. As he had learned the difficult art of honoring all men, he was not likely to run after those whom the world counted great. "We must get Garibaldi to come some Friday evening," said a member of the Institution, during the visit of the Italian hero to London. "Well, if Garibaldi thinks he can learn any thing from us, we shall be happy to see him," was Faraday's reply. This nobility of regard not only preserved him from envying the success of other explorers in the same field, but led him heartily to rejoice with them in their discoveries.

Healthy Houses: A Hand-Book of the History, Defects, and Remedies of Drainage, Ventilation, and Warming. With upward of Three Hundred Illustrations. By William Eassie, C. E.

This is an excellent little manual on sanitary science, intended, as the author observes, to be a record of facts—of acquired experiences and published inventions in relation to house-construction. It is both scientific and practical, the science being universal, and the practice English. But, from an hygienic point of view, the subject of house-construction is much the same in given latitudes. Human life and its conditions being everywhere similar wherever the largest number are "to be fed, housed, educated, amused, enriched, and all in the smallest possible space," which is Mr. Eassie's ideal of a dwelling, the same questions must constantly arise, the same dangers are to be avoided, and the same advantages secured. The author has compressed an enormous amount of valuable information on the subject of sanitary construction within very narrow limits, and his book is written in an unusually compressed and pithy style. He gives descriptions of the best contrivances in use for attaining salubrity in all parts of the dwelling, and furnishes the reader with exact estimates of their cost. His book, indeed, is a condensed report upon the present state of art and science in England as applied to the utilities of household arrangement and construction. The following passage, describing a faulty English residence, illustrates the author's appreciation of the practical detail of his subject:

A residence in which unhealthiness reaches about its maximum may be said to be one which is built on a damp site, with higher ground behind, pouring down its waters against walls without areas—walls innocent of a damp-proof course to arrest the rising wet—and walls, likely enough, also exposed, by insufficient thickness, to driving rains. It may be in the neighborhood of low-lying fields, undug, unditched, undrained, or with the tiles long since choked up. The rooms throughout are low, with a haphazard ventilation, insufficiently furnished with windows, and with perhaps too many doors. The main staircase is without a lantern-vent, or the wall there is pierced by a window not sufficiently high to empty the gasometer overhead. As for the back-stairs, the basement-smells climb them *en route* for the dormitories. The chimney-flues are also badly constructed, and a smoky atmosphere is all but constant. Overcrowding lends its quota of evils—as press-beds in every available corner testify. The drain-pipes are injudiciously laid inside instead of outside the basement, with leaky joints, owing to indifferent luting, and with pipes broken where they pass through the walls, owing to continuous settlement. A foul soakage of the soil around the unpuddled pipes speedily follows. The lead-work is also defective, dishonestly executed with thinnest material, badly junctioned to the drains; or, if once properly performed, the maintenance of that state of things is neglected from ignorance or parsimony. The water-pipes, too, are all built in the brick-work, or buried deep in plaster, a burst pipe soon causing the walls to resemble a huge sheet of wet blotting-paper. As for the sinks, they are far too numerous, and made to perform improper services. The scullery-traps have long ago lost their gratings, and are filled up with grease or other refuse. Up-stairs the waste-pipe of the lavatory and of the bath are connected direct with the sewer. There is, moreover, only one cistern for the multitudinous necessities of a family. The closets, supplied from this same cistern, stand directly in the passage, and have only one door; the apparatus is faulty, and the hidden soil-pipe is somewhere imperfect. Ventilation of the drains there was originally none, and none is contemplated; the accumulated gases, therefore, take the water-trap by storm, and invade the atmosphere of the house. Even the flushing of the too flatly laid house-drains is unattended to, or left to the periodical downfall of rain through the rain-water pipes, which only serves to stir up the nuisances, not carry them resistlessly away.

The Lens: A Quarterly Journal of Microscopy and the Allied Natural Sciences. Edited by S. A. Briggs, Chicago.

This elegant periodical, a credit alike to science and to Chicago, has now reached its third number, which comes filled with interesting and valuable articles. It is published by the State Microscopical Society of Illinois—a significant fact, as indicating an extending taste for nice and critical observation. The use of the microscope combines elegant and refined recreation with serious and solid scientific work, and we are glad to see these evidences of its increasing appreciation. For a long time the microscope was but a plaything, and the share it was to take in the development of knowledge was little suspected. Even so late as 1839, according to Mr. Lewes, Magendie denied that it could be of any use in physiology. But, since then, it may almost be said that it has given us a new physiology, while it has become perfectly indispensable in intelligent medical practice, and is in constant requisition in nearly every department of science. It is important, therefore, that we should have a periodical especially devoted to the interests of the instrument, its results, and the numerous subjects which are dependent upon its application. *The Lens* promises to supply this need. Its papers are varied and able, and the illustrations excellent. We cordially wish it the success it deserves.

Dr. H. Charlton Bastian's long-expected work, "The Beginnings of Life," is now completed, and will be speedily published in two volumes. Dr. Bastian is the leading "representative of the doctrine" popularly known as spontaneous generation, and this work will contain the results of his extensive experimental investigations concerning it. His treatise, however, goes much further than this, and is, in fact, a broad discussion of philosophical biology—a cyclopædia of facts, theories, processes, and conclusions respecting the origin of the simpler forms of life. He works the subject from the *a priori* and rational point of view, as well as from that of positive and rigorous experiment. He claims to have established directly, by observations that may be verified, that matter passes from the non-living to the living state, and he aims furthermore to show that this fact is consonant with the whole scheme of Nature's working. His preliminary chapters on the correlation of the vital and physical forces, on the nature and theories of life, on organized and organizable matter, on the relations of the animal, vegetable, and mineral kingdoms, and on cell-phenomena and cell-doctrines, form the clearest and most readable exposition of these subjects that we have yet seen, and they have a value quite independent of the special inquiry to which they are an introduction.

Geological Survey of Ohio. Report of Progress in 1870, by J. S. Newberry, Chief Geologist, including Reports by the Assistant Geologists, Chemists, and Local Assistants. (Columbus: Nevin & Myers, State Printers, 1871, pp. 568.)

The labors of Prof. Newberry and his colleagues during the year 1870 have resulted in the accumulation of a great many details relating chiefly to the structure of that portion of the great Appalachian coal-field which extends over a considerable part of Ohio. Without the aid of a good map it is somewhat difficult to follow the descriptions given in this report, the numerous local references and details having a tendency to bewilder the reader. This, however, is unavoidable under the circumstances; and those who desire to obtain a full and clear conception of the geological structure of Ohio will have to wait the completion of the map and final report promised by Dr. Newberry, the present volume not pretending to be more than its title implies. Nevertheless, it contains a very large and varied amount of information, which will, no doubt, be duly appreciated by those for whom it has been prepared. Especially noteworthy are the numerous illustrative sections of Carboniferous strata, and analyses of coals, iron-stones, fire-clays, and soils, as also two ably-written sketches, "On the Present State of the Manufacture of Iron in Great Britain," and "On the State of the Steel Industry," both of which will repay perusal by those who are interested in these matters.

Scattered through the purely geological portion of the report are many points of interest, which arrest attention as one glances over the pages. Thus we are told that "at Zaleski, in mining the Nelsenville coal, a fine bowlder of gray quartzite was found half embedded in the coal, and the other half in the overlying shale. The quartzite is very hard, and the bowlder was rounded and worn by friction before it came to the coal." It measured 17 in. by 12 in., and had adhering to it in places bits of coal and black slate which showed a slicken-sided surface. The stone appeared to have settled into the coal when the latter was in a soft state. Prof. Newberry speculates with diffidence on the possibility of the bowlder having been "brought down by river-ice from some higher and older part of the old continent, which was skirted by the coal-producing lowlands." In connection with this, it is somewhat interesting to find that a local deposit of quartz conglomerate occurs here and there underneath and skirting the coal-strata, and is believed by Dr. Newberry to represent an old beach of the period. From some such gravel and shingle deposit the bowlder may have been transported, but whether by means of ice, water-plant, or land-plant, who shall tell?

Another exceedingly interesting and readable portion of the Report is the "Agricultural Survey," by Mr. J. H. Klippart, in which the writer discusses, among other subjects (such as prairies, forests, etc.), the origin of the soils in certain districts of the State. Those geologists who believe in the former existence, during the Glacial epoch, of mild interglacial periods, will find much here to support their opinion. We are told that the succession of the drift-materials, beginning with the oldest, is as follows:

a. Glacial drift.
b. Erie clays.
c. Forest-bed.
d. Iceberg-drift.
e. Alluvium.
f. Peat, calcareous tufa, shell-marl.

The oldest deposit is believed to be the product of land-ice, and the presence of the Erie clays betokens that, after the disappearance of the great glaciers, wide sheets of fresh water overspread some districts of the State. The forest-bed (cousisting of roots, trunks, branches, and leaves of such trees as sycamore, beech, hickory, and red cedar) shows that by-and-by the fresh-water basins were in some places filled up, and the new soil eovered with an abundant forest-growth. After this came a period of depression, when great deposits of gravel and sand gathered over the surface of the drowued laud, and large bowlders and erraties were floated by ice from the north.

These and other matters of interest and importance will, no doubt, be fully treated of in the final report, which is to consist of four volumes, the first two being devoted to the geology and paleontology of the State, the third to its economic geology, and the fourth to its agriculture, botany, and zoology. A large collection of fossils has been made, many species being new to science. It is to be hoped that the good people of Ohio will not grudge the money that will be required for the adequate representation and description of these remains, but that, when published, the final report will be found in every way as complete as those admirable works which have been issued by other States of the Union. Prof. Newberry seems to have little doubt that it will be so, for he thinks that the value and significance of fossils are coming to be generally appreciated. "There are, however," he says, "yet some intelligent men, even editors and members of Legislatures, who cherish the notion that there is nothing which has any value in this world but that thing which has a dollar in it, and that so plainly visible as to be seen by them. Such men, to quote the language of one of them, 'don't care a row of pins for your clams and salamanders, but want something practical.'" This "practical" man must surely have been related to that colonial official who is said to have objected strongly to the expense of "engraved portraits of extinct bugs and beetles," as he irreverently styled certain Silurian fossils. But the day of such wiseacres has gone past, and it may be confidently expected that Dr. Newberry and his colleagues will have no difficulty in getting the necessary funds voted for the completion of their important survey.—*Nature.*

MISCELLANY.

Experiments on the Solar Spectrum.—Some experiments recently published by Dr. John W. Draper, of the New York University, on the heat of different portions of the solar spectrum, will ehange, in several important particulars, the views hitherto held on that subject.

Until now, it has been supposed that the heat of the spectrum is greatest below the red region, and that it gradually declines as the thermometer passes through the orange, yellow, green, blue, indigo, and violet, successively.

Dr. Draper shows that, while this is true as a matter of observation, the general conclusion drawn from it is altogether incorrect. In the prismatic spectrum the red and less refrangible colors are compressed together, the violet and more refrangible are expanded. This distortion is necessarily due to the action of the prism itself. But, in the diffractive spectrum, formed by lines drawn with the point of a diamond on glass, the arrangement of the colors is altogether different; they are placed according to their wave-lengths.

Dr. Draper proves that, for the correct solution of this problem of the distribution of heat, the visible spectrum *alone* should be employed, the ultra-red and ultra-violet invisible rays being removed. He next finds the centre of the visible spectrum, proving that it is a little beyond the sodium-line D. He then, by the aid of a silver mirror, collects all the less refrangible rays up to this centre into one focus, and all the more refrangible rays from this centre into another focus, and measures the heat of each. On the received view, the former of these foci should contain nearly all the heat, the latter little or none. In several hundred experiments in which exact measures have been made, it turns out that the heat is the same in both.

From this, some very remarkable results follow. Among them we may mention, that all the rays of the spectrum, irrespective of their color or wave-length, have equal heating-power; and that, in fact, the heat manifested in any part of the spectrum is due to the stoppage of the motion of the rays—their extinction. It is the transmutation of motion into heat.

Extensive Conglomerate Formation on Long Island.—A short distance northeast of the village of Farmingdale, on Long Island, there is an extensive formation of ferruginous conglomerate, of much geological interest, and considerable economic value. It is found in the level sandy tract which extends from near Farmingdale to some fifty miles eastward. Over this tract stones larger than good-sized pebbles are exceedingly scarce. In digging wells, it is found that pebbles and sand occur in layers, at all depths yet penetrated. The conglomerate consists simply of these sandy and gravelly layers, hardened into a compact, brown-colored mass, which can be blasted out in blocks, and which answer a very good purpose for the foundations of buildings. The thickness of the formation is thought to be about 12 feet. The rock appears to grow harder on exposure, and some specimens give out a clear, ringing sound when struck with a hammer. The sand-grains which enter into its composition are of a brown color throughout, while the pebbles are only colored externally. Compounds of iron are associated with the mass, and the waters of the district are also largely ferruginous, whence it is suggested that the formation may be due to a kind of cementing action exerted by the iron, left by the waters that have percolated through the sands.

Were the Ancient Italians Cannibals?—A somewhat remarkable discovery of human and animal remains is announced by Prof. Capellini, of Bologna, in a grotto in the island of Palmeria, the access to which is difficult and dangerous. Here he caused excavations to be made, and the result was the discovery of numerous flint and stone implements, the workmanship of which showed that they belonged to the earliest period of the stone age. Besides these wrought implements and various other objects brought into the cavern by its human occupants, he found a considerable quantity of bones of animals mingled with bones of human beings. The condition of these latter bones, he says, "would justify the inference that the grotto had been inhabited by anthropophagi, and that the Italians of that epoch were cannibals, like their contemporaries in Belgium, France, and Denmark."

"Among the human bones were found those of women, and part of the jawbone of a child some seven or eight years of age. Some of these bones were entire, others were partially calcined. In the centre of the cave it was possible to discern traces of a fireplace. Prof. Capellini says: 'Whoever has busied himself in prehistoric researches, whoever has read Spring's excellent work on the Chauvaux cavern in Belgium, and the writings of other authors on the subject of the caverns in France, will not hesitate to admit that the discoveries in the island of Palmeria prove that the Italians were, as I have said, man-eaters. For the present it will be sufficient for me to direct the attention of naturalists to the subject. The Cyclopians spoken of in the fable were probably these cannibals.'"

Coal-Lands of the Rocky Mountains.—According to "Hayden's Reports," which abound with useful information concerning the new Territories of the West, the coal-deposits of the Rocky Mountains far exceed any thing that had been hitherto suspected. Early travellers, as Lewis and Clarke, in 1800; Colonel Fremont, in 1842; Captain Stansbury, in his visit to Salt Lake, and others, had reported outcrops of coal on the slopes of these mountains, but probably none were aware either of its abundance, or the extent of country over which it is spread. Coal is found at different points in the Rocky-Mountain region over an area of some 250,000 square miles in extent, in strata which in some places are from five to thirty-five feet in thickness. Outcrops have been followed on the east flank of the mountains for more than 500 miles north and south; and if, as Hayden suggests, these are fragments of one great basin, broken only by mountain upheavals, or covered by later deposits, then the distance from east to west may be as much as 500 miles, or from the "Black Hills" to "Weber Cañon." If the coal-strata were ever continuous over this vast area, the subsequent formation of mountains and valleys would leave them broken and disconnected, as they are now found to be.

Yet it is the opinion of explorers, that here, as elsewhere, the deposits are in minor basins, united perhaps in places, but, as a rule, constituting separate beds, over a vast area of depression. Hayden says there is good reason to suppose that this area "extended northward far into Canada, and southward with the Cordilleras;" a supposition that, if true, would give an extent of coal-lands, in this section of the continent, much greater even than that just mentioned.

The Rocky-Mountain deposits are regarded as belonging to a much later geological age than those of Pennsylvania or of Rhode Island. While the latter belong to the Carboniferous age, the former are found chiefly in the upper Cretaceous or Chalk period, or in the so-called Tertiary; which brings the period of the Western coals nearly down to the latest geological ages.

The value of the Rocky-Mountain coals is unquestioned. From various analyses, it appears, that their volatile constituents reach about 38 per cent., while the amount of fixed carbon is estimated at about 50 per cent. Pennsylvania anthracite is much richer in fixed carbon, but the coals of Iowa, as well as some Scotch and English varieties, are considerably poorer in this respect. But, apart from their fixed value as sources of heat, the coals of this region derive an additional importance that can hardly be over-estimated, from their geographical position. In a country without timber, and far removed from other sources of fuel, they supply the first requirement for the development of its resources, and have already become the object of an extensive and thriving industry.

Lessons from a Brick.—An Austrian *savant* has discovered, by means of a microscope, in a brick taken from the pyramid of Dashour, many interesting particulars connected with the life of the ancient Egyptians. The brick itself is made of mud of the Nile, chopped straw, and sand, thus confirming what the Bible and Herodotus had handed down to us as the Egyptian method of brick-making. Besides these materials, the microscope has brought other things to light—the *débris* of river-shells, of fish, and of insects, seeds of wild and cultivated flowers, corn and barley, the field-pea, and the common flax, cultivated probably both for food and textile purposes, and the radish, with many others known to science. There were also manufactured products, such as fragments of tiles and pottery, and even small pieces of string made of flax and sheep's wool.

Zoology of the Galapagos.—A correspondent of the *Tribune*, accompanying the Hassler expedition, gives an interesting account of the animals observed in the Galapagos Islands. He says:

Over 50 different kinds of fishes were obtained, and of these over three-fourths are peculiar to the Galapagos. Of the Galapos, from which the islands are named, and in which they once so richly abounded, we only got a few specimens, and those very small compared with those of olden time. They have been so eagerly hunted for their flesh that they have been driven from the more accessible places, and stand a good chance of being altogether exterminated. Their brethren in the sea, the tortuga or sea-turtle, we saw in abundance, and got some very fine specimens. There are, as is tolerably well known, two other reptiles for which this archipelago is famous—two lizards, of a genus not found elsewhere, and very peculiar in their habits. The Spaniards called them iguanas, from their resemblance to that reptile in the West Indies and Central America. But they differ so much from their American cousin that they ought to have a name of their own, and if the scientific Amblyrhynehus looks too formidable, let us translate it and call the creature a Bluntnose. On Charles Island we found abundance of the crested Bluntnose climbing with great agility over the roeks near Black Beach. The creature is about 30 inches long, nearly black, the old males having a deep-red hue on the sides. It swims with great ease by its flat tail, and uses its long fingers and long nails for scrambling on the rocks, holding them, while swimming, close to the body. There is not a trace of web-footedness about them, and they make no use of the feet iu swimming. They live on sea-weeds from the rocks in deep water, and their expression is mild and herbivorous, with a little clear, innocent eye. I was prepared for something hideous, and was agreeably disappointed. In another respect our experience differed from Darwin's, for we sometimes had no difficulty in frightening them into the water, and they came fearlessly swimming about the Hassler as she lay in Tagus Cove. These crested Bluntnoses we found upon all the islands. The slightly-crested Bluntnose we found only on Albemarle and Indefatigable.

Its scientific name might mislead one, for its head is just as much crested as its aquatic brother's. The only differences between them, apparent at first sight, are these: The terrestrial animal is somewhat stouter, his nose is longer, his eye brighter, his tail less flattened and less crested, and his color is a dusky orange, deepening into brown on the hind-quarters. His habits of life are very different, as he does not go near the sea, but lives upon land-plants, and makes a burrow for himself in the sand and among the fragments of lava. He spreads his hind-legs flat on the ground, raises his chest to the height of his fore-legs, and then nods and winks at you in a very odd way. It looked to me very much like swallowing, and I thought it possible that the creature, with his head in that position, swallowed air like a toad, as a means of breathing—swallowing into the lungs, not into the stomach.

One of our most interesting adventures was landing in a little bay full of seals, so tame, or rather so little afraid of men, that we could tramp past groups of sleepers on the beach without awakening half of them, and without apparently frightening half of those that we did awake. They seemed to be fond of crawling under bushes just above high-water mark, and sleeping, two or three in a place, huddled close together. Under one bush lay a mother and her two cubs, so fearless that one of our officers held a piece of cracker to the old one, and she smelled it in his fingers as fearlessly as if she had been a pet dog. The cubs quarrelled with each other as to which should cuddle nearest the mother, and they all three snarled and snapped at the flies in the manner of a sleepy dog, and all this while a party of ladies and gentlemen, creatures as large as the seals, and which the seals could scarce have seen before, stood looking on within touching distance. These seals had much more length of arm, and used their arms more in the manner of a quadruped, than I had supposed any seal could do. I saw them walk on the beach with the whole chest clear of the ground, and even jump upon the sand. Their favorite gymnastic exercise, however, was to lie upon their backs and roll, in the manner of a horse. The tameness of these seals and of many of the land-birds was very surprising; the Bluntnoses were more shy than we had expected. I repeatedly put my fingers within half an inch of little yellow-birds and phœbes, and within six inches of mocking-birds. On James Island the birds were so numerous and so tame that, while I was trying the experiment whether whistling to a yellow-bird would divert his attention so much as to make him allow me to touch him, six other birds—including two mocking-birds—came up and alighted on twigs within two yards of the yellow-bird to see what was going on between us. As for the flies, their tameness and pertinacity of adhesion, at the Galapagos, goes far beyond all travellers' accounts. I knew a good house-keeper in New England who affirmed that house-flies could not be driven out of a room unless you struck and killed one or two, in order to show the others that you were in earnest. You cannot drive the Galapagos flies from you even with that expedient. The birds and seals are not frightened by being stoned or shot; they don't know what stones and guns mean, and the flies are not frightened or discouraged by having any amount of their comrades killed. When a boat was coming off-shore, the usual occupation, in order to prevent carrying the nuisances on ship, was for everybody to be picking the flies off themselves (almost as they would burrs), killing them, and throwing them into the water, from the time of leaving the beach to the arrival on the deck of the ship; and the last fly slaughtered before you go into the cabin is no more afraid of you than the first one you slew at the beach. They are not all biting flies; we have escaped trouble from mosquitoes and biting flies during the whole voyage, but they are crawling, tickling, adhesive, tantalizing creatures. It was pleasant to find here at the Galapagos a species of penguin, smaller and more sober in dress than our old friends of the Straits of Magellan, but with the same winning, cunning manners that made the birds in the Straits such favorites with our party. And, while speaking of the birds of these islands, I would not forget the splendid flamingoes, six feet high, of which we got many fine specimens. They sailed about in parties of 12 or 20 birds together, making long lines of scarlet flame floating through the air. We tried their flesh on the table, and found it the most delicious game, fully equal to the canvas-back, as it seemed to us. The archipelago offers at present a fine opportunity for a naturalist, who desires to make a residence here for several years, and thoroughly explore their structure, and their productions, to throw a strong light upon the great modern question of the origin of species, and the doctrines of evolution. Younger than Juan Fernandez, purely volcanic, bringing no seeds with them from the bottom of the sea, not having had time to alter and amend species introduced from the main-land, how did these islands come in possession of their peculiarly-organized beings—their Bluntnoses, for example? This was the question constantly recurring to me during my visit to the Galapagos, as it had been at Juan Fernandez. Prof. Agassiz gave us a little talk one day on our way to Panama, and discussed the same point. Expressing his warm admiration for Darwin's moral and intellectual character, and earlier scientific labors, he said that he considered his present influence on science very pernicious as favoring the habit of "filling up the wide gaps of knowledge by inaccurate and superficial hypotheses." What we need, in order to extend our knowledge of the origin of species, is not hypothesis and speculation, but a careful collation of facts, and a careful extension of our observation of facts. The hypothesis that the differences of species were produced by variations taking place in unlimited, in indefinitely long periods of time, is, at all events, strongly negatived by this occurrence of such marked peculiarities of difference from the surrounding world, in an archipelago that belongs wholly to the present geological epoch, and has not existed an indefinite time.

The Bore of cutting Leaves.—A correspondent of the *Scientific American* thus complains to its managers: "*You do not cut your paper;* you compel us, the 50,000, each to cut his own! You have this day robbed me of five minutes precious time in cutting your paper, and the 50,000 each of five minutes! This would make about 520 days of the popular eight-hour kind. Suppose it reached a year or half a year of our most inestimable time; by machinery you could cut the whole edition for $25. Can you excuse yourself? Can all the slovenly publishers of books, periodicals, and newspapers furnish any sort of apology for this wasting of priceless time, amounting to some hundreds of times your own culpability? Why, *Harper's Monthly* has just cost me thirteen minutes, worth to me twice the price of the magazine! What! 100 years or 500 years of human labor wasted weekly in cutting the leaves of your paper, when a few dollars' worth of work by machinery would do it greatly better, and keep your papers and books neat, genteel, and durable! Shame on your whole fraternity!"

Curious Effects of a Brain-Injury.—The recent legal contest over the will of Davis B. Lawler, of Cincinnati, involved many interesting medical and psychological questions. Mr. Lawler died at eighty-two, without issue, leaving an estate valued at $500,000. The question arose concerning his mental state at the time when certain codicils were added to his will, which gave the bulk of his property to the German relatives of his deceased wife.

In October, 1867, nearly two years before his death, Mr. Lawler had a severe fall and concussion of the brain, which was followed by loss of memory of written language, and the codicils in question were made about a month after the accident. His physician, who saw him first six months after the fall, says that he ascertained definitely on his first visit that Mr. Lawler could see printed characters, but that they conveyed no ideas to his mind. The large head-lines of the newspaper, the *Cincinnati Gazette*, he could not read, though he saw them perfectly. He could write his name, and yet could not tell whether what he had written was or was not his name. He could write directions about his business, but could not read the writing though it was plain enough to others. The sight of written or printed characters failed to be converted into ideas, while his power to make them seemed to imply the possession of such ideas. But such writing as he did was shown to have been done automatically. It is well known that many acts, at first acquired with great labor, by endless repetition come to be performed without will and even without consciousness. Piano-playing, dressing, winding a watch, are acts of this nature, and signing one's name may be classed with them. Herbert Spencer says: "The actions we call rational are, by long-continued repetition, rendered automatic and instinctive." He further says: "In short, many, if not most of our daily actions (actions every step of which was originally preceded by a consciousness of consequences, and was therefore rational), have, by perpetual repetition, been rendered more or less automatic. The requisite impressions being made on us, the appropriate movements follow without memory, reason, or volition coming into play." Maudsley holds that, "when an idea or mental state has been completely organized, it is revived without consciousness and takes its part automatically in our mental operations, just as an habitual movement does in our bodily activity." And again: "As it is with memory, so it is with volition, which is a physiological function of the supreme centres, and which, like memory, becomes more unconscious and automatic the more completely it is organized by repeated practice."

After his death, there was found in the brain of Mr. Lawler a globular calcareous mass half an inch in transverse diameter, so wedged into its substance as to obstruct the backward flow of the blood. There were indications that this mass had occupied a different position, and was dislodged at the time of his fall. This case confirms the growing opinion that the faculty of language is associated with the left hemisphere of the brain, and demonstrates, as far as one case can, that the posterior lobe takes part in the operations of speech and written language.

Ascent of Mount Seward.—This mountain is, with the numerous lesser peaks connected with it, the most westerly of the Adirondack range in New York. The ascent in company with a guide has recently been made, and its barometrical measurement taken by Verplanck Colvin, Esq. The ascent took two days and a part of a third. The barometric observations were laid before Prof. Hough, of the Dudley Observatory, who made the computations, and gave as the result an altitude of 4,462 feet. Mr. Colvin speaks of the wanton waste by fire of the woods, and the consequent diminution of the rivers, and recommends to the State government the creation of an *Adirondack park*, or *timber preserve*, suggesting that the officers necessary for its care might be supported by a *per-capita* tax upon sportsmen, artists, and tourists — a tax which he says they would willingly pay if the game should be protected from unlawful slaughter, and the grand primeval forest be saved from ruthless desolation.

A Four-legged Fish.—The members of the Australian Eclipse Expedition, if they were unsuccessful in the primary object of their voyage, saw some strange things along the shores to the north of the great Continent of Australia. Mr. Foord tells a wonderful story, "amply attested by witnesses," of a fish with four hands. This extraordinary creature was found crawling on a piece of coral dredged up from the bottom of the sea. "The body was that of a fish," says Mr. Foord, before the Royal Society on January 22d, "but, wonderful to relate, it had in the place of fins four legs, terminated by what you might call hands, by means of which it made its way rapidly over the coral reef. When placed on the skylight of the steamer, the fish stood up on its legs, a sight to behold. It was small, and something like a lizard, but with the body of a fish." It is to be hoped that a full and scientific description of this latest marvel of deep-sea dredging may soon be published, as the specimen appears to have been brought back to Melbourne. Mr. White, too, of the same expedition, tells strange tales about the rats. "The little island," he said, "upon which we pitched our tent was overrun with them, and what was most extraordinary, they were of every color, from black to yellow, and some tortoise-shell."—*Nature.*

Fungi in Cow's-Milk.—On this subject, Prof. Law, of Cornell University, makes a communication to *The Lens* for July. He says the presence of living organisms in milk has been recognized by various observers. In milk of an abnormally blue color, cryptogams and swarms of infusoria have been noticed, and kindred objects have been seen in milk of a yellow and greenish tint. Dr. Percy's "Report to the New York Academy of Medicine, in 1858, 'On Swill Milk,' shows the presence of spores in such milk when drawn, and the growth of mycelium within twenty-four hours thereafter, though the liquid had stood in a well-corked bottle in the interval. This report shows, further, the tendency of such milk to induce severe and even fatal disorders of the digestive organs of infants, fed upon it exclusively in its fresh condition." Prof. Law examined some specimens of milk, two of which, after twelve hours' exposure, being "placed under the microscope, showed an abnormal adhesiveness of the oil-globules, which had accumulated in dense masses instead of remaining apart as in healthy milk. Intermixed with the globules were dark-colored, spherical bodies of a much larger size, 'spores,' and filaments. Upon examination of the water drunk by the cows, it was found to contain numerous spores of low forms of vegetable life. The cows yielding the morbid milk appeared in health so far as appetite, rumination, pulse, breathing, and state of skin were con cerned, but the temperature was higher than usual, and, on a microscopical examination of the blood, it was found to contain certain ovoid bodies of at least double the size of the ordinary blood-globules. Upon withholding the water, the impurity of the milk at once disappeared." Prof. Law says: "The chain of evidence now appeared complete. The water contained vegetable spores, which developed into a luxuriant growth of mycelium when allowed to stand, or when added to milk of known purity. The presence of similar germs in the blood was demonstrated, by microscopical examination, by the further development of the cryptogam when the blood was allowed to stand, and by the appearance of the same product in milk to which a drop of this blood had been added. The constitutional effect of its presence was slight, being manifested by a rise of temperature not exceeding 2° Fahr. The germs in question were present in the milk, and grew with great rapidity in this medium. Lastly, the disuse of the contaminated water and the administration of sulphites put an end to the affection."

Preservation of Meat.—Of the vacuum-process for the preservation of meats the *Food Journal* says:

Taking the various methods as a whole, there seems to be as yet nothing better than the vacuum-process, and it is to the results of our examination of a set of samples of meat preserved by a new modification of this plan to which we desire to direct attention. These specimens have been transmitted to us by Mr. Richard Jones, and were preserved under his vacuum-method by Messrs. Forbes & Co., of London and Aberdeen. By Mr. Jones's process, the meat is put into tins and entirely soldered up, except a small tube, which is about the size of a quill, and is soldered into the top of the tin. This tube is placed in connection with a vacuum-chamber, and the air exhausted. The cooking is then commenced, and, without entering into details, we have simply to say the principle involved is, the production of a vacuum before beginning to cook, and the maintaining of the same during the time that the operation is in progress. The special feature claimed for the system is, that "poultry, game, fish, and whole joints of beef and mutton, can be as readily preserved with as without bone—so obviating the hitherto unsatisfactory appearance of preserved meat." Having thus given the *rationale* of the process, we will proceed to the results of the examination of samples.

No. 1 was a roasted sirloin of beef preserved entire. Before opening the package, the tin was observed to have the battered appearance produced by the external pressure of the air, which is always indicative of a perfect vacuum in such tins, and without which no package of preserved meat should ever find a purchaser. On opening, the meat was found to be devoid of the usual shrivelled appearance, and, in fact, presented the characteristics of a joint of meat cooked the day before, and served cold in any ordinary household. Upon cutting into the joint there was no appearance of overcooking and stringiness; it came off in good slices, and was even somewhat ruddy in the centre. It was remarked by our friends who were present at the trial, that the flavor was not at all like the common tinned beef. A portion from the inner part of the joint was cut off for analysis, with the following result:

Water	69.337
Muscular fibre, coagulated albumen, etc.	17.653
Soluble organic salts	2.790
Fat	6.710
Mineral matter	3.510
	100.000

No. 2 was a partridge roasted whole, which presented no trace of a shrivelled or discolored appearance, and stood carving in the ordinary way without tearing into shreds. The flavor was exceedingly fresh and agreeable; the only objection made to it by some of the party was, that it was not sufficiently "high" for their palates.

No. 3 was a section of cod boiled in one piece. This was an exceedingly happy specimen of food preservation. It was so firm in consistence, and so perfect in flavor, that no one would have imagined that it had not been cooked the same morning. It possessed, as one of the company remarked, that peculiar liveliness of flavor which cold fish only retains for a limited period after cooking.

It was not thought necessary to submit either the game or fish to analysis.

Looking to the results of our experiments, we cannot but think that the method of preservation in tins has at last reached perfection in this process, for the development of which we were informed that a company has recently been formed with every prospect of success. When it gets into working-order, there is little doubt but that this meat will head the market until such time as some happy inventors can produce a reliable plan of importing raw meat from our colonies in a sound state.

Scientific Associations.—The twenty-first annual meeting of the American Association for the Advancement of Science will be held at Dubuque, Iowa, commencing Wednesday, August 21st, at 10 o'clock A. M. On the evening of the same day a formal reception will be extended to the Association by United States Senator Wm. B. Allison, of the reception committee; after a response from the Association, Prof. Asa Gray, retiring president, will deliver his address, and give up the chair to his successor, Dr. J. Lawrence Smith. The British Association for the Advancement of Science will convene this year at Brighton; the first general meeting is appointed for August 14th, at 8 o'clock P. M., when Prof. Sir William Thomson, F. R. S., will resign the chair, and Dr. W. B. Carpenter, F. R. S., will assume the presidency, and deliver an address. The forty-fifth annual session of the German Society of Naturalists and Physicians will be held in Leipsic, commencing Monday, August 12th, and ending Sunday, August 18th.

Providence in Physical Affairs.—The Archbishop of York lately stated, at a meeting of the supporters of the Palestine Exploration Fund, that the progress of the human mind is from vagueness toward precision. In conformity with this tendency, it has been proposed to arrive at more precise ideas in regard to the efficacy of prayer in affecting the course of physical events. An anonymous letter, proposing a plan by which this may be done, was sent to Prof. Tyndall, who approved the suggestion, and forwarded the communication to the editor of the *Contemporary Review*, in which it has just been published.

The writer states that prayers are regularly offered by the Church, designed to secure preservation from pestilence, famine, and battles, the fertility of the soil, and weather suitable for the growth and preservation of vegetable products, for the protection of all that are in danger, and for the preservation of travellers and of sick persons. He proposes to test the efficacy of this influence, and to determine its degree, by a grand experiment, and selects the case of "sick persons" as best suited for his purpose. His plan is thus stated:

The following appears to me to indicate the manner of conducting the inquiry: it should be pursued on a system somewhat analogous to that which is pursued by the Faculty, when a question arises as to the value of any particular mode of treating disease. For example: a new remedy has been proposed, or is said, on high authority, to be efficacious, and, as authority does not suffice in medicine, further than to recommend a given course, and never to prescribe it, the remedy is carefully tested. Usually a hospital or a ward is assigned for the purpose. All the patients suffering from the disease to be treated are, during a certain period, divided into two classes, and all are subjected, as far as possible, to the same conditions, that single one of treatment alone excepted. The ages, sexes, and many other particulars of the patients, are taken into account, and duly noted. The one class is treated by the old system, and the other by the new remedy. When a very large number—for in large numbers only is there truth—has been thus dealt with, the results are compared, and the value of the remedy can be definitely expressed; that is, its influence above or below that of the old treatment, as the case may be, will appear in the percentage of recovery, or of other results.

Now, for the purpose of our inquiry, I do not propose to ask that one single child of man should be deprived of his participation in all that belongs to him of this vast influence. But I ask that one single ward or hospital, under the care of first-rate physicians and surgeons, containing certain numbers of patients afflicted with those diseases which have been best studied, and of which the mortality-rates are best known, whether the diseases are those which are treated by medical or by surgical remedies, should be, during a period of not less, say, than three or five years, made the object of special prayer by the whole body of the faithful, and that, at the end of that time, the mortality-rates should be compared with the past rates, and also with that of other leading hospitals, similarly well managed, during the same period. Granting that time is given, and numbers are sufficiently large, so as to insure a minimum of error from accidental disturbing causes, the experiment will be exhaustive and complete.

Alcoholic Hallucinations.—Dr. Magnan has been investigating the psychical and physiological effects of alcoholism upon the lower animals, and has described the symptoms of hallucination that followed in certain cases of prolonged alcoholic action. He had drugged certain ill-fated dogs for some time with liberal doses, and from the fifteenth day to the end of the experiment the following is what he observed:

One of the dogs remained almost unaffected by the protracted action of alcohol;

he became intoxicated every day, but, once the drunkenness had disappeared, he resumed his usual habits; the other four, on the contrary, exhibited a very remarkable nervous susceptibility. They became restless—listened; the slightest noise caused them to start, whenever the door opened they hastened to cower in the most obscure corner of the hall, leaving in their way a trail of urine; they paid no attention to petting; when one came near them, they bit; if one threatened to strike them, they uttered piercing cries. A short time afterward, hallucinations occurred in two of them. As if pursued by an enemy, they barked violently, they ran wildly in every direction, the head turned back, and biting in the air. Whenever one entered, they crowded against the wall, moaning, crying, trembling in all their limbs. In the middle of the night they began sometimes to howl loudly, to utter doleful cries, and stopped only when one went in with the light.

These attacks of delirium were transient, and occurred regularly toward the end of the state of drunkenness. One of the dogs had hallucinations of a cheerful character, under the immediate influence of alcohol; he appeared affectionate whenever he began to stumble; later, on the contrary, he was indifferent—or, rather, he growled and bit.

These hallucinations, of frequent occurrence during two months of the experiment, became afterward rarer, probably on account of the ingestion of less alcohol.

The author gives the following indications of the stages of hallucination in cases of delirium tremens among men: In the first degree the patient believes he hears abusive language, provocations; he sees thieves, armed persons, animals, or else he hears the voice of his parents, of his friends who call him, who warn him of a danger, who appeal for his help, etc. Stimulated by these incitements, the patient answers, injures, quarrels, runs, rushes off, becomes furious, etc., all which acts tend to develop in him a boisterous condition, a state of mania.

In other circumstances he believes himself to be in prison, before a court of justice; he is accused of various crimes; he believes that he has committed them; he believes that his wife is unfaithful to him, that he is deceived by his friends; he is present at the funeral of his parents, etc. Under the weight of these distressing impressions, he is dull, restless, suspicious; he laments, he becomes terrified, he attempts to escape, sometimes even he meditates homicide or suicide; he presents, in a word, the aspect of a melancholic. Finally, in the most intense form, he believes himself chained at the foot of a scaffold, he has before him the bleeding corpses of his children, every thing is on fire, he is about to be swallowed up, etc. These appearances have astounded, appalled him, he remains motionless, in a complete state of stupor.

The Office of Lightning-Rods.—In his valuable little work on "Lightning-Rods, and how to construct them," Prof. John Phin thus states what the lightning-rod should do:

The function or office of the lightning-rod is twofold. In the first place, it acts as a means whereby the accumulated electricity existing in the atmosphere is silently drawn off, and allowed to pass into the earth, and thus prevent an explosion; and in the second, it acts as a path by which explosions, lightning-flashes, or disruptive discharges (as they are more properly called), may find their way to the earth freely, and thus be carried off without any danger of their acting with mechanical violence, as they are certain to do when made to pass through what are called non-conductors. Experience teaches us that, so long as a discharge of electricity passes off through a wire that is large enough to carry it safely, it does not cause any damage, or give rise to the exhibition of mechanical violence. A spark from the prime conductor of an electrical machine, if passed through a moderately fine wire, does not injure it; if passed through a thick card, it will pierce it; and, if passed through a small block of wood, it will rend it asunder. On the occasion of every thunder-storm, there is a large quantity of electricity to be conveyed from the clouds to the earth, through the air, which is in general a very poor conductor. This electricity always tends to pass by the easiest path, or, as electricians say, *the line of least resistance*. The resistance of any line may be lessened by various circumstances, such as the presence of hot vapors, as from chimneys, heated hay-stacks in the open field, or heated hay-mows in the barn; the existence of a line of carbonaceous matter, such as exists in a column of smoke; the presence of a tree with its leaves and sap, or of a house with its chimneys; or the fact that the air has been rendered moist by the passage of a shower of rain. So difficult is it, however, to detect the circumstances which render any particular path more easy than others, for the electricity to follow, that we are often unable to give a reason for its following a particular course, and the action of this mighty force seems to us like a mere freak. Such ideas, are, however, entirely wrong; and we may accept most implicitly the statement that the flash will always take the easiest path, and it must be our duty to determine beforehand what this path shall be, and to make it so easy and so perfect that the resistance will not cause the electricity to produce the slightest mechanical violence.

NOTES.

The Academy of Sciences in Bologna has announced that a prize of 1,200 lire (about $240), the "Aldini Prize," will be awarded to the author of the best scientific experimental essay on galvanism or dynamic electricity. Essays intended for the competition must be sent in between July 1, 1872, and June 30, 1874, and must be written in Italian, Latin, or French. They must be either written or printed; but, in the latter case, must not have been published previously to the two years above mentioned. Each essay is to bear a motto, and to be accompanied with an envelope stating the name of the author. They must be addressed to the Perpetual Secretary of the Academy of Sciences of the Bologna Institution.

Harvey, the discoverer of the circulation of the blood, is at length to be honored by the erection of a national memorial. The townsmen of his native place, Folkestone, have resolved not to allow the tercentenary of his birth to pass unnoticed, and it has been decided that a bronze statue, if possible, of a very superior class, shall be erected to his memory. A committee is in progress of formation in London to assist the Folkestone committee, and public scientific bodies and individuals are being asked for aid and coöperation.

Repeated spectroscopic measurements made last year by Profs. Zöllner and Vogel, in Germany, show that the velocity of rotation of the sun on its own axis is at the rate of 660 miles an hour.

Dr. Angus Smith gives a good rule for ascertaining the amount of carbonic acid in the air of houses: "Let us keep our rooms so that the air does not give a precipitate when a 10½ ounce bottle full is shaken with half an ounce of clear lime-water," a sanatory regulation which can easily be carried out.

A French doctor has recently been making some curious experiments as to the effect of alcohol on fowls. The birds took to dram-drinking with evident delight, and many an old cock consumed his bottle of wine a day, so that it became necessary to limit the allowance. They all lost flesh rapidly, more especially those which drank absinthe. Two months of absinthe-drinking was found sufficient to kill the strongest cock or hen. The fowls which indulged in brandy alone, lasted, however, four months and a half, while the wine-bibbers survived for ten months. Their crests also swelled to four times the original size, and became unnaturally red.

A German naturalist answers the question, how many eggs a hen can possibly lay, as follows: The ovary of a hen contains about 600 embryo eggs, of which, in the first year, not more than 20 are matured. The second year produces 120; the third, 135; the fourth, 114; and in the following four years the number decreases by 20 yearly. In the ninth year only 10 eggs can be expected, and thus it appears that, after the first four years, hens cease to be profitable as layers.

It is proposed by the United States Signal Service to institute, during the present season, a series of observations, in connection with balloon ascensions, upon temperature, barometric pressure, currents, etc., in the higher atmosphere. Sergeant Schaeffer, one of the corps, has been designated for the service, and is now preparing for the work, which is to be begun in the neighborhood of Boston.

The experiment of introducing salmon into the Delaware River, though a failure last year, through the death of the larger portion of the young fish while on their way from the hatching-houses to the river, has this year been attended with success; owing, it is said, to the hatching being done near the river, whereby transportation for long distances was avoided.

According to Prof. Gould, electric waves travel through the Atlantic cables at the rate of between 7,000 and 8,000 miles per second; or, about half as fast as they traverse the wires suspended on telegraph-poles.

A hundred thousand young shad have been put into Lake Champlain during the present season, for the purpose of determining whether they will live and multiply when confined exclusively to fresh water.

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THE STUDY OF SOCIOLOGY.

By HERBERT SPENCER.

IV.—Difficulties of the Social Science.

FROM the intrinsic natures of its facts, from our own natures as observers of its facts, and from the peculiar relation in which we stand toward the facts to be observed, there arise impediments in the way of Sociology greater than those standing in the way of any other science.

The phenomena to be generalized are not of a directly-perceptible kind—cannot be noted by telescope and clock, like those of Astronomy; cannot be measured by dynamometer and thermometer, like those of Physics; cannot be elucidated by scales and test-papers, like those of Chemistry; are not to be got at by scalpel and microscope, like the less-obvious biological phenomena; nor are to be recognized by introspection, like the phenomena Psychology deals with. They have severally to be established by the putting together of many details, no one of which is simple, and which are dispersed both in Space and Time, in ways that make them difficult of access. Hence the reason that some of its cardinal truths, such as the division of labor, remain long unrecognized. That in advanced societies men follow different occupations, was indeed a generalization easy to make; but that this form of social arrangement had neither been specially created, nor enacted by a king, but had grown up without forethought of any one, was a conclusion that could be reached only after many transactions of many kinds between men had been noted, remembered, and accounted for, and only after comparisons had been made between those transactions and these taking place between men in simpler societies, and in earlier times. And when it is remembered that the data from which only there can be drawn the inference that labor becomes specialized, are far more accessible than the data for most other sociological inferences, it will be seen how greatly the advance of Sociology is hindered by the nature of its subject-matter.

The characters of men as observers, add to this first difficulty a second that is perhaps equally great. Necessarily men carry with them into sociological inquiries, the modes of observation and reasoning which they have been accustomed to in other inquiries—those of them, at least, who make any inquiries worthy to be so called. Passing over the great majority of the educated, and limiting ourselves to the very few who consciously collect data, compare them, and deliberately draw conclusions; we may see that even these have to struggle with the difficulty that the habits of thought generated by converse with relatively simple phenomena, partially unfit them for converse with these highly-complex phenomena. Faculty of every kind tends always to adjust itself to its work; special adjustment to one kind of work involves more or less non-adjustment to other kinds; and hence, intellects disciplined in dealing with less-involved classes of facts, cannot successfully deal with this most-involved class of facts without partially unlearning the methods they have learned.

From the emotional nature, too, there arise great obstacles. Scarcely any one can contemplate social arrangements and actions with the unconcern felt when contemplating arrangements and actions of other kinds. For correct observation and correct drawing of inferences, there needs the calmness that is ready to recognize or to infer one truth as readily as another. But it is next to impossible thus to deal with the truths of Sociology. In the search for them, each carries with him feelings, more or less strong, which make him eager to find this evidence, oblivious of that which is at variance with it, reluctant to draw any conclusion but that already drawn. And though perhaps one in ten among those who think, is conscious that his judgment is being warped by prejudice, yet even in him the warp is not adequately allowed for. It is true that in nearly every field of inquiry emotion is a perturbing intruder: mostly there is some preconception, and some *amour propre* that resists disproof of it. But the peculiarity of Sociology is, that the emotions with which its facts and conclusions are regarded, have unusual strength. The personal interests are directly affected, or there is gratification or offence to sentiments that have grown out of them; or else other sentiments which have relation to the existing form of society, are excited, agreeably or disagreeably.

And here we are introduced to the third kind of difficulty—that caused by the position occupied in respect to the phenomena to be generalized. In no other case has the inquirer to investigate the properties of an aggregate in which he is himself included. His relation toward the facts he here studies, we may figure to ourselves by comparing it to the relation between a single cell forming part of a living body, and the facts which that living body presents as a whole. There is, indeed, nothing like so close a dependence of the unit upon the aggregate; but still there is a very decided dependence. Speaking generally, the citizen's life is made possible only by due performance of his function in the place he fills; and he cannot wholly free himself from the beliefs and sentiments generated by the vital connections hence arising between himself and his society. Here, then, is a difficulty to which no other science presents anything analogous. To cut himself off in thought from all his relationships of race, and country, and citizenship—to get rid of all those interests, prejudices, likings, superstitions, generated in him by the life of his own society and his own time—to look on all the changes societies have undergone and are undergoing, without reference to nationality, or creed, or personal welfare; is what the average man cannot do at all, and what the exceptional can do very imperfectly.

The difficulties of the Social Science, thus indicated in vague outline, have now to be described and illustrated in detail.

V.—*Objective Difficulties.*

Along with much that has of late years been done toward changing primitive history into myth, and along with much that has been done toward changing once-unquestioned estimates of persons and events of past ages, much has been said about the untrustworthiness of historical evidence. Hence there will be ready acceptance of the statement that one of the impediments to sociological generalization, is the uncertainty of our data. When we bear in mind that from early stories such as those about the Amazons, their practices, the particular battles with them, and particular events in those battles, all of which are recorded and sculptured as circumstantially as they might be were the persons and events historic—when we bear in mind, I say, that from such early stories down to accounts of a well-known people like the New-Zealanders, who, "by some . . . . are said to be intelligent, cruel, and brave; by others, weak, kindly, and cowardly,"[1] we have to deal with an enormous accumulation of conflicting statements; we cannot but feel that the task of collecting facts from which to draw conclusions, is in this case a more arduous one than in any other case. Passing over remote illustrations, let us take an immediate one:

Last year advertisements announced the "Two-headed Nightingale;" and the walls of London were placarded with a figure in which one pair of shoulders was shown to bear two heads looking the same way (I do not refer to the later placards, which partially differed from the earlier). To some, this descriptive name and answering diagram seemed sufficiently exact; for in my hearing a lady, who had been to see this compound being, referred to the placards and handbills as giving a good representation. If we suppose this lady to have re-

[1] Thomson's "New Zealand," vol. i., p. 80.

peated in a letter that which I heard her say, and if we ask what would appear the character of the evidence to one who, some fifty years hence, had before him the advertisement, the representation, and the letter, we shall see that the alleged fact would be thought by him incontestable. Only if, after weary search through all the papers and periodicals of the time, he happened to come upon a certain number of the *Lancet*, would he discover that this combination was not that of two heads on one body, but that of two individuals united back to back, with heads facing opposite ways, and severally complete in all respects, except where the parts were so fused as to form a double pelvis, containing certain pelvic viscera common to the two. If, then, respecting facts of so simple and so easily-verifiable a kind, where no obvious motive for misrepresentations exists, we cannot count on true representations, how shall we count on true representations of social facts, which, being so diffused and so complex, are so difficult to observe, and in respect of which the perceptions are so much perverted by interests, and prepossessions, and party feelings?

In exemplifying this difficulty, let us limit ourselves to cases supplied by the life of our own time; leaving it to be inferred that if, in a comparatively calm and critical age, sociological evidence is vitiated by various influences, much more must there have been vitiation of such evidence in the past, when passions ran higher and credulity was greater.

Those who have lately become conscious of certain facts are apt to suppose those facts have lately arisen. After a changed state of mind has made us observant of occurrences we were before indifferent to, there often results the belief that such occurrences have become more common. It happens so even with accidents and diseases. Having lamed himself, a man is surprised to find how many lame people there are; and, becoming dyspeptic, he discovers that dyspepsia is much more frequent than he supposed when he was young. For a kindred reason he is prone to think that servants do not behave nearly so well as they did during his boyhood—not remembering that in Shakespeare's day the service obtainable was similarly reprobated in comparison with "the constant service of the antique world." Similarly, now that he has sons to establish in life, he fancies that the difficulty of getting places is much greater than it used to be.

As witnesses to social phenomena, men thus impressed by facts which did not before impress them, become perverters of evidence. Things they have suddenly recognized, they mistake for things that have suddenly come into existence; and so are led to regard as a growing evil or good, that which is as likely as not a diminishing evil or good. Take an example or two:

In generations not long passed away, sobriety was the exception rather than the rule: a man who had never been drunk was a rarity.

Condiments were used to stimulate drinking; glasses were so shaped that they would not stand, but must be held till emptied; and a man's worth was in part measured by the number of bottles he could take in. After a reaction had already greatly diminished the evil among the upper and middle ranks, there came an open recognition of the evil; resulting in Temperance Societies, which did their share toward further diminishing it. Then came the Teetotal Societies, more thoroughgoing in their views and more energetic in their actions, which have been making the evil still less; the accumulated effect of these causes being, that for a long time past among the upper classes, the drinking which was once creditable has become a disgrace; while among the lower classes it has greatly decreased, and come to be generally reprobated. Those, however, who, carrying on the agitations against it, have had their eyes more and more widely opened to the vice, assert or imply in their speeches and petitions that the vice is not only great but growing. Having in the course of a generation much mitigated it by their voluntary efforts, they now make themselves believe, and make others believe, that it is too gigantic to be dealt with otherwise than by repressive enactments—Maine Laws and Permissive-Prohibitory Bills. And, if we are to be guided by a Select Committee which has just reported, fines and imprisonments for drunkenness must be made far more severe than now, and reformatories must be established in which inebriates shall be dealt with much as criminals are dealt with.

Take, again, the case of education. Go back far enough, and you find nobles not only incapable of reading and writing, but treating these accomplishments with contempt. Go back not quite so far, and you find, along with a slight encouragement by authority of such learning as referred to Theology, a positive discouragement of all other learning;[1] joined with the belief that only for the clergy is learning of any kind proper. Go back a much smaller distance, and you find in the highest classes inability to spell tolerably, joined with more or less of the feeling that good spelling was a pedantry improper for ladies—a feeling akin to that named by Shakespeare as shown by those who counted it "a meanness to write fair." Down even to quite modern times, well-to-do farmers and others of their rank were by no means all of them able to read and write. Education, spreading thus slowly during so many centuries, has during the last century spread with comparative rapidity. Since Raikes commenced Sunday-schools in 1771; since Lancaster, the Quaker, in 1796 set up the first of the schools that afterward went by his name; since 1811, when the Church had to cease its opposition and become a competitor in educating poor children; the strides have been enormous: a degree of ignorance which had continued the rule during so many centuries was made in the course of half a century the exception. And then in 1834, after

[1] Hallam's "Middle Ages," chap. ix., part ii.

this unobtrusive but speedy diffusion of knowledge, there came, along with a growing consciousness of the still-remaining deficiency, the system of State-subsidies; which, beginning with £20,000, grew, in less than thirty years, to more than a million. Yet now, after this vast progress at an ever-increasing rate, there has come the outcry that the nation is perishing for lack of knowledge. Any one not knowing the past, and judging from the statements of those who have been urging on educational organizations, would suppose that strenuous efforts are imperative to save the people from some gulf of demoralization and crime, into which ignorance is sweeping them.

How testimonies respecting objective facts are thus perverted by the subjective states of the witnesses, and how we have to be ever on our guard against this cause of vitiation in sociological evidence, may indeed be inferred from the illusions that daily mislead men in their comparisons of past with present. Returning after many years to the place of his boyhood, and finding how insignificant are the buildings he remembered as so imposing, every one discovers that in this case it was not that the past was so grand, but that his impressibility was so great and his power of criticism so small. He does not perceive, however, that the like holds generally; and that the apparent decline in various things is really due to the widening of his experiences and the growth of a judgment no longer so easily satisfied. Hence the mass of witnesses may be under the impression that there is going on a change just the reverse of that which is really going on; as we see, for example, in the notion current in every age, that the size and strength of the race have been decreasing, when, as proved by bones, by mummies, and by armor, and by the experiences of travellers in contact with aboriginal races, they have been on the average increasing.

Most testimony, then, on which we have to form ideas of sociological states, past and present, has to be discounted to meet this cause of error; and the rate of discount has to be varied according to the epoch, and the subject, and the witness.

Beyond this vitiation of sociological evidence by general subjective states of the witnesses, there are vitiations due to more special subjective states. Of these, the first to be noted are those which foregone conclusions produce.

Extreme cases are furnished by fanatical agitators, such as members of the Anti-Tobacco Society, in the account of whose late meeting we read that "statistics of heart-disease, of insanity, of paralysis, and the diminished bulk and stature of the population of both sexes proved, according to the report, that these diseases were attributable to the use of tobacco." But without making much of instances so glaring as this, we may find abundant proof that evidence is in most cases unconsciously distorted by the pet theories of those who give it.

Early in the history of our sanitary legislation, a leading officer of health, wishing to show the need for those measures he advocated, drew a comparison between the rate of mortality in some most salubrious village (in Cumberland, I think it was), and the rate of mortality in London; and then, pointing out the marked difference, alleged that this difference was due to "preventible causes"—to causes, that is, which good sanitary administration would exclude. Ignoring the fact that the carbonic acid exhaled by nearly three millions of people and by their fires, caused in the one case a vitiation of the air which in the other case did not exist—ignoring the fact that most city-occupations are of necessity in-door, and many of them sedentary, while the occupations of village life are out-of-door and active—ignoring the fact that in many of the Londoners the activities are cerebral in a degree beyond that to which the constitution of the race is adapted, while in the villagers the activities are bodily, in a degree appropriate to the constitution of the race; he set down the whole difference in the death-rate to causes of the kind which laws and officials might get rid of.

A still more marked example of this effect of a cherished hypothesis in vitiating the evidence given by an inquirer, was once unconsciously yielded to me by another enthusiast for sanitary regulation. Producing his papers, he pointed out a statistical contrast he had been drawing between the number of deaths *per annum* in the small town near London where he lived, and the number of deaths *per annum* in a low district of London—Bermondsey, or Lambeth, or some region on the Surrey side. On this great contrast he triumphantly dilated as proving how much could be done by good drainage, ventilation, etc. On the one hand, he passed over the fact that this small suburban town was, in large measure, inhabited by a picked population—people of means, well fed and clothed, able to secure all appliances of comfort, leading regular and quiet lives, free from overwork and anxiety. On the other hand, he passed over the fact that this low region of London was, by virtue of its lowness, one out of which all citizens pecuniarily able to take care of themselves escaped if they could, and into which were thrust an unusual number of those whose poverty excluded them from better regions—the ill-fed, the drunken, the dissolute, and others on the highway to death. Though, in the first case, the healthiness of the locality obviously drew to it an excess of persons otherwise likely to live long; and though, in the second case, the unhealthiness of the locality made it one in which an excess of those not likely to live long were left to dwell or brought to die; yet the whole difference was put down to direct physical effects of pure air and impure air respectively.

Statements proceeding from witnesses whose judgments are thus warped—statements republished by careless sub-editors, and readily accepted by the uncritical who believe all they see in print, diffuse erroneous prepossessions; which, again, tend to justify themselves by drawing the attention to confirmatory facts and away from facts that are adverse. Throughout all past time vitiation of evidence by influences of this nature has been going on to a degree varying with each people and each age; and hence arises an additional obstacle to the obtainment of fit data.

Yet another, and perhaps stronger, distorting influence existing in the medium through which facts reach us, results from the self-seeking, pecuniary or other, of those who testify. We require constantly to bear in mind that personal interests affect most of the statements on which sociological conclusions are based, and on which legislation proceeds.

Every one knows this to be so where the evidence concerns mercantile affairs. That railway enterprise, at first prompted by pressing needs for communication, presently came to be prompted by speculators, professional and financial; and that the estimates of cost, of traffic, of profits, etc., set forth in prospectuses, were grossly misleading; many readers have been taught by bitter experience. That the gains secured by schemers who float companies have fostered an organized system which has made the falsification of evidence a business, and which, in the case of bubble insurance companies, has been worked so methodically that it has become the function of a journal to expose the frauds continually repeated, are also familiar facts; reminding us how in these directions it is needful to look very skeptically on the allegations put before us. But there is not so distinct a consciousness that in other than business enterprises, self-seeking is an active cause of misrepresentation.

Like the getting up of companies, the getting up of agitations and of societies has become, to a considerable extent, a means of advancement. As in the United States politics has become a profession, into which a man enters to get an income, so here there has grown up, though happily to a smaller extent, a professional philanthropy, pursued with a view either to position, or to profit, or to both. Much as the young clergyman in want of a benefice, feeling deeply the spiritual destitution of a suburb that has grown beyond churches, busies himself in raising funds to build a church, and probably does not, during his canvass, understate the evils to be remedied; so every here and there an educated man with plenty of leisure and small income, greatly impressed with some social evil to be remedied or benefit to be achieved, becomes the nucleus to an institution, or the spur to a movement. And since his success depends mainly on the strength of the case he makes out, it is not to be expected that the evils to be dealt with will be faintly pictured, or that he will insist very strongly upon facts adverse to his plan. As I can personally testify, there are those who, having been active in getting up schemes for alleged beneficial public ends, consider themselves aggrieved when not afterward appointed salaried officials. The recent exposure of the "Free Dormitory Association," which, as stated at a meeting of the Charity-Organization Society, was but one of a class, shows what this process may end in. And the vitiation of evidence is an inevitable concomitant. One whom I have known during his thirty years' experience of Leagues, Alliances, Unions, etc., for various purposes, writes: "Like religious bodies, they (Associations) form creeds, and every adherent is expected to cry up the shibboleth of his party. . . . All facts are distorted to the aid of their own views, and such as cannot be distorted are suppressed. . . . In every association with which I have had any connection, this fraud has been practised."

The like holds in political agitations. Unfortunately, agencies established to get remedies for crying evils, are liable to become agencies maintained and worked in a considerable degree, and sometimes chiefly, for the benefit of those who reap incomes from them. An amusing instance of this was furnished, not many years ago, to a Member of Parliament who took an active part in advocating a certain radical measure which had for some years been making way, and which then seemed not unlikely to be carried. Being a member of the Association that had pushed forward this measure, he happened to step into its offices just before a debate which was expected to end in a majority for the bill, and he found the secretary and his subs in a state of consternation at the prospect of their success: feeling, as they obviously did, that their occupation was in danger.

Clearly, then, where personal interests come into play, there must be, even in men intending to be truthful, a great readiness to see the facts which it is convenient to see, and such reluctance to see opposite facts as will prevent much activity in seeking for them. Hence a large discount has mostly to be made from the evidence furnished by institutions and societies in justification of the policies they pursue or advocate. And since much of the evidence respecting both past and present social phenomena comes to us through agencies calculated thus to pervert it, there is here a further impediment to clear vision of facts.

That the reader may fully appreciate the difficulties which these distorting influences, when combined, put in the way of getting good materials for generalization, let him contemplate a case:

All who are acquainted with such matters know that, up to some ten years since, it was habitually asserted by lecturers when addressing students, and by writers in medical journals, that, in our day, syphilis is a far less serious evil than it was in days gone by. Until quite recently this was a commonplace statement, called in question by no one in the profession. But just as, while a gradual decrease of drunkenness has been going on, Temperance-fanatics have raised an increasing outcry for strenuous measures to put down drunkenness; so, while venereal disease has been diminishing in frequency and severity, certain instrumentalities and agencies have created a belief that rigorous measures are required to check its progress. This incongruity would by itself be a sufficient proof of the extent to which, on the one side or the other, evidence must have been vitiated. What, then, shall we say of the incongruity on finding that the first of these statements has recently been repeated by many of the highest medical authorities, as one verified by their experience? Here are some of their testimonies:

The Chairman of the late Government Commission for inquiring into the treatment and prevention of syphilis, Mr. Skey, Consulting-Surgeon to St. Bartholomew's Hospital, gave evidence before a House of Lords Committee. Referring to an article expressing the views of the Association for promoting the extension of the Contagious Diseases Acts, he said it was—

"largely overcharged," and "colored too highly. . . . The disease is by no means so common or universal, I may say, as is represented in that article, ... and I have had an opportunity, since I had the summons to appear here to-day, of communicating with several leading members in the profession at the College of Surgeons, and we are all of the same opinion, that the evil is not so large by any means as it is represented by the Association."

Mr. John Simon, F. R. S., for thirty-five years a hospital surgeon, and now Medical Officer to the Privy Council, writes in his official capacity:

"I have not the least disposition to deny that venereal affections constitute a real and great evil for the community; though I suspect that very exaggerated opinions are current as to their diffusion and malignity."

By the late Prof. Syme it was asserted that—

"It is now fully ascertained that the poison of the present day (true syphilis) does not give rise to the dreadful consequences which have been mentioned, when treated without mercury. . . . None of the serious effects tha used to be so much dreaded ever appear, and even the trivial ones just noticed comparatively seldom present themselves. We must, therefore, conclude either that the virulence of the poison is worn out, or that the effects formerly attributed to it depended on treatment." [1]

The *British and Foreign Medico-Chirurgical Review*, which stands far higher than any other medical journal, and is friendly to the Acts as applied to military and naval stations, writes thus:

"The majority of those who have undergone the disease, thus far" (including secondary manifestations), "live as long as they could otherwise have expected to live, and die of diseases with which syphilis has no more to do than the man in the moon." [2] . . . . "Surely 455 persons suffering from true syphilis in one form or another, in a poor population of 1,500,000" (less than one in 3,000) . . . . "cannot be held to be a proportion so large as to call for exceptional action on the part of any government." [3]

[1] "Principles of Surgery." Fifth edition, p. 434.

[2] *British and Foreign Medico-Chirurgical Review*, January, 1870, p. 103.

[3] Ibid., p. 106.

Mr. Holmes Coote, F. R. C. S., Surgeon and Lecturer on Surgery at St. Bartholomew's Hospital, says:

"It is a lamentable truth that the troubles which respectable, hard-working married women of the working-class undergo are more trying to the health, and detrimental to the looks, than any of the irregularities of the harlot's career."

Again, it is stated by Mr. Byrne, Surgeon to the Dublin Lock Hospital, that "there is not nearly so much syphilis as there used to be;" and, after describing some of the serious results that were once common, he adds: "You will not see such a case for years—a fact that no medical man can have failed to remark." Mr. W. Burns Thompson, F. R. C. S., for ten years head of the Edinburgh Dispensary, testifies as follows:

"I have had good opportunities of knowing the prevailing diseases, and I can only say that the representations given by the advocates of these Acts are to me perfectly unintelligible; they seem to me to be gross exaggeration."

Mr. Surgeon-Major Wyatt, of the Coldstream Guards, when examined by the Lords' Committee, stated that he quite concurred with Mr. Skey. Answering question 700, he said:

"The class of syphilitic diseases which we see are of a very mild character; and, in fact, none of the ravages which used formerly to be committed on the appearance and aspect of the men are now to be seen. . . . It is an undoubted fact that in this country and in France the character of the disease is much diminished in intensity.—*Question:* 708. I understand you to say, that in your opinion the venereal disease has generally, independent of the Act, become more mitigated, and of a milder type? *Answer:* Yes; that is the experience of all surgeons, both civil and military."

Dr. Druitt, President of the Association of the Medical Officers of Health for London, affirmed at one of its meetings—

"that speaking from thirty-nine years' experience, he was in a position to say that cases of syphilis in London were rare among the middle and better classes, and soon got over."

And even Mr. Acton, a specialist, to whom more than to any other man the Acts are due, admitted before the Lords' Committee that "the disease is milder than it was formerly."

Like testimony is given by Continental surgeons, among whom it was long ago said by Ambrose Paré, that the disease "is evidently becoming milder every day;" and by Auzias Turenne, that "it is on the wane all over Europe." Astruc and Diday concur in this statement. And the latest authority on syphilis, Lancereaux, whose work is so valued that it has been translated by the Sydenham Society, asserts that—

"In these cases, which are far from being rare, syphilis is but an abortive disease; slight and benignant, it does not leave behind any troublesome trace of its passage. It is impossible to lay too much stress upon this point. At the present day especially, when syphilis still inspires exaggerated fears, it should be known that this disease becomes dissipated completely in a great number of cases after the cessation of the cutaneous eruptions, and perhaps sometimes even with the primary lesion." [1]

It will, perhaps, be remarked that these testimonies of medical men who, by their generally high position, or their lengthened experience, or their special experience, are so well qualified to judge, are selected testimonies; and against them will be set the testimonies of Sir James Paget, Sir W. Jenner, and Mr. Prescott Hewett, who regard the evil as a very grave one. To gather accurately the *consensus* of medical opinion would be impracticable without polling the whole body of physicians and surgeons; but we have a means of judging which view most truly meets with "the emphatic concurrence of numerous practitioners:" that, namely, of taking a local group of medical men. Out of fifty-eight physicians and surgeons residing in Nottingham and its suburbs, fifty-four have put their signatures to a public statement that syphilis is "very much diminished in frequency, and so much milder in form that we can scarcely recognize it as the disease described by our forefathers." And among these are the medical men occupying nearly all the official medical positions in the town—Senior Physician to the General Hospital, Honorary Surgeon ditto, Surgeons to the Jail, to the General Dispensary, to the Free Hospital, to the Union Hospital, to the Lock Hospital (four in number), Medical Officers to the Board of Health, to the Union, to the County Asylum, etc., etc. Even while I write there comes to me kindred evidence in the shape of a letter published in the *British Medical Journal* for July 20, 1872, by Dr. Carter, Honorary Physician to the Liverpool Southern Hospital, who states that, after several debates at the Liverpool Medical Institution, "a form of petition strongly condemnatory of the Acts was written out by myself, and . . . . in a few days one hundred and eight signatures" (of medical men) "were obtained." Meanwhile, he adds, "earnest efforts were being made by a number of gentlemen to procure medical signatures to the petition in favor of the Acts known as the 'London Memorial'—efforts which resulted in twenty-nine signatures only."

Yet notwithstanding this testimony great in quantity, and much of it of the highest quality, it has been possible so to present the evidence as to produce in the public mind, and in the Legislature, the impression that peremptory measures for dealing with a spreading pest are indispensable. As lately writes a Member of Parliament:

[1] "A Treatise on Syphilis," by Dr. E. Lancereaux, vol. ii., p. 120. This testimony I quote from the work itself, and have similarly taken from the original sources the statements of Skey, Simon, Wyatt, Acton, and the *British and Foreign Medico-Chirurgical Review*. The rest, with various others, will be found in the pamphlet of Dr. C. B. Taylor on "The Contagious Diseases Acts."

"We are assured, on what appeared unexceptionable testimony, that a terrible constitutional disease was undermining the health and vigor of the nation, and especially destroying innocent women and children."

And then note the startling circumstance that while so erroneous a conception of the facts may be spread abroad, there may, by the consequent alarm, be produced a blindness to facts of the most unquestionable kind, established by the ever-accumulating experiences of successive generations. Until quite recently, our forms of judicial procedure embodied the principle that some overt injury must be committed before legal instrumentalities can be brought into play; and conformity to this principle was in past times gradually brought about by efforts to avoid the terrific evils that otherwise arose. As a Professor of Jurisprudence reminds us, "the object of the whole complicated system of checks and guards provided by English law, and secured by a long train of constitutional conflicts, has been to prevent an innocent man being even momentarily treated as a thief, a murderer, or other criminal, on the mere alleged or real suspicion of a policeman." Yet now, in the state of groundless fright that has been got up, "the concern hitherto exhibited by the Legislature for the personal liberty of the meanest citizen has been needlessly and recklessly lost sight of."[1] It is an *a priori* inference from human nature that irresponsible power is sure, on the average of cases, to be grossly abused. The histories of all nations, through all times, teem with proofs that irresponsible power has been grossly abused. The growth of representative governments is the growth of arrangements made to prevent the gross abuse of irresponsible power. Each of our political struggles, ending in a further development of free institutions, has been made to put an end to some particular gross abuse of irresponsible power. Yet the facts thrust upon us by our daily experiences of men, verifying the experiences of the whole human race throughout the past, are now tacitly denied; and it is tacitly asserted that irresponsible power will not be grossly abused. And all because of a manufactured panic about a decreasing disease, which kills not one-fifteenth of the number killed by scarlet fever, and which takes ten years to destroy as many as diarrhœa destroys in one year.

See, then, what we have to guard against in collecting sociological data—even data concerning the present, and, still more, data concerning the past. For testimonies that come down to us respecting bygone social states, political, religious, judicial, physical, moral, etc., and respecting the actions of particular causes on those social states, have been liable to perversions not simply as great, but greater; since, while the regard for truth was less, there was more readiness to accept unproved statements.

[1] Prof. Sheldon Amos. See also his late important work, "A Systematic View of the Science of Jurisprudence," pp. 119, 303, 512, 514.

Even where deliberate measures are taken to obtain valid evidence on any political or social question raised, by summoning witnesses of all classes and interests, there is difficulty in getting at the truth; because the circumstances of the inquiry tend of themselves to bring into sight some kinds of evidence, and to keep out of sight other kinds. In illustration may be quoted the following statement of Lord Lincoln on making his motion concerning the enclosures of commons:

"This I know, that in nineteen cases out of twenty, committees sitting in this House on private bills neglected the rights of the poor. I do not say that they wilfully neglected those rights—far from it; but this I affirm, that they were neglected in consequence of the committees being permitted to remain in ignorance of the rights of the poor man, because by reason of his very poverty he is unable to come up to London to fee counsel, to procure witnesses, and to urge his claims before a committee of this House."—(*Hansard*, May 1, 1845.[1])

Many influences of a different order, but similarly tending to exclude particular classes of facts pertinent to an inquiry, come into play. Given a question at issue, and it will very probably happen that witnesses on the one side may, by evidence of a certain nature, endanger a system on which they depend for the whole or for part of their livelihood; and by evidence of an opposite nature may preserve it. By one kind of testimony they may offend their superiors and risk their promotion: doing the reverse by another kind. Moreover, witnesses not thus directly interested are liable to be indirectly swayed by the thought that to name certain facts they know will bring on them the ill-will of important persons in their locality—a serious consideration in a provincial town. And while such influences strongly tend to bring out evidence, say in support of some established organization, there may very possibly, and, indeed, very probably, be no organized adverse interest with abundant resources which busies itself to bring out a contrary class of facts—no occupation in danger, no promotion to be had, no applause to be gained, no odium to be escaped. Contrariwise, there may be positive sacrifices, serious in amount, to be made before such contrary class of facts can be brought to light. And thus it may happen that, perfectly open and fair as the inquiry seems, the circumstances will insure a one-sided representation.

A familiar optical illusion well illustrates the nature of these illusions which often deceive sociological inquirers: When standing by a lake-side in the moonlight, you see, stretching over the rippled surface toward the moon, a bar of light which, as shown by its nearer part, consists of flashes from the sides of separate wavelets. You walk, and the bar of light seems to go with you. There are, even among cultivated people, many who suppose that this bar of light has an objective

[1] Quoted by Nasse, "The Agricultural Community of the Middle Ages," etc., English translation, p. 94.

existence, and who believe that it really moves as the observer moves—occasionally, indeed, as I can testify, expressing surprise at the fact. But, apart from the observer, there exists no such bar of light; nor when the observer moves is there any movement of this glittering line of wavelets. All over the dark part of the surface the undulations are just as bright with moonlight as those he sees; but the light reflected from them does not reach his eyes. Thus, though there seems to be a lighting of some wavelets and not of the rest, and though, as the observer moves, other wavelets seem to become lighted that were not lighted before, yet both these are utterly false seemings. The simple fact is, that his position in relation to certain wavelets brings into view their reflections of the moon's light, while it keeps out of view the like reflections from all other wavelets.

Sociological evidence is largely vitiated by illusions thus caused. Habitually the relations of observers to the facts are such as make visible the special, and exceptional, and sensational, and leave invisible the commonplace and uninteresting, which form the great body of the facts. And this, which is a general cause of deceptive appearances, is variously aided by those more special causes above indicated; which conspire to make the media, through which the facts are seen, transparent in respect of some and opaque in respect of others.

A GLASS OF WATER.

By FRIEDRICH MOHR.[1]

In tracing the history of the civilization and growth of humanity, it becomes noticeable that long periods of time often witness but slow and gradual progress; but that from time to time a few inventions and discoveries of eminent men suddenly kindle a revolution in all the spheres of human affairs. To trace to their source the changes so wrought, presents to the historian and scientist one of the most interesting subjects. In nearly every place, the most ancient of such great events, the invention of language and of written characters, are wrapped in complete darkness. As history can be handed down to posterity by means of language only, it is obvious that ages without language can have no history. It is language which introduces nations into history. As regards written speech the case is somewhat different. The most distinguished people of antiquity, the Greeks, emerged from obscurity into history with a language wonderfully complete, but without written characters. During several centuries the Homeric songs had to wan-

[1] Translated from the German, by C. L. Hotze, Teacher of Physics and Chemistry in the High School of Cleveland, Ohio.

der from mouth to mouth before they were intrusted to the graphic symbols; from this moment they disappeared from memory. Written language is the downfall of tradition.

The history of the rise of the two great races of antiquity, the Greek and the Roman, is barren of important inventions. Their blue sky made them wellnigh independent of Nature. Amid the cheerful enjoyment of the natural, intellect in Greece flourished as never before or afterward in any clime; the age of Pericles—

> "The age of godlike fantasy,
> Is vanished, never to return."

The palmy days soon passed away, however; the mountainous land of small extent succumbed first to the Macedonian, then to the Roman victor. The descendants of the conquerors of Asia became private teachers to the Roman grandees.

Rome herself developed into political greatness only. With the exception of her historians, her scientific lustre was merely a faint image of Grecian culture, very much like German literature of the first half of the eighteenth century when compared with the times of Louis XIV. and Queen Anne. No remarkable invention, of lasting benefit to humanity, sprang from the Romans. Even the weapons of war, down to the invention of gunpowder, remained the same as when Glaucus and Diomedes handled them. Shield, spear, and sword, had changed shape and size, but none of their functions.

Not until the invention of gunpowder was the aspect of society essentially changed. A bit of charcoal, a nitre-crystal, and a few grains of sulphur mixed together, made up a powder that rent mountains and crushed walls. At once all the then prevailing systems of attack and defence were overthrown. The nation most advanced in technical matters became the most powerful. With a few thousand blunderbusses, a handful of adventurers conquered a new continent. The history of the invention of gunpowder is as yet a myth. Very likely, an accident was the main cause. Science claims no reward. Then came a series of inventions and discoveries, each of which played an important part in framing society anew. The compass emboldened the mariner to leave the coast for the open sea, and helped to discover a new continent and circumnavigate an old one; the telescope revealed celestial spaces hitherto unknown; the laws of the pendulum, discovered at that epoch, the laws of compressed air, of the circulation of the blood, of the motions of the planets, furnished important building-material with which to rear culture and civilization. The newly-invented art of printing rendered the sources of knowledge accessible to all. Our purpose is not to unfold all this in detail; but it was necessary to show the distances of those stopping-points where history changes horses in order to go forward with renewed vigor. With the invention of printing, history commenced making more rapid strides. A few centuries later, however, events occurred which were originated and put upon the scene by means of the art of printing, and which greatly diminished the blessings of the invention on account of the almost total destruction of national prosperity during the Thirty Years' War. The art itself meanwhile had not improved. The prints of those times are poor and wretched compared with the excellent works of Guttenberg. The importance of the art by far exceeds its intellectual merit. Many inventions have since been made, which involve far higher intellectual endowments than the invention of printing. The Jacquard loom, the stocking-frame, the carding-machine, the watch, the chronometer, and other inventions, unquestionably involve rarer gifts of combination and executive force; yet, as regards influence, none of them can even remotely be compared with the printing-press; none would at that time have come to light without the press.

This vast capital handed down to us by former generations, modern humanity has immeasurably increased, even doubled and trebled. The inventions and discoveries mentioned thus far are fully known, as to their immense bearing upon the direction of human life.

In addition to these, let us record two events of the second half of the last century, which, more promptly and thoroughly than even any of the preceding, changed the entire social conditions of humanity: one an invention, that of the steam-engine; the other a discovery, that of oxygen.

The importance of the steam-engine requires no comment. Man derives power from the rays of the sun which were stored up as carbon in the vegetable kingdom from time immemorial. The steam which to-day gushes from the locomotive is an equivalent of the rays that decomposed the carbonic acid of the huge marine plants of those early periods, and accumulated the carbon as a source of power—a sleeping affinity, a lifted weight. In combining this carbon again with oxygen, we produce precisely as much heat as disappeared during the growth of those plants. The steam generated by this heat we allow to push against a movable obstacle, and to this obstacle we attach the resistances to be overcome—a train of cars, a number of looms or hammers, grindstones or rolls. The power is neither given us nor is it generated. It disappears with the wood or the coal.

The discovery of oxygen has an altogether different importance. We are confronted by an apparently insignificant fact which Destiny seemed for a time to have permanently assigned to the chemist's laboratory. It was on the 1st of August, in 1774, that Priestley, an English clergyman and a naturalist, for the first time performed the celebrated experiment which up to the present day is repeated in nearly every course of lectures on experimental chemistry. He heated red oxide of mercury in a small glass retort, and obtained an invisible, colorless gas together with drops of liquid mercury. To collect the gas he employed the same means which we still use to-day. He took a *glass*, filled and inverted it under water, and lifted it inverted so that it remained full on the surface of the water. Then he made the new gas pass through a tube and rise under the glass; the ascending bubbles soon filled the vessel with the pure gas. Thus he had oxygen collected in a *glass of water;* he held the microcosm in his grasp, and could investigate its properties. Almost at the same time the gas was discovered by the Swede Scheele, who prepared it by heating oxide of manganese. This was but one step, however; the substance that was to initiate a new era in the world was discovered but not yet recognized. As yet an error swayed the mind of man.

The phenomenon of combustion which, at the present time, is ascribed to the chemical union of oxygen with combustible bodies, was at that time explained as due to the escape of an unknown *fire-substance* called *phlogiston.* The products of combustion were said to be *dephlogisticated.* That substance was thought to escape from the burning body during the act of combustion; and yet experience demonstrated that the result of the combustion, such as, for example, the rusts of lead, zinc, and copper, had more weight than the original metals. In reply to this, it was maintained that the phlogiston possessed negative weight (that it buoyed up the substances on account of its *levity*). Thus error begat error. At length the mystery was solved by Lavoisier. He distinctly recognized the nature of oxygen as that of a simple body, and asserted that combustion was the combination of a substance with oxygen. This introduced the element into chemistry, a conception which formed at once the basis of an exact science. Priestley was the Copernicus of Chemistry, Lavoisier became its Kepler.

An immense number of familiar facts now easily clustered around this fundamental conception; and the so-called *antiphlogistic system* sprang into life, a system which has prevailed up to this day, although its name is no longer in use, there being no purpose in maintaining a term that would perpetuate the memory of an error.

The system met with the fate of that of Copernicus; after a protracted struggle it came out victorious, the tenet of every naturalist now living. Oxygen being the most frequently-occurring substance, entering into combinations with all bodies, forming eight-ninths of the weight of water, and over one-half the mass of our globe, and being the conspicuous element ever present in the phenomena of combustion and respiration—it was eminently the substance to establish the new system everywhere. More than half the science of chemistry is taken up by oxygen and its compounds. Priestley and Scheele, its discoverers, remained to the ends of their lives enemies to the new theory. On the 16th of Floreal, in the year II. of the French Republic, Lavoisier was compelled to lay his head under the guillotine.

The composition of water was discovered by Cavendish. This completed the antiphlogistic system. Water consists of two gases, oxygen and hydrogen, which, with the characteristics of combustion, combine to form the well-known liquid. This fact was of such paramount importance, that at great expense a whole *glass of water* was produced by combustion, and the water was shown to possess the identical properties of pure rain-water.

In the beginning, chemistry, being still a young science, had to attend to domestic arrangements. It must first obtain the substances and contrive the apparatus wherewith to explore the natures of the various bodies composing our globe. A celebrated period soon followed, during which every number of a scientific journal would be filled with important and most momentous discoveries. So glorious an epoch as this probably never before occurred in the history of mankind. New elements, new compounds, were discovered—unknown compounds separated into their component elements. The discovery of the alkaline metals and earths was an event which astonished the world. The natures of such bodies as would not yield to analysis were divined, and subsequent experimentation has verified the speculations. Thus the presence of a metal in clay, lime, and quartz, was distinctly foretold; fifty years later it was actually produced.

The consequences of any discovery are incalculable. Davy investigated the nature of the flame, and communicated his discoveries in a lecture before a large audience. He demonstrated that it was within our power to produce a flame which, at a state of extreme heat, contained either free oxygen or unburnt carbon; that a large grate with a limited supply of coal would generate the former, the oxidizing flame, while a small grate with a larger amount of coal would yield the other, the flame devoid of oxygen, but in which combustible substances might be melted without the danger of combustion. Among the hearers sat a young man by the name of Cort, who directed his mind to these remarks. Up to that time cast-iron was converted into wrought-iron by heating it with charcoal and exposing the melted metal to a blast of air. By this process only small quantities of wrought-iron were obtained at a time, through the necessity of producing but one *bloom* in a heat, which might easily be hammered out; and also on account of the cost of charcoal. In this process mineral coal could not be placed in contact with the iron, because the never-failing presence of sulphur in that kind of coal would render the iron unfit for use. From Davy's lecture on the flame, Cort struck upon the idea of decarbonizing cast-iron without exposing it to the danger of the contact with coal, by allowing the flames only of the coal to play upon the cast-iron. Thus originated that wonderful operation called the *puddling process*. Large quantities of cast-iron are melted on the floor of a reverberatory furnace (so named from having an arch which throws the flame back on the iron), and a portion of the carbon in the iron is burnt up by the oxidizing flame; as soon as the iron passes from the liquid state to a pasty condition, the puddler rakes it by means of a long iron bar called a *paddle*, and finally separates the whole mass of iron into large lumps, each weighing from 60 pounds upward. After this, the opening in the door of the furnace is closed, and the hot oxidizing flame allowed to impinge upon the balls until they are completely converted into bar-iron. The balls are then placed under a hammer; and, the melted slag being forced out, they are rolled into bars between the *puddling-rolls*.

The ancient mode of refining iron needed no rolls, a hammer was sufficient; nowadays, the huge quantities of refined iron turned out by the puddling-furnace require more than a hammer. The invention of the puddling-rolls was the natural sequence of the puddling-furnace. This furnace yields more than a hundred times the quantity of bar-iron produced by the bloomery of former times; and the *blooms* —or balls—can be made of a size sufficient to be turned into iron rails of from 16 to 24 feet in length.

At this point let us cast a glance upon the past. We are contemporaries of the great discovery which shortens the distances upon the globe. About forty years have passed since the first locomotive dashed over the track, and already our social and political conditions are mainly dependent on this invention. Not many years ago, a whole army was conveyed from the southern part of Germany to the north within a few days, and this without a straggler—an operation formerly requiring months. In 1866 we saw how an army, equal in size to the one that perished in Russia in 1812, started from the farthermost limits of Germany, was moved in a very short period to another field, and arrived there at the appointed time. Within a day or so, Germany or France can be passed over in its longest extent. The rapid supply of local wants by the importation of grain and cattle acts most powerfully upon the stability of prices. A famine, in the proper sense of the word, can scarcely be thought of at the present time, unless it be a universal famine. Fresh sea-produce, which formerly gladdened only the coast-land, penetrates now into the interior. Districts far remote from the commerce of the earth, but crossed by the iron track, can now take their produce to the great markets of the world. Hence it cannot be denied that the form of modern society depends upon the railroads. But where would our railroads be if we could not roll rails? Where the rails, if we had no puddling-furnace? Where the puddling-furnace, without a knowledge of the flame? And this knowledge is simply the result of the study of chemical science, which, in turn, may be traced back to the discovery of oxygen. This whole series of wonderful effects and causes dates from that *glass of water* in which Priestley first collected oxygen. Not a member of that series could have been passed by, not a link of that chain been wanting, without rendering impossible the remaining links. It can be asserted fearlessly, that the favorable condition of modern society has its rise in the discovery of oxygen.

Let me here allude to those stupendous processes, the manufactures of sulphuric acid and of soda. To sketch the influence of chemistry upon life would carry us too far. Glass and soap are better to-day, and, despite their hundred-fold increased consumption, no dearer than in former times. Chlorine, as a bleaching agent, in place of the sun, has restored to agriculture thousands of acres of meadow-land.

But the powerful impulse carried also the kindred sciences. The Italian physician Galvani accidentally noticed the convulsions of a frog recently killed, whenever he touched him with two metals in contact with each other. This observation became the starting-point of the electric telegraph. The experiments of *Volta* resulted in the pile named after him. Two heterogeneous metals, such as zinc and copper, are immersed in a *glass of water*, to which a few drops of sulphuric acid have been added; both metals we connect by means of a long wire, and then we find the wire possessed of a new force which can transmit a motion through the distance of a hundred miles and over. For a long time the voltaic pile had been the subject of unsuccessful experiments for the purpose of finding its relation to the magnet, to which, on account of its poles, it bears a certain resemblance. One day, Oersted, at a lecture in Copenhagen in 1819, noticed that a magnetic needle on his table was disturbed by a communicating wire that happened to pass over it. He removed the wire, and the needle resumed its polar direction; he then replaced the wire, and the needle again turned aside. Electro-magnetism was discovered. At once he recognized the immense bearing of the phenomenon, repeated the experiment in presence of the magistrate, a notary public, and other witnesses, and made a Latin affidavit; this places his name, for all time to come, among the benefactors of the human race. The advantage of his invention is enjoyed by all of us who daily read telegrams from distant parts of the world as if this rapid transmission of news were a matter of course. The wonder has become a fact of daily occurrence; it rises with us and accompanies us through the day. Do you ever consider that, without this discovery of Oersted, the telegraph would not exist?

We place thirty or forty *glasses of water* in adjacency, each containing a plate of zinc and one of copper, together with a small quantity of sulphuric acid; we join the vessels by means of metallic wires soldered to the opposite plates, and connect the two extreme plates of the series with the ground, the extreme zinc plate by a short wire, the last copper by, say, a hundred-mile wire. A slight pressure of the finger upon a knob supported by a spring, and a dash or dot is produced a hundred miles away; thought is transmitted to that distance by the electric current; it makes its own record, the recipient needs simply to read off the marks. And through still greater distances it may be flashed by what is termed *a relay*, so that there is no greater difficulty in forwarding a dispatch from New York to San Francisco than from New York to Boston.

The more securely chemistry had established its household, the more willingly were its services offered to its neighbors. In investigating the composition of minerals, an exact science was created out of our collections of specimens. What meaning had a mineral whose constituents were unknown, in which nothing was observable but what every layman could perceive, viz., color, hardness, and form? Owing to chemistry, mere knowledge about minerals ripened into the science of mineralogy; she induced basalt and granite to yield a *glass of water*, and taught the process of their formation.

Casual observations had shown that certain substances changed their color on exposure to light. This was especially the case with several silver compounds. The attempt to utilize this property resulted in the invention of photography. A film of albumen or collodion on a glass plate contains a material which, together with silver, makes up a substance sensitive to the action of light. Thus prepared, the glass plate is immersed in a *glass of water* containing an argentic solution. When the plate is exposed in an optical apparatus to the action of the luminous rays of an object, the result of this action is an image produced on the plate, though invisible to the eye. In the places acted upon by the light-rays, the connection between the constituents of the sensitive argentic substance is not dissolved entirely, but rendered very unstable. The additional action of an oxidizing agent, such as a ferrous salt or pyro-gallic acid, causes opaque metallic silver to be formed on the lighted parts of the image, and a reversed picture, the so-called negative, is produced. The plate is now dipped again into a *glass of water*, containing a substance which removes the last traces of the sensitive coating, leaving the darkened picture behind. In this way the negative is protected from any further influence of light. Of course, the picture is not recognizable, for the lights and shadows are reversed, but by the same process they can be reversed a second time. A sheet of paper is covered with albumen and thereby sensitized, then laid under the negative and exposed to the action of the sun. The parts of the paper under the darkened portions of the negative remain unchanged; those under the lighted portions are changed by the sunlight. On their withdrawing, by means of hyposulphite of soda, the sensitive substance remaining on the paper, a real picture of the object, the so-called positive, is obtained. This wonderful process of sun-drawing was also involved in the discovery of oxygen, albeit that accident and planless searching had much to do with it. Accident, however, was unthinkable, had not chemistry first defined the substances and their properties. In photography great use is made of iodine, an element existing in the ocean. An eminent chemist, Gay-Lussac, investigated and described this body, without which no photograph can be made. Who would have thought at that time that the violet vapors of iodine contained both an invaluable medicine and photography?

The most difficult task for chemistry was the investigation of the laws of life. All that was known in regard to this was, that the living organisms of the animal and vegetable kingdoms consisted of a few elements, say three or four, which were the same in both. The difference, then, in the manifold organisms of the kingdoms must needs be quantitative; and here the first want was an accurate method of analysis. This presented a difficult problem. The first successful experiments date back as far as 1809, but the method of determining weight was as yet so complicated and wasteful of time, and required so much skill and practice, that only a few substances could be analyzed. To investigate the two organic kingdoms with greater hope of success, an easier method of analysis must be found, and here we meet the name of a man whom Germany proudly calls her own.

To Justus Liebig belongs the merit of having discovered a method by which, without loss of accuracy, the whole process was greatly simplified, and of which he himself made extensive use. As his great teacher, Gay-Lussac, had done before him, he burned the organic substance to be analyzed, in a dry glass tube with oxide of copper, condensed the resultant water in an apparatus containing a water-absorbing salt, calcium chloride, and the resultant carbonic acid was absorbed in a *glass of water*. This last was a glass of a peculiar shape, with a clear liquid consisting of an aqueous solution of pure caustic potash. This glass of water, which has rendered such great services to humanity, bears the name of "Liebig's potash apparatus," and appears on his pictures as interwoven with the clouds of the higher regions, thus enabling the chemist to recognize the portrait even without the signature.

By that simplified method and by the aid of the labors of his many talented students, who now adorn most of the chairs of chemistry in Europe, as well as through the geniality of the master, the immense material from which he reared the structure of organic chemistry could be collected and properly used. Agricultural chemistry may be considered a part of organic chemistry; its province is to determine the laws of the growth of plants. The year 1840 is of the same importance in the history of the world as the years 1436, 1492, and 1774, which mark the invention of printing, the discovery of America, and that of oxygen.

A report upon the application of chemistry to agriculture, which Liebig had agreed to prepare for the British Association for the Advancement of Science, convinced him of the fact that the then existing views regarding this subject consisted mainly of errors. Instead, therefore, of reporting upon agricultural chemistry, he must first create the science. He demonstrated this in the ever-memorable report which may be said to contain nearly three-fourths of the agricultural chemistry of the present day. The immense materials collected by him and his assistants were of excellent service in this work, for they had closely investigated almost all the familiar ingredients of animals and vegetables, and, after comparing them, induced the great laws of nutrition and the mutual dependency of the two orders. He found that plants derived their nutriment solely from inorganic substances, taking their carbon from carbonic acid, their nitrogen from ammonia, their hydrogen from water; that animals drew their sustenance from organic substances only; that vegetable albumen had the same composition as the albumen in the egg and the blood, and that its admission was the result of its being dissolved by digestion. He then first announced the theory that the inorganic constituents, the so-called *ashes*, played an important part in the growth of vegetables, and that without their presence no vegetable structure could subsist. Thousands of facts and results of experiments had previously existed, but no one had found the law. After Liebig's announcement and demonstration, it became the starting-point of a new science.

He has not been spared the struggles which Copernicus and Lavoisier had to encounter; yet it may now be said that the warfare has terminated in his favor. The ships searching for guano-islands on the coast of Peru and in the Pacific Ocean do so upon the advice of Liebig; the agricultural colleges and similar institutions which sprang from his breath, may now be counted by the dozen. He was the first to assert that the most important changes and revolutions in the history of the world arose from the destruction of the wealth of the soil; and that the conquerors of the savage hordes of Central Asia were forced to march on by the violation of a law of Nature. Now, since the change of habitations is an unavoidable, ever-occurring element in the world's history, he who must be considered the greater conqueror is the man who teaches humanity what to do in order not to fall again a prey to Nature's law. Attila and Alaric were driven onward unconsciously, because forced by a natural law; far superior, far more powerful, is the natural philosopher who unfolds the law and teaches how to obey it. More enduring than the supremacy of the Roman Empire is the influence of that knowledge which teaches man how he may live on a soil for an unlimited period of time and with ever-constant result.

All this the illustrious inquirer obtained from the accurate investigations of animal and vegetable bodies; but the results would not have been possible without the improved method of analysis contained in that glass of water.

The causes of great inventions and discoveries have always been small, the results always incalculable—as incalculable as those of the glass of water spilled at Queen Anne's court. The investigator of Nature, therefore, must value every observation, every new fact, for they may result in *a glass of water*.

HAS OUR CLIMATE CHANGED?[1]

By DANIEL DRAPER, Esq.,
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Does the Clearing of Land affect the Fall of Rain?

MUCH solicitude is publicly felt as regards the supposed diminished quantity of water which fell last year—a point of the highest concern. There is a general impression that this alleged deficiency was to such an amount as to endanger a due supply to New York for the current year. And not only this, it has also been asserted that for several years past there has been a steadily occurring diminution in the rainfall. While the quantity of water has thus been becoming less and less, the demand has been becoming greater. Not only has the population of the city increased, but also that of the suburban districts, which derive their supplies from the same water-gathering grounds that we do.

I therefore, supposed, since the registering rain gauge furnishes very reliable measures, that it would be useful to examine this subject critically. But, since we have had these gauges in operation only about three years, and as the investigation proved to be full of interest, I was led to draw upon other additional sources of information, selecting such as seemed to be of the most trustworthy kind. By the aid of these the examination has been extended as far back as 1836, and with the following results:

1. As respects the indications given by our own instruments, which may be thoroughly relied on, for the years 1869, 1870, 1871.

For the first of these years, 1869, the total rainfall was 46.82 inches, distributed as follows:

During the first quarter	15.06	inches.
" " second "	10.24	"
" " third "	7.72	"
" " fourth "	13.80	"
Total	46.82	inches.

For 1870 the total rainfall was 42.32 inches, distributed as follows:

During the first quarter	12.86	inches.
" " second "	10.29	"
" " third "	9.39	"
" " fourth "	9.78	"
Total	42.32	inches.

[1] Abstract from the Meteorological Report of Daniel Draper, Director of Meteorological Observatory, Central Park, to the Commissioners of Public Parks (1871).

For 1871 the total rainfall was 52.06 inches, distributed as follows:

During the first quarter	10.33	inches.
" " second "	14.12	"
" " third "	14.21	"
" " fourth "	13.40	"
Total	52.06	inches.

So far as these years are concerned, there does not appear any evidence of a decrease; on the contrary, in the last there is a very considerable excess over either of the others.

Extending our examination to preceding years, as far back as the beginning of 1836, and grouping those years into three periods, each of ten, and one of six years, the statement comes to this:

First period from 1835 to 1846	39.5	inches.
Second " " 1845 to 1856	47.0	"
Third " " 1855 to 1866	52.0	"
Fourth " " 1865 to 1872	52.0	"

This would make the annual rainfall, throughout these thirty-six years, 47.62 inches. That of the last three years is 47.06 inches. These numbers being substantially the same, it may be concluded that, though there are large variations from year to year, these on the whole will neutralize one another, when very long periods of time are considered.

In the foregoing table the numbers from 1836 to 1854 inclusive are derived from the observations made by the military officers at Fort Columbus, New York Harbor; those for the next twelve years are from the records of Prof. Morris in New York City; and the remainder are from the registers of this observatory. It is, of course, assumed that the rainfall at Fort Columbus, that in New York City, and that in the Central Park, are the same—an assumption which, I suppose, is under the circumstances admissible.

The amount of rainfall not only influences in a predominant manner the growth of plants, and therefore agricultural pursuits, determining the profitable cultivation of many different crops, it also exerts an influence on several manufacturing operations. If, therefore, the above statement be correct, no apprehension need be entertained of a permanent disturbance in these particulars. Although in the last 36 years great changes have been made in all those portions of the United States intervening between the Mississippi and the Atlantic Ocean, large surfaces having been cleared of the primeval forest, and brought under cultivation, their physical character and aspect having therefore been essentially altered, no corresponding diminution can nevertheless be traced in the mean amount of water that has fallen. On the contrary, there has been an actual increase. It appears, therefore, that the wide-spread public impression, that the clearing of lan diminishes the volume of rain, is not founded on fact, and in trutl this is no more than might have been expected from a correct consideration of the meteorological circumstances under which rain is produced.

It is the belief of European meteorologists that the mean rainfall on the western portions of that continent varies little, if at all, when periods of many years are considered. In England there are rainfall records reaching back to 1677. Since 1725 these records are unbroken; at present there are more than 1,500 rain-gauge stations in that country. The Scotch observations extend to 1731, the Irish to 1791.

A discussion of the observations made at the Royal Observatory at Greenwich, in 1859, led to the conclusion that the annual fall of rain, as compared with that previous to 1815, was becoming smaller; but more extended observations, taken from gauges at stations widely separated, led to the opposite conclusion, viz., that there was a perfect compensation, the decrease at one place being compensated by the increase at another.

This conclusion was strikingly illustrated by the Continental observatories. The rainfall at Paris was found not to have altered in 130 years, and, though the observations of 50 years at Marseilles gave a decrease, those for 54 years at Milan gave an increase.

Even in the same locality this principle of compensation may be noticed. Thus the rainfall in England, in the ten years from 1850 to 1859, was found by Mr. Symons to be five per cent. less than during the previous 40 years, but during the following six years it was five per cent. above the mean of the preceding ten.

It may, however, be supposed, that conclusions which apply to the old settled countries of Europe, in which but few important topographical changes through agricultural or other operations have taken place for many years, will scarcely apply to America, wherein the clearing of land and agricultural surface changes have been occurring on a very extensive scale. The foregoing conclusions, however, show us how insignificant is the meteorological result which these variations produce.

The Available Supply of Water.

The actual supply of water does not depend on rainfall alone. It is diminished by evaporation and also by percolation. When the condition of the atmosphere is such that, either by reason of the heat, the prevalence of dry winds, and other such causes, the water that has fallen is exposed to rapid vaporization, the available supply necessarily becomes less.

As regards percolation, much depends on the rate at which the rain falls, and the contemporaneous condition of the surface of the ground. The supply may come so rapidly that there is not time for it to soak into the earth. In this manner the quantity that properly belongs to a whole month may fall in the course of a few hours, and, rushing over the surface, may be lost. Again, if the surface be frozen, it may be impossible for the water to percolate into the ground, and, though it may descend in a more moderate manner, it may, in this as in the preceding case, be lost. Obviously, there are many causes of the kind which might be referred to; these, however, are sufficient to indicate the principle involved.

We have shown that agricultural conditions do not perceptibly affect the rainfall; they do, however, very powerfully influence what may be designated as the rain-waste. Thus, a growing plant vaporizes from its leaves an immense amount of water which its roots have abstracted from the ground. A sunflower will thus remove twenty ounces of water in a single day. There is in this respect a waste which varies in the different months, being greatest in those during which general vegetation is most rapid, and less in those—the winter months—when it is torpid. For these and other such reasons the monthly distribution of rain influences the actual supply.

It is interesting to remark that the rainfall in New York greatly exceeds that of London. Here it is 47.62 inches, in London it is but 25 inches, and the mean for all England is estimated at 31.25 inches.

But these considerations of the amount of rainfall are only a portion of a far more general and most important problem, viz.:

Is the Climate of New York changing, or, more generally, is that of the Atlantic States undergoing Modification?

In this case, as in the preceding, there is a popular belief that clearing of land, drainage, and other agricultural operations, tend to produce such a result. Land that has been ploughed and exposes a dark surface to the sun, absorbs more heat, that is, becomes hotter, than land covered with forest-growth. It does not seem unreasonable, then, to suppose that, where thousands of square miles of surface have been submitted to such operations, the corresponding effect should be traceable, at least in the temperature of certain seasons of the year.

Moreover, there are some interesting facts which are matters of public observation and constant remark. Thus, as every one knows, in the city of New York itself, there are no longer the deep snows which characterized the winter seasons years ago. The large sleighs, often drawn by very many horses, used in those times as the public conveyances, have altogether disappeared from the streets. It would seem, therefore, that the winters have become milder. In like manner, though in support of this conclusion we have less palpable evidence, there is a very general opinion that the intolerable and long-continued heats, which formerly made the summer months almost unbearable, have greatly moderated, and, that, though the thermometer may occasionally rise as high as it formerly did, the continuance of the hot weather is shorter.

This popular opinion of change of climate through agricultural operations is far from being restricted to America. In Western Europe there is a belief that a great amelioration has taken place in all the Baltic countries since the time of the Roman domination.

In many instances these popular impressions are contradicted by well-ascertained facts. Thus, as respects the Baltic, there are records of the time of the breaking of the ice in some of the great rivers, such as the Dwina and Neva, for several centuries. These show that, during the last 300 years, the variation amounts but to a fraction of a single day.

Such fragments as have been preserved of the observations of the first discoverers of North America—the Icelandic voyagers—have been supposed to prove a change in the climate of New England during the last 800 years, it being affirmed that the vine formerly flourished in regions where it cannot now exist. One of the first papers communicated to the American Philosophical Society, in Philadelphia, was by Dr. Williamson, offering proof that, during the previous 40 or 50 years, a very great climate change had taken place; he attributed it to cultivation. Soon afterward, Dr. Williams, of Harvard University, offered evidence that the climate of Boston had changed 10° or 12° in about 160 years. A close examination of the evidence by more recent authorities has, however, shaken these conclusions. Thus, as regards the Icelandic voyages, it is shown that the description they give of the forest-growth of New England is the same that might be given now. Humboldt, in his "Views of Nature," comes to the conclusion that there has not been any change in the climate of the United States since its first colonial settlement, and in this, Noah Webster, Forry, and other American writers agree.

It is evident, however, that in a rapidly-growing city there are several local causes which may be assigned as giving origin to an increase of temperature. The quantity of fuel burnt increases with increased population and with the number of houses, and this must exert a perceptible effect in ameliorating the rigor of winter. Moreover, on sunshiny days, the reflection and radiation of the sun's warmth from the vertical sides of the houses must tend in no inconsiderable degree to raise the temperature locally, and aid in producing a thaw. The facts observed in a city are hence not a complete guide in the discussion of general climate changes.

If our climate be gradually changing, if the heat of summer is becoming less excessive, and the cold of winter more moderate, there are impending over us modifications in our social habits, and in many of our business occupations. Not only is the settlement of this question interesting in a meteorological or scientific point of view—the sanitary, engineering, manufacturing, mercantile, and agricultural consequences are also of the utmost importance.

Impressed with these considerations, I was therefore led to extend my researches from the rainfall question to this more general problem; and, with the intention of not being misled by local observations made in the city itself, which, as we have just remarked, are not altogether to be trusted, I have resorted to data of a more general topographical kind, such, for instance, as the times of closing and opening of the Hudson River. Also, with a view of extending the conclusions, whatever they might prove to be, to the Atlantic coast generally, I have used such published records of the meteorology of Philadelphia, Boston, and Charleston, as I could find access to. These reach from 1738, with certain breaks, up to the present time.

TABLE SHOWING THE NUMBER OF DAYS THAT THE HUDSON RIVER HAS BEEN CLOSED BY ICE.

FIRST PERIOD.		SECOND PERIOD.		THIRD PERIOD.		FOURTH PERIOD.		FIFTH PERIOD.	
Years.	Days closed.	Years.	Days closed.	Years.	Days closed.	Years.	Days closed.	Years.	Days closed.
1817–18	108	1827–28	75	1837–38	94	1847–48	89	1857–58	82
1818–19	110	1828–29	100	1838–39	116	1848–49	82	1858–59	85
1819–20	102	1829–30	63	1839–40	65	1849–50	73	1859–60	85
1820–21	123	1830–31	82	1840–41	109	1850–51	69	1860–61	80
1821–22	92	1831–32	111	1841–42	47	1851–52	105	1861–62	100
1822–23	90	1832–33	80	1842–43	136	1852–53	91	1862–63	109
1823–24	78	1833–34	73	1843–44	95	1853–54	85	1863–64	82
1824–25	60	1834–35	100	1044–45	74	1854–55	108	1864–65	94
1825–26	75	1835–36	125	1845–46	100	1855–56	111	1865–66	90
1826–27	86	1836–37	111	1846–47	112	1856–57	93	1866–67	103
Mean of 10 y's	92 days.		92 days.		94 days.		90 days.		91 days.

The data connected with the Hudson River have been derived from the Annual Reports of the Regents of the University; those of temperature for the locality of New York itself, from the observations taken at Fort Columbus, and by Prof. Morris, for the Smithsonian Institution. The remainder are from the records of this observatory. In the case of other Atlantic cities, the data are chiefly derived from the reports of the United States Army officers to the Secretary of War.

It appears from this that, from 1816 to the present time, we have an unbroken register. Taking 1817 as our starting-point, we have to 1868 five periods of ten years each. The number of days during which the river was closed in each of these five periods is: For the first, 92 days; second, 92; third, 94; fourth, 90; fifth, 91.

The third period gives a greater number of days than any of the others; the general mean is about 91 days.

The conclusion at which we arrive from the evidence thus furnished by the Hudson River is, that during 50 years, that is to say, the whole period of trustworthy records, there has been no important change in the number of days that the river has remained frozen. In this respect the conclusion is the same as that which we have seen in the case of the Baltic rivers for a period of 300 years.

The evidence thus furnished from the closure of a river by ice differs from that of thermometric observations. The latter give merely the intensity of heat at the special moment, and in the special locality at which the observation is made. The former represents the quantity of heat over a long line, including many localities. It is, therefore, the better form, and furnishes more trustworthy results.

Turning now to the records of the city of New York, as obtained from the sources above specified, we find they are continuous from 1821 to the present time. It would extend this report unduly were we to enter on an examination of each of these years respectively. Making a selection, then, let us compare the following groups of five years—first, from 1821 to 1827; second, from 1831 to 1837; third, from 1841 to 1847; fourth, from 1866 to 1872. It will be understood that the months selected are January, February, and March.

TABLE, SHOWING THE MEAN TEMPERATURE IN NEW YORK, FOR THE FIRST THREE MONTHS OF THE YEAR, JANUARY, FEBRUARY, AND MARCH.

FIRST PERIOD.		SECOND PERIOD.		THIRD PERIOD.		FOURTH PERIOD.	
Years.	Temperature.	Years.	Temperature.	Years.	Temperature.	Years.	Temperature
1822	32.71	1832	33.25	1842	38.81	1867	30.94
1823	30.96	1833	33.95	1843	30.81	1868	29.46
1824	34.78	1834	35.04	1844	31.43	1869	34.77
1825	36.36	1835	30.72	1845	36.36	1870	34.27
1826	32.62	1836	27.18	1846	32.69	1871	34.22
Mean for 5 y's.	33.48		32.02		34.02		32.73

The mean for January, February, and March, for thirty-three years, is 32.90 degrees. The mean for the above selection is 33.06 degrees.

The evidence thus derived from thermometric observations corroborates that derived from the freezing of the river, and undeniably leads to the conclusion that, if there has been any change in the winter climate of New York, it cannot be demonstrated by the extant thermometrical records of the last fifty years. This, therefore, adds weight to Humboldt's conclusion that there has been no sensible change in the Atlantic States since the time of their first settlement.

Let us next see what is the evidence afforded by an examination of the Philadelphia records. As in the preceding case, a discussion of all these would be too lengthy. They go as far back as 1748, but present, however, a broken series. Selecting from this, here and there, periods of five years, we may thus group them: first, from 1766 to 1772; second, from 1797 to 1803; third, from 1821 to 1827; fourth, from 1831 to 1837; fifth, from 1851 to 1857.

TABLE, SHOWING THE MEAN TEMPERATURE OF PHILADELPHIA, FOR THE FIRST THREE MONTHS OF THE YEAR, JANUARY, FEBRUARY, AND MARCH.

FIRST PERIOD.		SECOND PERIOD.		THIRD PERIOD.		FOURTH PERIOD.		FIFTH PERIOD.	
Year.	Temperature.	Year.	Temperature.	Year.	Temperature.	Year.	Temperature.	Year.	Temperature.
1767	35.06	1798	36.20	1822	33.40	1832	37.66	1852	34.10
1768	37.83	1799	35.13	1823	32.53	1833	37.33	1853	37.83
1769	35.66	1800	33.96	1824	35.36	1834	38.50	1854	36.56
1770	35.50	1801	36.70	1825	37.93	1835	33.33	1855	34.00
1771	35.33	1802	39.20	1826	36.33	1836	27.96	1856	27.66
Mean for 5 years.	35.87		36.23		35.11		34.95		34.03

The mean for January, February, and March, for fifty-six years, is 35.56 degrees. The mean for the above selection is 35.23 degrees.

From this, it would seem that the mean temperature of the first three months of the year at Philadelphia is 2.66 degrees above that of New York, and that the same conclusion arrived at in the preceding instances reappears in this, viz., that there has been no change in the winter climate.

The Boston records reach back to 1780. Taking the same periods as in the preceding instances, as far as these records will permit, they are—first, 1797 to 1803; second, 1821 to 1827; third, 1831 to 1837; fourth, 1850 to 1856. It is to be remarked that these observations are not all from the same station.

TABLE, SHOWING THE MEAN TEMPERATURE OF BOSTON FOR THE FIRST THREE MONTHS OF THE YEAR, JANUARY, FEBRUARY, AND MARCH.

FIRST PERIOD.		SECOND PERIOD.		THIRD PERIOD.		FOURTH PERIOD.	
Year.	Temperature.	Year.	Temperature.	Year.	Temperature.	Year.	Temp'rature
1798	29.83	1822	29.26	1832	31.00	1851	30.53
1799	27.33	1823	27.63	1833	29.86	1852	27.03
1800	29.80	1824	31.60	1834	32.16	1853	30.26
1801	31.36	1825	33.16	1835	28.50	1854	26.46
1802	32.86	1826	31.26	1836	26.52	1855	26.96
Mean for 5 y's.	30.23		30.58		29.61		28.25

The mean for January, February, and March, for eighty-six years, is 29.63 degrees. The mean for the above selection is 29.66 degrees.

The mean temperature for the first three months of the year at Boston is 3.27 degrees lower than that of New York. These records give no substantial reason for supposing that, during the period of time to which they refer, there has been any sensible change in the winter climate of that locality.

In like manner, making a selection from the Charleston records, first, from 1749 to 1755; second, from 1754 to 1760; third, from 1822 to 1829; fourth, from 1830 to 1836; fifth, from 1849 to 1855—which date from 1738.

TABLE, SHOWING THE MEAN TEMPERATURE OF CHARLESTON FOR THE FIRST THREE MONTHS OF THE YEAR, JANUARY, FEBRUARY, AND MARCH.

FIRST PERIOD.		SECOND PERIOD.		THIRD PERIOD.		FOURTH PERIOD.		FIFTH PERIOD.	
Year.	Temperature.	Year.	Temperature.	Year.	Temperature.	Year.	Temperature.	Year.	Temperature.
1750	51.00	1755	51.66	1823	49.56	1831	51.26	1850	53.98
1751	54.33	1756	59.00	1824	54.06	1832	54.66	1851	56.26
1752	55.33	1757	53.33	1825	54.83	1833	55.20	1852	52.13
1753	57.00	1758	52.00	1827	55.73	1834	55.10	1853	52.20
1754	59.33	1759	48.66	1828	63.40	1835	46.20	1854	52.20
Mean for 5 years.	55.39		52.93		55.51		52.48		53.34

In this series, again, unfortunately the observations are from different stations. They exhibit greater divergences than any of the preceding cases; but notwithstanding that, so far from invalidating, they strongly confirm the conclusion arrived at in those cases. Thus the mean of the first series is substantially the same as that of the third, being 55.39 and 55.51 respectively, though there is between them an interval of seventy-three years. The mean of the second is substantially the same as that of the fourth, being 52.93 degrees and 52.48 respectively, their interval being seventy-six years; and it may be especially remarked that the mean of the fifth series is very nearly the mean of all the other four, theirs being 54.07, and its 53.34 degrees.

Thus, again, we reach the same conclusion in the case of the city of Charleston that we arrived at in the case of New York, Philadelphia, and Boston, that the winter climate has not undergone any change.

The general conclusion which this examination seems to warrant, both as regards rainfall and winter climate, is this, that there has been no change in the lapse of many years. None can be substantiated as having occurred within a century. This proves that surface changes through agriculture, drainage, etc., give rise to no appreciable meteorological effect, and that the public opinion which asserts such an influence is altogether erroneous.

Only recently have precise and correct views been entertained of the progress of atmospheric changes. It is now known that cloudy weather, or rains, or fluctuations of the barometer and of the thermometer, are not of restricted or local origin, but that they have a progress in a determinate direction, often of thousands of miles. This fact is at the basis of the duties in which the Storm-Signal Corps is so ably engaged. In many parts of the United States there are prairie or treeless regions several hundreds of square miles in extent, yet these are not rainless because they are treeless; clouds drop water upon them to the same amount that they do on the neighboring wooded regions. Considerations such as these may satisfy us that the surface modifications which the Atlantic States have undergone, since their first settlement, have produced no meteorological effect, and that the rainfall and winter probably remain the same. that they were many centuries ago.

I have restricted myself, in the foregoing climate examinations, to the winter season, and have said nothing as regards the summer. Had I done otherwise, it would have extended this report to an inconvenient length. Perhaps, however, what has here been substantiated, as to the permanency in the cold of the winter, will be held as affording strong presumptive evidence of a like permanency in the heats of summer, and that in these respects there is a mean degree which is maintained through indefinitely long periods of time.

While such is our final conclusion, we must bear in mind that these mean or average results exhibit only one phase of the problem. They do not show the fact that there are brief cycles of heat and cold, of moisture and dryness, following each other under the operation of some unknown law, a law perhaps not of a meteorological but of an astronomical origin.

We should remember, however, the imperfections and probable errors of the old tables. In former times due care was not taken in the construction and verification of the thermometers. Making every allowance for this, we may perhaps admit that the conclusion at which we have arrived cannot be very far from the truth.

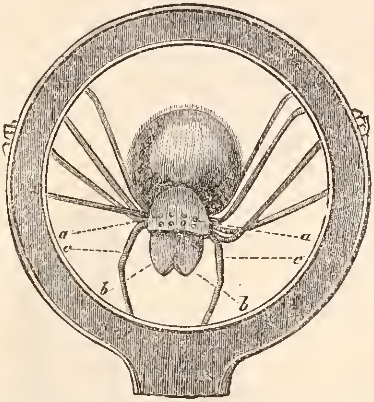
AS REGARDS SPIDERS.

"WHAT can there be interesting in that commonplace, repulsive little creature, which infests our houses, annoys us by its presence, and shocks our sense of decency with its filthy webs—in that cruel little monster, whose whole life is employed in weaving snares to entrap unwary flies; lying in wait for them in dark, damp corners of crevices, murdering them remorselessly when they are caught in its toils, and then sucking their life's-blood? The house-spider, indeed! Why, we sweep it from the very face of Nature wherever we find it, together with its chamber of horrors; and it must indeed be some strong temptation that would induce one to defile one's hands by contact with a creature the very idea of which suffices to inspire terror and disgust."

It is true that spiders are not very lovable creatures, but this is a prejudiced statement. Spiders are only repulsive as long as we are ignorant of them. If we will but stop to observe their wonderful structure and their ingenious ways, we shall quickly get rid of these foolish notions, and find that the creature will richly repay us for the time and pains of studying it. Spiders have a great deal of character, and, although very savage, they have also much in common with the vaunted heads of creation. Let us consider some of their peculiarities.

Spiders were formerly classed as insects, and they are commonly so regarded still, but this is an error. Insects have but six legs, while spiders have eight; there is a division in insects between the head and the trunk, but spiders have no separate head, the head and thorax being fused together, under the name of *cephalothorax.* In many kinds, body, thorax, and abdomen, are so closely merged together that their parts cannot be traced. Again, insects undergo metamorphoses or transformations in their growth, while spiders do not. They belong to a group which includes mites and scorpions, and is named the *Arachnida.* There are multitudes of different kinds, and they vary in dimensions from the size of a grain of sand to several inches in diameter. Some spiders are met with in all parts of the world, and some are limited to special localities; some live in the fields, and others on the water; some dwell habitually in houses, and others are driven in by cold weather; some inhabit the cellar, and others establish themselves in the corners of rooms, the angles of windows, openings in the wood-work, or chinks in the walls, and each has its special adaptations and modes of life.

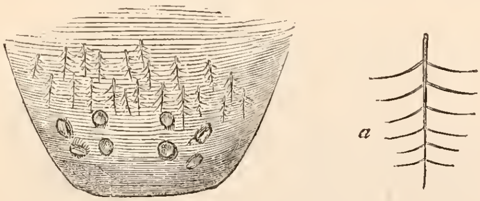
Fig. 1.



The Female House-Spider (*Tegenaria domestica*), as seen with a Magnifier.—*a a*, Eyes; *b b*, Mandibles; *c c*, Maxillary Palpi.

Fig. 1 represents a small house-spider as seen under a magnifying-glass. It has eight eyes, simple in structure, and incapable of motion, but disposed in two rows on the top of the head, so that they enable the creature to espy its prey, from whatever quarter it may approach. Fig. 2 is this part of the animal represented still more highly magnified.

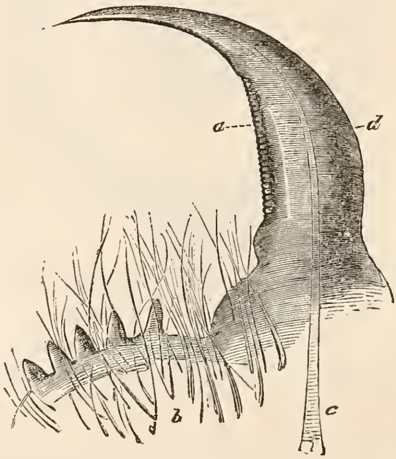
Fig. 2.



Enlarged View of Anterior Portion of Cephalothorax, bearing the Eight Eyes, and Hairs.—*a*, one of the Hairs magnified.

Spiders, being carnivorous, must make other creatures their prey, and they are very effectually provided with the means of doing so. No other animal is so terribly armed. Below the eyes (Fig. 1, *b b*) you perceive the large basal joints of the jaws, or mandibles as they are termed, with which they do their small work of butchery. Fig. 3 shows the appearance of this deadly instrument greatly magnified. "Picture to yourself a pair of huge, sharp-pointed jack-knives with extremely broad handles, the blades being so opposed to one another, that, when they are forcibly driven into an object, their pointed extremities encounter each other in the centre. Then conceive these knives to have the edges of their blades serrated with a row of fine teeth commencing near the haft, and on the handle itself five large, pointed teeth, shaped like the head of a lance, and upon which the saw-like blade can be brought to work to and fro." The large claw or horn (Fig. 3) answers to the blade, *a* representing its fine teeth, while *b* shows the five lance-like teeth in the handle against which the blade works. But, besides these mandibles, the spider possesses a smaller pair of jaws, called

Fig. 3.

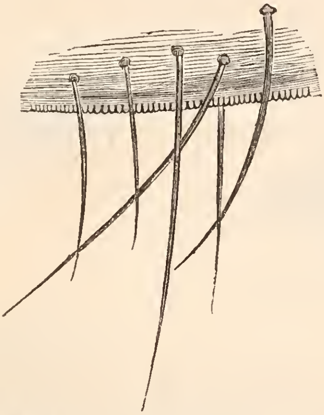


Termination of the Jaw, or Mandible.—*a*, Row of Teeth on the Claw; *b*, Basal Joint of Mandible, showing the Five Large Teeth; *c*, Commencement of Poison-sac; *d*, Course of the Poison-duct. The last two are only visible when the mandible has been carefully bleached with chlorine.

the "maxillæ," which also have finely-toothed edges like deeply-cut rasps that most probably operate one against the other, to enlarge the wound made by the mandibles. This looks formidable enough, but it is not the worst. Nature has equipped the spider for very thorough work. This combination of dirks and saws is poisoned. At the basal joints of the mandibles there is a receptacle filled with a subtle venom which is conveyed through a tube (Fig. 3, *d*) to the pointed extremity of the blade. The moment this pierces the body of the prey, the poison is emitted, and, entering the wound, renders it fatal, probably at the same time benumbing the sensibility of the victim. The injected poison is nearly colorless, and possesses most of the properties that exist in the venom of the rattlesnake or the viper. The bite of a large spider on the back of the hand has been known to swell the whole arm, so that it was hardly recognizable as belonging to the human figure.

There is a famous spider called the *tarantula*, from the town of Tarentum, in Italy, where it is plentiful. It is believed by the people of that region that the bite of the tarantula produces the most extraordinary effects—a silent melancholy, and convulsive movements, which can only be cured by music, while a certain tune is needful in each particular case. No doubt an epidemic nervous disease spread among persons of both sexes in this community, but it was a kind of contagious hysteria, that had nothing to do with the tarantula. That

Fig. 4.

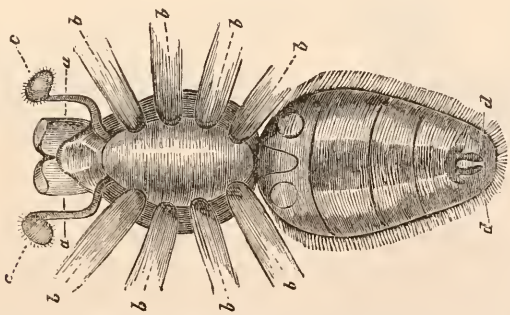


Edge of Maxilla, greatly enlarged, showing Teeth and Hairs.

this malady was cured by music, and consequent dancing, is very probable. The patient having indulged in long and continuous exercise, producing violent perspiration, became exhausted, fell asleep, and awoke cured.

The legs of the spider are admirably adapted to its peculiar mode

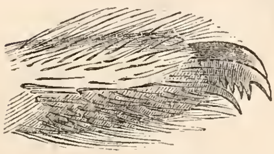
Fig. 5.



View of Under Surface of *Male* Spider, with the First Joints of the Legs.—*a a*, Mandibles; *b b*, Legs; *c c*, Maxillary Palpi; *d d*, Spinnerets.

of life. Fig. 5 represents the under surface of its body. Its eight legs are disposed in an oval upon the cephalothorax, and are long and slender, each having seven joints. They are suited for firmly grasping its prey, and, when stretched out, while the creature is watching or moving, they cause the weight of the body to be distributed over a large surface of the fragile web. All this preparation for war is not thrown away, as spiders are plucky and desperate fighters. Although consummate strategists, and availing themselves to the utmost of cunning snares, they are ever ready for an attack, and fight ferociously. Their muscular force is very great, and some of them are so tenacious

Fig. 6.



Terminal Point of the Spider's Foot, showing the Hooked Comb.

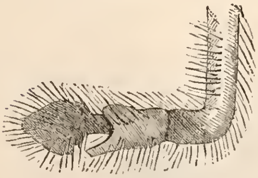
Fig. 7.

One of the Combs, highly magnified.

that it is difficult to make them let go their hold of the enemy that has been seized. Of the great crab-spider it is said that the obstinacy and bitterness which it exhibits in combat cease only with its life. Some of them have been seen, which, though pierced twenty times through and through, still continued to assail their adversaries without showing the least desire of escaping them by flight.

But let us proceed with the animal's structure. The long, many-jointed legs are terminated with a beautiful apparatus resembling a

Fig. 8.



Last Joint of one of the Maxillary Palpi of Male Spider.

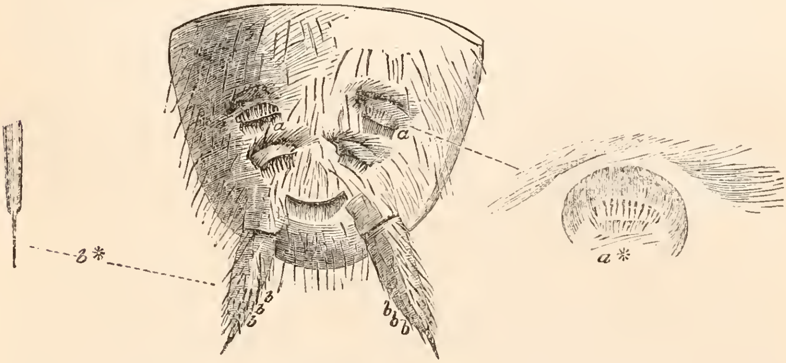
Fig. 9.

The same in the Female.

comb, with a pointed hook at the extremity. These instruments are not only of service in its encounters with enemies, but they are skilfully constructed to grasp, card, disentangle, or wind its threads with the utmost facility. Nothing comparable to it for this purpose can be found among all the contrivances of our factories. Again, glancing at Fig. 5, we notice, on either side of the head, what might be mistaken for a fifth pair of shorter legs: these are the *maxillary palpi*, which probably correspond partially to the feelers or antennæ of insects. They differ in the male and female, and the club-shaped palpi are said to serve a most remarkable physiological end in connection with generation. The palpi of the male are furnished with several hooks, and a kind of cup (Fig. 8), while those of the female taper to a point, and are armed at the extremity with a toothed comb, like those at the end of the feet, and with several long, sword-shaped hairs.

But if, at the anterior extremity of the spider, we see in miniature the most perfect enginery of destruction, at its posterior extremity there is an equally marvellous device for the work of construction. If you direct your lens to the abdominal segment, you will observe what is represented in Fig. 10. The projections there seen are called *spinnerets*, and are contrivances for producing the web. One pair is prominent, the remaining two pairs having the appearance of circlets (Fig. 10, *a*), and they are all studded over with rows of little microscopic tubes (Fig. 10, *b b*). From these minute tubes there exudes a glutinous substance prepared in the spider's body, which solidifies into

Fig. 10.



Posterior Portion of Spider's Body, showing the Six Spinnerets.—*a*, Shorter Spinnerets, with Circlets of Tubes; *a**, the same magnified; *b b b*, Spinning-tubes on Long Spinnerets; *b**, Single Tube magnified.

a fine, strong filament as soon as it is exposed to the air. The microscope has proved that every one of these almost invisible fibres is composed of hundreds of finer ones, just as a ship's cable is formed of minute hempen fibres, while the main strand is spun far more rapidly than the eye can follow the process. The strength thus secured is very great, and the line is not only strong but elastic, like an India-rubber thread. Leuwenhoek, the renowned microscopist, who studied this subject carefully, made some extraordinary statements in regard to the minuteness of these threads. Some spiders, he says, that are not larger than a grain of sand, spin complex cords of which it would take millions to equal in thickness one of the hairs of his beard. If we ask why the mechanism was not simplified so that the animal should pay out only a single line, the obvious reply is that the multitude of finer filaments were necessary for quick drying and the firmest cohesion. It is a remarkable fact that the spinnerets are under the prompt control of the spider's will, so that, in dropping from a height by the rapidly-forming line, the descent can be instantaneously stopped at any point. It is equally curious that, in ascending the line, a spider winds up the superfluous cord into a ball, and has a special claw or comb inserted between the others for the purpose.

Some kinds of spiders take to ballooning or migrating from place to place through the air. For this purpose they spin those long, loose and amazingly attenuous threads called *gossamer*, which exert a buoyant influence by which the animal is enabled to commit itself to atmospheric currents and move from place to place, and by which it gains the partial advantage of wings.

In the construction of webs for the snaring of its prey, the resources of the spider are endless. Dr. Samuelson, from whose admirable monograph our illustrations are taken, says: "With wonderful rapidity and instinct, the spider employs these threads to weave its web, or wanders from place to place, often constructing a perfect net, to entrap its prey, upon accurate geometrical principles, in less than an hour; and, what is most remarkable of all, performing this task in what to us would be total darkness. There are many other curious and mysterious circumstances connected with these webs. The garden-spider, for instance, covers all the concentric filaments of its net, at regular intervals, with glutinous or adhesive globules, presenting under the microscope the appearance of pearls strung upon a thread, and destined to facilitate the capture of its prey."

The work of the geometrical spiders may at almost any time in the proper season be observed in the garden. As the flight of insects is mainly in an horizontal direction, the net is usually fixed in a perpendicular or somewhat oblique position to intercept them. The first thing is to enclose a space with strong lines as a kind of frame, within which the web is to be formed. It is immaterial what is the shape of this enclosed area, as the spider is aware that she can as well inscribe a circle in a triangle as in a square. But these outside lines must be strong, and so they are formed of several threads glued together and attached to various objects of support. Mr. Spence thus describes the subsequent construction: "Having completed the foundations of her snare, she proceeds to fill up the outline. Attaching a thread to one of the main lines, she walks along it, guiding it with one of her hind-feet that it may not touch in any part, and be prematurely glued. and crosses over to the opposite side, where, by applying her spinners, she firmly fixes it. To the middle of this diagonal thread, which is to form the centre of her net, she fixes a second, which, in like manner, she conveys and fastens to another part of the lines encircling the area. Her work now proceeds rapidly. During the preliminary operations she sometimes rests, as though her plan required meditation. But no sooner are the marginal lines of her net firmly stretched, and two or three radii spun from its centre, than she continues her labor so quickly and unremittingly that the eye can scarcely follow her progress. The radii, to the number of about twenty, giving the net the appearance of a wheel, are speedily finished. She then proceeds to the centre, quickly turns herself round, and pulls each thread with her feet to ascertain its strength, breaking any one that seems defective and replacing it by another. Next, she glues immediately round the centre five or six small, concentric circles, close to each other, and then four or five larger ones, each separated by a space of half an inch or more. These last serve as a sort of temporary scaffolding to walk over, and to keep the radii properly stretched while she glues to them the concentric circles that are to remain, which she now proceeds to construct. Placing herself at the circumference, and fastening her thread to the end of one of the radii, she walks up that one toward the centre, to such a distance as to draw the thread from her body of a sufficient length to reach to the next; then stepping across, and conducting the thread with one of her hind-feet, she glues it with her spinners to the point in the adjoining radius to which it is to be fixed. This process she repeats until she has filled up nearly the whole space from the circumference to the centre with concentric circles, distant from each other about the sixth of an inch. Besides the main web, the spider sometimes carries up from its edges and surface a number of single threads, often to the height of many feet, joining and crossing each other in various directions. Across these lines, which may be compared to the tackling of a ship, flies seem unable to avoid directing their flight. The certain consequence is that, in striking against these ropes, they become slightly entangled, and, in their endeavors to disengage themselves, rarely escape being precipitated into the net spread underneath for their reception, where their doom is inevitable."

The weaving-spider that is found in houses having selected a suitable site, in the same way forms first the margin or selvage of her web. From these she draws other threads, the spaces between which she fills up by running from one to the other, and connecting them by new lines, until the gauze-like texture is formed. The spider seems to be aware that she is no beauty, and had better conceal herself; so she constructs a small silken apartment, completely hidden from view, in which she lies in wait for her victims. But as this is often at a distance from the net, and entirely out of sight of it, how is she to know when an insect is caught? To meet this emergency, she spins several threads from the edge of the net to that of her hole, which answers as a telegraph by its vibrations, and is a railroad over which she can pass to secure it.

In their vital physiology spiders are quite as wonderful as in their other characters. We have said that they do not undergo metamorphoses, like insects, but the common household spider, which we have figured (*Tegenaria domestica*), changes its integument, or skin, nine times before arriving at maturity, once in the cocoon and eight times after quitting it. If they lose a leg it is quickly reproduced, and this may take place half a dozen times in succession. Mr. Wood says, indeed, that "the harvest-spider seems to set little store by its legs, and will throw off one or two of them on the slightest provocation. Indeed, it is not very easy to find a harvest-spider with all its limbs complete; and, if such a being should be captured, it is nearly certain to shed a leg or two during the process. It appears to be totally indifferent to legs, and will walk off quite briskly with only half its usual complement of limbs. I have even known this arachnid to be deprived of all its legs save one, and to edge itself along by this solitary member, in a manner sufficiently ludicrous. The cast legs contain much irritability, and, even after they have been severed from the body, continue to bend and straighten themselves for some little time." The household spider above referred to lives four years; and the female, after one impregnation, is capable of producing nine sets of prolific eggs in succession, more than two years elapsing before all are deposited.

Morally, the spider has a bad reputation, and is the subject of many vile epithets; but, when compared with its accusers, it presents by no means a bad case. The Arachnidian ethics are in many respects strikingly coincident with more ambitious systems. The spider practises the virtues of industry, patience, and perseverance, under difficulties. The female is an affectionate parent, and very fond of her young. About June the garden-spider makes up her little packet of eggs, and encloses them in a snow-white silken envelope, and carries it about with her wherever she goes. If it is forcibly removed, she remains on the spot, hunting in every direction, and evidently in great distress; and if the white ball be laid near her she soon spies it, darts at it almost fiercely, and carries it off. "When the time comes for the little spiders to make their appearance in the world, the mother tears open the envelope, and so aids her young to escape. As soon as they are fairly out of the egg, they transfer themselves to the body of their parent, where they cling in such numbers that she is hardly visible under her swarming brood. They remain with their mother through the winter, and in the following spring the bonds of mutual affection are loosened, and the young disperse to seek their own living." If the spider is a skilful hunter and an ingenious trapper, so are the heroes of many novels; but the animal has not yet been known to indulge its predaceous practices in the way of mere wanton sport. It is merciless and cruel, like inquisitors and tyrants, but does not perpetrate its cruelties on the ground of difference of opinions. It is moved by self-interest, the alleged basis of all political economy. The spider "must live, you know," and it is a maxim with it to "look out for number one;" while it has a high appreciation of the advantages of "corner lots," but in all this it is by no means singular. Besides, the spider contributes its share to the general weal. What would this world come to, if the flies could have their own way in it without let or hindrance? Killing flies is a necessary and righteous thing, and, as it is jointly undertaken by men, women, and spiders, for purposes of common beneficence, each should have an aliquot share of the honor. The spider, as we have seen, is also courageous and soldierly. He is fond of war, and, having taken a position, is very apt to "fight it out on that line," or system of lines, till crowned with victory. But it invests war with no sentiment of "glory," does not dress it up with gilt and feathers, nor use its passions as political stock-in-trade. Sundry misanthropes have claimed for the spider a standard of virtue higher than the human, as witness the following effusion:

"Ingenious insect, but of ruthless mould,
  Whose savage craft, as Nature taught, designs
  A mazy web of death—the filmy lines
That form thy circling labyrinth enfold
Each thoughtless fly that wanders near thy hold,
  Sad victim of thy guile; nor aught avail
  His silken wings, nor coat of glossy mail,
Nor varying lines of azure, jet, or gold;
Yet though thus ill the fluttering captive fares,
  Whom heedless of the fraud thy toils trepan;
Thy tyrant fang that slays the stranger, spares
  The bloody brothers of thy cruel clan;
While *man* against his fellows spreads his snares,
  Then most delighted when his prey is *man*."

This is tolerable poetry, but very poor science. Truth compels us to drag the spider down to the human level—it does kill its own kind. Had it not been for this habit, men would have long ago enslaved the spiders to the silk-business. It is again charged that the spider is a cannibal, and, having killed his fellow-citizens, proceeds to devour them. But here, again, the spider can claim no originality, and is but an humble imitator of the lords of creation. It has, moreover, been accused of practising murder under very delicate circumstances, when its mind should only be occupied with tender feelings. It is true that love and courtship in the Arachnidian world are apt to be tragical. These creatures are quite too literal in their construction of the phrases, "You will kill me with your coldness," "Love me or I die;" but, in a higher sphere, does not love often become a bloody business of suicide and murder? Yet to the honor of humanity be it said, spiders do one thing which our sort do not: they kill their lovers, and then eat them up on the spot. In many species the male is much smaller than the female, and with these courtship is perilous. The female of the garden-spider is a perfect Amazon, and, when she happens to object to the attentions of her intended spouse, he has to fly for his life; a feat which he generally performs by flinging himself like lightning out of the web, and lowering himself quickly to the earth by his silken ladder.

We here reach the perplexing question of "female rights," but decline to pursue it. "The Poet at the Breakfast-Table" has just bravely taken it up from this point of view, recommending the reformatory ladies to organize "Arachnoid Associations," with "Spinsters and Spiders" for a motto, and we leave the subject trustingly in his hands.

MAN AS THE INTERPRETER OF NATURE.

By WILLIAM B. CARPENTER, LL. D., F. R. S.[1]

It has been customary with successive occupants of this chair to open the proceedings of the meetings over which they respectively presided with a discourse on some aspect of Nature in her relation to man. But I am not aware that any one of them has taken up the other side of the inquiry—that which concerns man as the "Interpreter of Nature;" and I have therefore thought it not inappropriate to lead you to the consideration of the mental processes by which are formed those fundamental conceptions of matter and force, of cause and effect, of law and order, which furnish the basis of all scientific reasoning, and constitute the *Philosophia prima* of Bacon. There is a great deal of what I cannot but regard as fallacious and misleading philosophy—"oppositions of science, falsely so called"—abroad in the world at the present time. And I hope to satisfy you that those who set up their own conceptions of the orderly sequence which they discern in the phenomena of Nature as fixed and determinate laws, by which those phenomena not only are, but always have been, and always must be, invariably governed, are really guilty of the intellectual arrogance they condemn in the systems of the ancients, and place themselves in antagonism to those real philosophers by whose grasp and insight that order has been so far disclosed. For what love of the truth, as it is in Nature, was ever more conspicuous than that which Kepler displayed in his abandonment of each of the conceptions of the planetary system which his imagination had successively devised, so soon as it proved to be inconsistent with the facts disclosed by observation? In that almost admiring description of the way in which his enemy Mars, "whom he had left at home a despised captive," had "burst all the chains of the equations, and broke forth from the prisons of the tables," who does not recognize the justice of Schiller's

[1] Inaugural Address of Dr. Carpenter before the British Association for the Advancement of Science, at Brighton, England, August 14, 1872, upon assuming the chair as president of that body.

definition of the real philosopher—as one who always loves truth better than his system? And when at last he had gained the full assurance of a success so complete that (as he says) he thought he must be dreaming, or that he had been reasoning in a circle, who does not feel the almost sublimity of the self-abnegation with which, after attaining what was in his own estimation such a glorious reward of his life of toil, he abstains from claiming the applause of his contemporaries, but leaves his fame to after-ages in these noble words: "The book is written; to be read either now or by posterity, I care not which. It may well wait a century for a reader, as God has waited 6,000 years for an observer."

And when a yet greater than Kepler was bringing to its final issue that grandest of all scientific conceptions, long pondered over by his almost superhuman intellect—which linked together the Heavens and the Earth, in the *nexus* of a universal attraction, establishing the truth for whose utterance Galileo had been condemned, and giving to Kepler's Laws a significance of which their author had never dreamed—what was the meaning of that agitation which prevented the philosopher from completing his computation, and compelled him to hand it over to his friend? That it was not the thought of his own greatness, but the glimpse of the grand universal order thus revealed to his mental vision, which shook the soul of Newton to its foundations, we have the proof in that comparison in which he likened himself to a child picking up shells on the shore of the vast ocean of truth—a comparison which will be evidence to all time at once of his true philosophy and of his profound humility.

Though it is with the intellectual representation of Nature which we call science that we are primarily concerned, it will not be without its use to cast a glance in the first instance at the other two principal characters under which man acts as her interpreter—those, namely, of the artist and of the poet.

The artist serves as the interpreter of Nature, not when he works as the mere copyist, delineating that which he sees with his bodily eyes, and which we could see as well for ourselves, but when he endeavors to awaken within us the perception of those beauties and harmonies which his own trained sense has recognized, and thus impart to us the pleasure he has himself derived from their contemplation. As no two artists agree in the original constitution and acquired habits of their minds, all look at Nature with different (mental) eyes; so that, to each, Nature is what he individually sees in her.

The poet, again, serves as the interpreter of Nature, not so much when by skilful word-painting (whether in prose or verse) he calls up before our mental vision the picture of some actual or ideal scene, however beautiful, as when, by rendering into appropriate forms those deeper impressions made by the Nature around him on the moral and emotional part of his own nature, he transfers these impressions to the corresponding part of ours. For it is the attribute of the true poet to penetrate the secret of those mysterious influences which we all unknowingly experience; and, having discovered this to himself, to bring others, by the power he thus wields, into the like sympathetic relation with Nature, evoking with skilful touch the varied response of the Soul's finest chords, heightening its joys, assuaging its griefs, and elevating its aspirations. While, then, the artist aims to picture what he sees in Nature, it is the object of the poet to represent what he feels in Nature; and to each true poet Nature is what he individually finds in her.

The philosopher's interpretation of Nature seems less individual than that of the artist or the poet, because it is based on facts which any one may verify, and is elaborated by reasoning processes of which all admit the validity. He looks at the universe as a vast book lying open before him, of which he has in the first place to learn the characters, then to master the language, and finally to apprehend the ideas which that language conveys. In that book there are many chapters, treating of different subjects; and, as life is too short for any one man to grasp the whole, the scientific interpretation of this book comes to be the work of many intellects, differing not merely in the range but also in the character of their powers. But while there are "diversities of gifts," there is "the same spirit." While each takes his special direction, the general method of study is the same for all. And it is a testimony alike to the truth of that method and to the unity of Nature that there is an ever-increasing tendency toward agreement among those who use it aright—temporary differences of interpretation being removed, sometimes by a more complete mastery of her language, sometimes by a better apprehension of her ideas—and lines of pursuit which had seemed entirely distinct or even widely divergent being found to lead at last to one common goal. And it is this agreement which gives rise to the general belief—in many, to the confident assurance—that the scientific interpretation of Nature represents her not merely as she seems but as she really is.

When, however, we carefully examine the foundation of that assurance, we find reason to distrust its security; for it can be shown to be no less true of the scientific conception of Nature than it is of the artistic or the poetic, that it is a representation framed by the mind itself out of the materials supplied by the impressions which external objects make upon the senses, so that, to each man of science, Nature is what he individually believes her to be. And that belief will rest on very different bases, and will have very unequal values, in different departments of science. Thus in what are commonly known as the "exact" sciences, of which astronomy may be taken as the type, the data afforded by precise methods of observation can be made the basis of reasoning, in every step of which the mathematician feels the fullest assurance of certainty; and the final deduction is justified either by its conformity to known or ascertainable facts—as when Kepler determined the elliptic orbit of Mars; or by the fulfilment of the predictions it has sanctioned—as in the occurrence of an eclipse or an occultation at the precise moment specified many years previously; or, still more emphatically, by the actual discovery of phenomena till then unrecognized—as when the perturbations of the planets, shown by Newton to be the necessary results of their mutual attraction, were proved by observation to have a real existence; or, as when the unknown disturber of Uranus was found in the place assigned to him by the computations of Adams and Le Verrier.

We are accustomed, and I think most rightly, to speak of these achievements as triumphs of the human intellect. But the very phrase implies that the work is done by mental agency, and the coincidence of its results with the facts of observation is far from proving the intellectual process to have been correct. For we learn, from the confessions of Kepler, that he was led to the discovery of the elliptic orbit of Mars by a series of happy accidents, which turned his erroneous guesses into the right direction; and to that of the passage of the radius vector over equal areas in equal times by the motion of a whirling force emanating from the sun, which we now regard as an entirely wrong conception of the cause of orbital revolution. It should always be remembered, moreover, that the Ptolemaic system of astronomy, with all its cumbrous ideal mechanism, did intellectually represent all that the astronomer, prior to the invention of the telescope, could see from his stand-point the earth, with an accuracy which was proved by the fulfilment of his anticipations. And in that last and most memorable prediction, which has given an imperishable fame to our two illustrious contemporaries, the inadequacy of the basis afforded by actual observation of the perturbations of Uranus required that it should be supplemented by an assumption of the probable distance of the disturbing planet beyond, which has been shown by subsequent observation to have been only an approximation to the truth.

Even in this most exact of sciences, therefore, we cannot proceed a step without translating the actual phenomena of Nature into intellectual representations of those phenomena, and it is because the Newtonian conception is not only the most simple, but is also, up to the extent of our present knowledge, universal in its conformity to the facts of observation, that we accept it as the only scheme of the universe yet promulgated which satisfies our intellectual requirements.

When, under the reign of the Ptolemaic system, any new inequality was discovered in the motion of a planet, a new wheel had to be added to the ideal mechanism—as Ptolemy said, "to save appearances." If it should prove, a century hence, that the motion of Neptune himself is disturbed by some other attraction than that exerted by the interior planets, we should confidently expect that not an ideal but a real cause for that disturbance will be found in the existence of another planet beyond. But I trust that I have now made it evident to you that this confident expectation is not justified by any absolute necessity of Nature, but arises entirely out of our belief in her uniformity; and into the grounds of this and other primary beliefs, which serve as the foundation of all scientific reasoning, we shall presently inquire.

There is another class of cases, in which an equal certainty is generally claimed for conclusions that seem to flow immediately from observed facts, though really evolved by intellectual processes; the apparent simplicity and directness of those processes either causing them to be overlooked or veiling the assumptions on which they are based. Thus Mr. Lockyer speaks as confidently of the sun's chromosphere of incandescent hydrogen, and of the local outbursts which cause it to send forth projections tens of thousands of miles high, as if he had been able to capture a flask of this gas, and had generated water by causing it to unite with oxygen.

Yet this confidence is entirely based on the assumption that a certain line which is seen in the spectrum of a hydrogen-flame means hydrogen also when seen in the spectrum of the sun's chromosphere; and, high as is the probability of that assumption, it cannot be regarded as a demonstrated certainty, since it is by no means inconceivable that the same line might be produced by some other substance at present unknown. And so, when Dr. Huggins deduces, from the different relative positions of certain lines in the spectra of different stars, that these stars are moving from or toward us in space, his train of reasoning is based on the assumption that these lines have the same meaning—that is, that they represent the same elements—in every luminary. That assumption, like the preceding, may be regarded as possessing a sufficiently high probability to justify the reasoning based upon it; more especially since, by the other researches of that excellent observer, the same chemical elements have been detected as vapors in those filmy cloudlets which seem to be stars in an early stage of consolidation. But, when Frankland and Lockyer, seeing in the spectrum of the yellow solar prominences a certain bright line not identifiable with that of any known terrestrial flame, attribute this to an hypothetical new substance which they propose to call Helium, it is obvious that their assumption rests on a far less secure foundation, until it shall have received that verification which, in the case of Mr. Crooke's researches on Thallium, was afforded by the actual discovery of the new metal, the presence of which had been indicated to him by a line in the spectrum not attributable to any substance then known.

In a large number of other cases, moreover, our scientific interpretations are clearly matters of judgment; and this is eminently a personal act, the value of its results depending in each case upon the qualifications of the individual for arriving at a correct decision. The surest of such judgments are those dictated by what we term "common-sense," as to matters on which there seems no room for difference of opinion, because every sane person comes to the same conclusion, although he may be able to give no other reason for it than that it appears to him "self-evident." Thus, while philosophers have raised a thick cloud of dust in the discussion of the basis of our belief in the existence of a world external to ourselves—of the Non-Ego, as distinct from the Ego—and while every logician claims to have found some flaw in the proof advanced by every other, the common-sense of mankind has arrived at a decision that is practically worth all the arguments of all the philosophers who have fought again and again over this battle-ground. And I think it can be shown that the trustworthiness of this common-sense decision arises from its dependence, not on any one set of experiences, but upon our unconscious coördination of the whole aggregate of our experiences—not on the conclusiveness of any one train of reasoning, but on the convergence of all our lines of thought toward this one centre.

Now, this "common-sense," disciplined and enlarged by appropriate culture, becomes one of our most valuable instruments of scientific inquiry; affording in many instances the best, and sometimes the only, basis for a rational conclusion. Let us take as a typical case, in which no special knowledge is required, what we are accustomed to call the "flint implements" of the Abbeville and Amiens gravel-beds. No logical proof can be adduced that the peculiar shapes of these flints were given to them by human hands; but does any unprejudiced person now doubt it? The evidence of design, to which, after an examination of one or two such specimens, we should only be justified in attaching a probable value, derives an irresistible cogency from accumulation. On the other hand, the improbability that these flints acquired their peculiar shape by accident becomes to our minds greater and greater as more and more such specimens are found; until at last this hypothesis, although it cannot be directly disproved, is felt to be almost inconceivable, except by minds previously "possessed" by the "dominant idea" of the modern origin of man. And thus what was in the first instance a matter of discussion has now become one of those "self-evident" propositions which claim the unhesitating assent of all whose opinion on the subject is entitled to the least weight.

We proceed upward, however, from such questions as the common-sense of mankind generally is competent to decide, to those in which special knowledge is required to give value to the judgment; and thus the interpretation of Nature by the use of that faculty comes to be more and more individual; things being perfectly "self-evident" to men of special culture which ordinary men, or men whose training has lain in a different direction, do not apprehend as such. Of all departments of science, geology seems to me to be the one that most depends on this specially-trained "common-sense;" which brings as it were into one focus the light afforded by a great variety of studies—physical and chemical, geographical and biological—and throws it on the pages of that Great Stone Book on which the past history of our globe is recorded. And while Astronomy is of all sciences that which may be considered as most nearly representing Nature as she really is, Geology is that which most completely represents her as seen through the medium of the interpreting mind; the meaning of the phenomena that constitute its data being in almost every instance open to question, and the judgments passed upon the same facts being often different according to the qualifications of the several judges. No one who has even a general acquaintance with the history of this department of science can fail to see that the geology of each epoch has been the reflection of the minds by which its study was then directed; and that its true progress dates from the time when that "common-sense" method of interpretation came to be generally adopted which consists in seeking the explanation of past changes in the forces at present in operation, instead of invoking the aid of extraordinary and mysterious agencies, as the older geologists were wont to do whenever they wanted—like the Ptolemaic astronomers—"to save appearances." The whole tendency of the ever-widening range of modern geological inquiry has been to show how little reliance can be placed upon the so-called "laws" of stratigraphical and paleontological succession, and how much allowance has to be made for local conditions. So that, while the astronomer is constantly enabled to point to the fulfilment of his predictions as an evidence of the correctness of his method, the geologist is almost entirely destitute of any such means of verification. For the value of any prediction that he may hazard—as in regard to the existence or non-existence of coal in any given area—depends not only upon the truth of the general doctrines of geology in regard to the succession of stratified deposits, but still more upon the detailed knowledge which he may have acquired of the distribution of those deposits in the particular locality. Hence no reasonably-judging man would discredit either the general doctrines or the methods of geology, because the prediction proves untrue in such a case as that now about to be brought in this neighborhood to the trial of experience.

We have thus considered man's function as the scientific interpreter of Nature in two departments of natural knowledge, one of which affords an example of the strictest and the other of the freest method which man can employ in constructing his intellectual representation of the universe. And, as it would be found that in the study of all other departments the same methods are used either separately or in combination, we may pass at once to the other side of our inquiry—namely, the origin of those primary beliefs which constitute the groundwork of all scientific reasoning.

The whole fabric of geometry rests upon certain axioms which every one accepts as true, but of which it is necessary that the truth should be assumed, because they are incapable of demonstration. So, too, the deliverances of our common-sense derive their trustworthiness from what we consider the "self-evidence" of the propositions affirmed. This inquiry brings us face to face with one of the great philosophical problems of our day, which has been discussed by logicians and metaphysicians of the very highest ability as leaders of opposing schools, with the one result of showing how much can be said on each side.

By the intuitionalists it is asserted that the tendency to form these primary beliefs is inborn in man, an original part of his mental organization; so that they grow up spontaneously in his mind as its faculties are gradually unfolded and developed, requiring no other experience for their geneses than that which suffices to call these faculties into exercise. But, by the advocates of the doctrine which regards experience as the basis of all our knowledge, it is maintained that the primary beliefs of each individual are nothing else than generalizations which he forms of such experiences as he has either himself acquired or has consciously learned from others, and they deny that there is any original or intuitive tendency to the formation of such beliefs, beyond that which consists in the power of retaining and generalizing experiences.

I have not introduced this subject with any idea of placing before you even a summary of the ingenious arguments by which these opposing doctrines have been respectively supported; nor should I have touched on the question at all, if I did not believe that a means of reconcilement between them can be found in the idea that the intellectual intuitions of any one generation are the embodied experiences of the previous race. For, as it appears to me, there has been a progressive improvement in the thinking power of man; every product of the culture which has preceded serving to prepare the soil for yet more abundant harvests in the future.

Now, as there can be no doubt of the hereditary transmission in man of acquired constitutional peculiarities, which manifest themselves alike in tendencies to bodily and to mental disease, so it seems equally certain that acquired mental habitudes often impress themselves on his organization, with sufficient force and permanence to occasion their transmission to the offspring as tendencies to similar modes of thought. And thus, while all admit that knowledge cannot thus descend from one generation to another, an increased aptitude for the acquirement, either of knowledge generally or of some particular kind of it, may be thus inherited. These tendencies and aptitudes will acquire additional strength, expansion, and permanence, in each new generation, from their habitual exercise upon the materials supplied by a continually-enlarged experience; and thus the acquired habitudes produced by the intellectual culture of ages will become "a second nature" to every one who inherits them.[1]

[1] I am glad to be able to append the following extract from a letter which Mr. John Mill, the great Master of the Experimental School, was good enough to write to me a few

We have an illustration of this progress in the fact of continual occurrence, that conceptions which prove inadmissible to the minds of one generation in consequence either of their want of intellectual power to apprehend them or of their preoccupation by other habits of thought, subsequently find a universal acceptance, and even come to be approved as "self-evident." Thus the first law of motion, divined by the genius of Newton, though opposed by many philosophers of his time as contrary to all experience, is now accepted by common consent, not merely as a legitimate inference from experiment, but as the expression of a necessary and universal truth; and the same axiomatic value is extended to the still more general doctrine that energy of any kind, whether manifested in the "molar" motion of masses, or consisting in the "molecular" motion of atoms, must continue under some form or other without abatement or decay; what all admit in regard to the indestructibility of matter being accepted as no less true of force—namely, that as *ex nihilo nil fit*, so *nil fit ad nihilum.*[1] But, it may be urged, the very conception of these and similar great truths is in itself a typical example of intuition. The men who divined and enunciated them stand out above their fellows, as possessed of a genius which could not only combine but create, of an insight which could clearly discern what reason could but dimly shadow forth. Granting this freely, I think it may be shown that the intuitions of individual genius are but specially-exalted forms of endowments which are the general property of the race at the time, and which have come to be so in virtue of its whole previous culture. Who, for example, could refuse to the marvellous aptitude for perceiving the relations of numbers, which displayed itself in the untutored boyhood of George Bidder and Zerah Colburn, the title of an intuitive gift? But who, on the other hand, can believe that a Bidder or a Colburn could suddenly arise in a race of savages who cannot count beyond five? Or, again, in the history of the very earliest years of Mozart, who can fail to recognize the dawn of that glorious genius, whose brilliant but brief

months since, with reference to the attempt I had made to place "Common-Sense" upon this basis (*Contemporary Review*, February, 1872): "When states of mind in no respect innate or instinctive have been frequently repeated, the mind acquires, as is proved by the power of Habit, a greatly-increased facility of passing into those states; and this increased facility must be owing to some change of a physical character in the organic action of the Brain. There is also considerable evidence that such acquired facilities of passing into certain modes of cerebral action can in many cases be transmitted, more or less completely, by inheritance. The limits of this power of transmission, and the conditions on which it depends, are a subject now fairly before the scientific world; and we shall doubtless in time know much more about them than we do now. But so far as my imperfect knowledge of the subject qualifies me to have an opinion, I take much the same view of it that you do, at least in principle."

[1] This is the form in which the doctrine now known as that of the "Conservation of Energy" was enunciated by Dr. Mayer, in the very remarkable Essay published by him in 1845, entitled "Die organische Bewegung in ihrem Zus ammenhange mit dem Stoff-

career left its imperishable impress on the art it enriched? But who would be bold enough to affirm that an infant Mozart could be born among a tribe whose only musical instrument is a tom-tom, whose only song is a monotonous chant?

Again, by tracing the gradual genesis of some of those ideas which we now accept as "self-evident"—such, for example, as that of the "Uniformity of Nature"—we are able to recognize them as the expressions of certain intellectual tendencies, which have progressively augmented in force in successive generations, and now manifest themselves as mental instincts that penetrate and direct our ordinary course of thought. Such instincts constitute a precious heritage, which has been transmitted to us with ever-increasing value through the long succession of preceding generations; and which it is for us to transmit to those who shall come after us, with all that further increase which our higher culture and wider range of knowledge can impart.

And now, having studied the working action of the human intellect in the scientific interpretation of Nature, we shall examine the general character of its products; and the first of these with which we shall deal is our conception of matter and of its relation to force.

The psychologist of the present day views matter entirely through the light of his own consciousness: his idea of matter in the abstract being that it is a "something" which has a permanent power of exciting sensations, his idea of any "property" of matter being the mental representation of some kind of sensory impression he has received from it; and his idea of any particular kind of matter being the representation of the whole aggregate of the sense-perceptions which its presence has called up in his mind. Thus, when I press my hand against this table, I recognize its unyieldingness through the conjoint medium of my sense of touch, my muscular sense, and my mental sense of effort, to which it will be convenient to give the general designation of the tactile sense; and I attribute to that table a hardness which resists the effort I make to press my hand into its substance, while I also recognize the fact that the force I have employed is not sufficient to move its mass. But I press my hand against a lump of dough, and, finding that its substance yields under my pressure, I call it soft. Or, again, I press my hand against this desk, and I find that, although I do not thereby change its form, I change its place; and so I get the tactile idea of motion. Again, by the impressions received through the same sensorial apparatus, when I lift this book in my hand, I am led to attach to it the notion of weight or ponderosity; and, by lifting different solids of about the same size, I am enabled, by the different degrees of exertion I find myself obliged to make in order to sustain them, to distinguish some of them as light, and others as heavy. Through the medium of another set of sense-perceptions, which some regard as belonging to a different category, we distinguish between bodies that feel "hot" and those that feel "cold;" and in this manner we arrive at the notion of differences of temperature. And it is through the medium of our tactile sense, without any aid from vision, that we first gain the idea of solid form, or the three dimensions of space.

Again, by the extension of our tactile experiences, we acquire the notion of liquids, as forms of matter yielding readily to pressure, but possessing a sensible weight which may equal that of solids; and of air, whose resisting power is much slighter, and whose weight is so small that it can only be made sensible by artificial means. Thus, then, we arrive at the notions of resistance and of weight as properties common to all forms of matter; and, now that we have got rid of that idea of light and heat, electricity and magnetism, as "imponderable fluids," which used to vex our souls in our scientific childhood, and of which the popular term "electric fluid" is a "survival," we accept these properties as affording the practical distinction between the "material" and the "immaterial."

Turning, now, to that other great portal of sensation, the sight, through which we receive most of the messages sent to us from the universe around, we recognize the same truth. Thus it is agreed, alike by physicists and physiologists, that color does not exist as such in the object itself; which has merely the power of reflecting or transmitting a certain number of millions of undulations in a second; and these only produce that affection of our consciousness, which we call color, when they fall upon the retina of the living percipient. And if there be that defect, either in the retina or in the apparatus behind it, which we call "color-blindness" or Daltonism, some particular hues cannot be distinguished, or there may even be no power of distinguishing any color whatever. If we were all like Dalton, we should see no difference, except in form, between ripe cherries hanging on a tree and the green leaves around them; if we were all affected with the severest form of color-blindness, the fair face of Nature would be seen by us as in the *chiaro-scuro* of an engraving of one of Turner's landscapes, not as in the glowing hues of the wondrous picture itself. And, in regard to our visual conceptions, it may be stated with perfect certainty, as the result of very numerous observations made upon persons who have acquired sight for the first time, that these do not serve for the recognition even of those objects with which the individual had become most familiar through the touch until the two sets of sense-perceptions have been coördinated by experience.[1] When once this coördination has been effected, however, the composite perception of

[1] Thus, in a recently-recorded case in which sight was imparted by operation to a young woman who had been blind from birth, but who had, nevertheless, learned to work well with her needle, when the pair of scissors she had been accustomed to use was placed before her, though she described their shape, color, and glistening metallic character, she was utterly unable to recognize them as scissors until she put her finger on them, when she at once named them, laughing at her own stupidity (as she called it) in not having made them out before.

form, which we derive from the visual sense alone, is so complete that we seldom require to fall back upon the touch for any further information respecting that quality of the object. So, again, while it is from the coördination of the two dissimilar pictures formed by any solid or projecting object upon our two retinæ that (as Sir Charles Wheatstone's admirable investigations have shown) we ordinarily derive through the sight alone a correct notion of its solid form, there is adequate evidence that this notion also is a mental judgment based on the experience we have acquired in early infancy by the consentaneous exercise of the visual and tactile senses.

Take, again, the case of those wonderful instruments by which our visual range is extended almost into the infinity of space or into the infinity of minuteness. It is the mental, not the bodily, eye that takes cognizance of what the telescope and the microscope reveal to us. For, we should have no well-grounded confidence in their revelations as to the unknown, if we had not first acquired experience in distinguishing the true from the false by applying them to known objects; and every interpretation of what we see through their instrumentality is a mental judgment as to the probable form, size, and movement of bodies removed by either their distance or their minuteness from being cognosced by our sense of touch.

The case is still stronger in regard to that last addition to our scientific *armamentum* which promises to be not inferior in value either to the telescope or the microscope; for it may be truly said of the spectroscope that it has not merely extended the range of our vision, but has almost given us a new sense by enabling us to recognize distinctive properties in the chemical elements which were previously quite unknown. And who shall now say that we know all that is to be known as to any form of matter, or that the science of the fourth quarter of this century may not furnish us with as great an enlargement of our knowledge of its properties, and of our power of recognizing them, as that of its third has done?

But, it may be said, Is not this view of the material universe open to the imputation that it is "evolved out of the depths of our own consciousness"—a projection of our own intellect into what surrounds us—an ideal rather than a real world? If all we know of matter be an "intellectual conception," how are we to distinguish this from such as we form in our dreams, for these, as our Laureate no less happily than philosophically expresses it, are "true while they last." Here our "common-sense" comes to the rescue. We "awake, and behold it was a dream." Every healthy mind is conscious of the difference between his waking and his dreaming experiences, or, if he is now and then puzzled to answer the question, "Did this really happen or did I dream it?" the perplexity arises from the consciousness that it might have happened. And every healthy mind, finding its own experiences of its waking state not only self-consistent, but consistent with the experiences of others, accepts them as the basis of his beliefs, in preference to even the most vivid recollections of his dreams.

The lunatic pauper, who regards himself as a king, the asylum in which he is confined as a palace of regal splendor, and his keepers as obsequious attendants, is so "possessed" by the conception framed by his disordered intellect that he does project it out of himself into his surroundings; his refusal to admit the corrective teaching of common-sense being the very essence of his malady. And there are not a few persons abroad in the world who equally resist the teachings of educated common-sense whenever they run counter to their own preconceptions, and who may be regarded as—in so far—affected with what I once heard Mr. Carlyle pithily characterize as a "diluted insanity."

It has been asserted over and over again of late years, by a class of men who claim to be the only true interpreters of Nature, that we know nothing but matter and the laws of matter, and that force is a mere fiction of the imagination. May it not be affirmed, on the other hand, that, while our notion of matter is a conception of the intellect, force is that of which we have the most direct—perhaps even the only direct—cognizance? As I have already shown you, the knowledge of resistance and of weight which we gain through our tactile sense is derived from our own perception of exertion; and in vision, as in hearing, it is the force with which the undulations strike the sensitive surface that affects our consciousness with sights or sounds. True it is that in our visual and auditory sensations we do not, as in our tactile, directly cognosce the force which produces them; but the Physicist has no difficulty in making sensible to us, indirectly, the undulations by which sound is propagated, and in proving to our intellect that the force concerned in the transmission of light is really enormous.

It seems strange that those who make the loudest appeal to experience as the basis of all knowledge, should thus disregard the most constant, the most fundamental, the most direct of all experiences; as to which the common-sense of mankind affords a guiding light much clearer than any that can be seen through the dust of philosophical discussion. For, as Sir John Herschel most truly remarked, the universal consciousness of mankind is as much in accord in regard to the existence of a real and intimate connection between cause and effect as it is in regard to the existence of an external world; and that consciousness arises to every one out of his own sense of personal exertion in the origination of changes by his individual agency.

Now, while fully accepting the logical definition of cause as the "antecedent or concurrence of antecedents on which the effect is invariably and unconditionally consequent," we can always single out one dynamical antecedent—the power which does the work—from the aggregate of material conditions under which that power may be distributed and applied. No doubt the term "cause" is very loosely employed in popular phraseology; often (as Mr. Mill has shown) to designate the occurrence that immediately preceded the effect—as when it is said that the spark which falls into a barrel of gunpowder is the cause of its explosion, or that the slipping of a man's foot off the rung of a ladder is the cause of his fall. But even a very slightly-trained intelligence can distinguish the power which acts in each case from the conditions under which it acts. The force which produces the explosion is locked up, as it were, in the powder; and ignition merely liberates it by bringing about new chemical combinations. The fall of the man from the ladder is due to the gravity which was equally pulling him down while he rested on it; and the loss of support, either by the slipping of his foot or by the breaking of the rung, is merely that change in the material conditions which gives the power a new action.

Many of you have doubtless viewed with admiring interest that truly wonderful work of human design, the Walter printing-machine. You first examine it at rest; presently comes a man who simply pulls a handle toward him, and the whole inert mechanism becomes instinct with life—the blank paper, continuously rolling off the cylinder at one end, being delivered at the other, without any intermediate human agency, as large sheets of print, at the rate of 15,000 in an hour. Now, what is the cause of this most marvellous effect? Surely it lies essentially in the power or force which the pulling of the handle brings to bear on the machine from some extraneous source of power, which we in this instance know to be a steam-engine on the other side of the wall. This force it is, which, distributed through the various parts of the mechanism, really performs the action of which each is the instrument; they only supply the vehicle for its transmission and application. The man comes again, pushes the handle in the opposite direction, detaches the machine from the steam-engine, and the whole comes to a stand; and so it remains, like an inanimate corpse, until recalled to activity by the renewal of its moving power.

But, say the reasoners who deny that force is any thing else than a fiction of the imagination, the revolving shaft of the steam-engine is "matter in motion;" and, when the connection is established between that shaft and the one that drives the machine, the motion is communicated from the former to the latter, and thence distributed to the several parts of the mechanism. This account of the operation is just what an observer might give who had looked on with entire ignorance of every thing but what his eyes could see; the moment he puts his hand upon any part of the machinery and tries to stop its motion, he takes as direct cognizance, through his sense of the effort required to resist it, of the force which produces that motion as he does through his eye of the motion itself.

Now, since it is universally admitted that our notion of the external world would be not only incomplete, but erroneous, if our visual perceptions were not supplemented by our tactile, so, as it seems to me, our interpretation of the phenomena of the Universe must be very inadequate if we do not mentally coördinate the idea of force with that of motion, and recognize it as the "efficient cause" of those phenomena—the "material conditions" constituting (to use the old scholastic term) only "their formal cause." And I lay the greater stress on this point, because the mechanical philosophy of the present day tends more and more to express itself in terms of motion rather than in terms of force—to become kinetics, instead of dynamics.

Thus, from whatever side we look at this question—whether the common-sense of mankind, the logical analysis of the relation between cause and effect, or the study of the working of our own intellects in the interpretation of Nature—we seem led to the same conclusion—that the notion of force is one of those elementary forms of thought with which we can no more dispense than we can with the notion of space or of succession. And I shall now, in the last place, endeavor to show you that it is the substitution of the dynamical for the mere phenomenal idea which gives their highest value to our conceptions of that order of Nature, which is worshipped as itself a god by the class of interpreters whose doctrine I call in question.

The most illustrative, as well as the most illustrious example of the difference between the mere generalization of phenomena and the dynamical conception that applies to them, is furnished by the contrast between the so-called laws of planetary motion discovered by the persevering ingenuity of Kepler, and the interpretation of that motion given us by the profound insight of Newton. Kepler's three laws were nothing more than comprehensive statements of certain groups of phenomena determined by observation. The first, that of the revolution of the planets in elliptical orbits, was based on the study of the observed places of Mars alone; it might or might not be true of the other planets; for, so far as Kepler knew, there was no reason why the orbits of some of them might not be the eccentric circles which he had first supposed that of Mars to be. So Kepler's second law of the passage of the radius vector over equal areas in equal times, so long as it was simply a generalization of facts in the case of that one planet, carried with it no reason for its applicability to other cases, except that which it might derive from his erroneous conception of a whirling force. And his third law was in like manner simply an expression of a certain harmonic relation which he had discovered between the times and the distances of the planets, having no more rational value than any other of his numerous hypotheses.

Now, the Newtonian "laws" are often spoken of as if they were merely higher generalizations in which Kepler's are included; to me they seem to possess an altogether different character. For, starting with the conception of two forces, one of them tending to produce continuous uniform motion in a straight line, the other tending to produce a uniformly accelerated motion toward a fixed point, Newton's wonderful mastery of geometrical reasoning enabled him to show that, if these dynamical assumptions be granted, Kepler's phenomenal "laws," being a necessary consequence of them, must be universally true. And while that demonstration would have been alone sufficient to give him an imperishable renown, it was his still greater glory to divine that the fall of the moon toward the earth—that is, the deflection of her path from a tangential line to an ellipse—is a phenomenon of the same order as the fall of a stone to the ground; and thus to show the applicability to the entire universe of those simple dynamical conceptions which constitute the basis of the geometry of the "Principia."

Thus, then, while no "law" which is simply a generalization of phenomena can be considered as having any coercive action, we may assign that value to laws which express the universal conditions of the action of a force, the existence of which we learn from the testimony of our own consciousness. The assurance we feel, that the attraction of gravitation must act under all circumstances according to its one simple law, is of a very different order from that which we have in regard (for example) to the laws of chemical attraction, which are as yet only generalizations of phenomena. And yet, even in that strong assurance, we are required, by our examination of the basis on which it rests, to admit a reserve of the possibility of something different—a reserve which we may well believe that Newton himself must have entertained.

A most valuable lesson as to the allowance we ought to make for the unknown "possibilities of Nature" is taught us by an exceptional phenomenon so familiar that it does not attract the notice it has a right to claim. Next to the law of the universal attraction of masses of matter, there is none that has a wider range than that of the expansion of bodies by heat. Excluding water and one or two other substances, the fact of such expansion might be said to be invariable, and, as regards bodies whose gaseous condition is known, the law of expansion can be stated in a form no less simple and definite than the law of gravitation. Supposing those exceptions then to be unknown, the law would be universal in its range. But it comes to be discovered that water, while conforming to it in its expansion from 39½° upward to its boiling-point, as also, when it passes into steam, to the special law of expansion of vapors, is exceptional in its expansion also from 39½° downward to its freezing-point; and of this failure in the universality of the law no *rationale* can be given. Still more strange is it that by dissolving a little salt in water we should remove this exceptional peculiarity, for sea-water continues to contract from 39° downward to its freezing-point 12° or 14° lower, just as it does with reduction of temperature at higher ranges.

Thus, from our study of the mode in which we arrive at those conceptions of the orderly sequence observable in the phenomena of Nature which we call "laws," we are led to the conclusion that they are human conceptions subject to human fallibility, and that they may or may not express the ideas of the Great Author of Nature. To set up these laws as self-acting, and as either excluding or rendering unnecessary the power which alone can give them effect, appears to me as arrogant as it is unphilosophical. To speak of any law as "regulating" or "governing" phenomena is only permissible on the assumption that the law is the expression of the *modus operandi* of a governing power. I was once in a great city which for two days was in the hands of a lawless mob. Magisterial authority was suspended by timidity and doubt; the force at its command was paralyzed by want of resolute direction. The "laws" were on the statute-book, but there was no power to enforce them. And so the powers of evil did their terrible work, and fire and rapine continued to destroy life and property without check, until new power came in, when the reign of law was restored.

And thus we are led to the culminating point of man's intellectual interpretation of Nature—his recognition of the unity of the power of which her phenomena are the diversified manifestations. Toward this point all scientific inquiry now tends. The convertibility of the physical forces, the correlation of these with the vital, and the intimacy of that *nexus* between mental and bodily activity which, explain it as we may, cannot be denied, all lead upward toward one and the same conclusion; and the pyramid of which the philosophical conclusion is the apex has its foundation in the primitive instincts of humanity.

By our own remote progenitors, as by the untutored savage of the present day, every change in which human agency was not apparent was referred to a particular animating intelligence. And thus they attributed not only the movements of the heavenly bodies, but all the phenomena of Nature, each to its own deity. These deities were invested with more than human power; but they were also supposed capable of human passions and subject to human capriciousness. As the uniformities of Nature came to be more distinctly recognized, some of these deities were invested with a dominant control, while others were supposed to be their subordinate ministers. A serene majesty was attributed to the greater gods who sit above the clouds; while their inferiors might "come down to earth in the likeness of men." With the growth of the scientific study of Nature, the conception of its harmony and unity gained ever-increasing strength. And so, among the most enlightened of the Greek and Roman philosophers, we find a distinct recognition of the idea of the unity of the directing mind from which the order of Nature proceeds; for they obviously believed that, as our modern poet has expressed it—

> "All are but parts of one stupendous whole,
> Whose body Nature is, and God the Soul."

The science of modern times, however, has taken a more special direction. Fixing its attention exclusively on the order of Nature, it has separated itself wholly from theology, whose function it is to seek after its cause. In this, science is fully justified, alike by the entire independence of its objects, and by the historical fact that it has been continually hampered and impeded, in its search for the truth as it is in Nature, by the restraints which theologians have attempted to impose upon its inquiries. But, when science, passing beyond its own limits, assumes to take the place of theology and sets up its own conception of the order of Nature as a sufficient account of its cause, it is invading a province of thought to which it has no claim, and not unreasonably provokes the hostility of those who ought to be its best friends.

For, while the deep-seated instincts of humanity and the profoundest researches of philosophy alike point to mind as the one and only source of power, it is the prerogative of science to demonstrate the unity of the power which is operating through the limitless extent and variety of the universe, and to trace its continuity through the vast series of ages that have been occupied in its evolution.

PHYSIOLOGICAL INFLUENCE OF CONDIMENTS.

BY PROF. VOIT.

(ABSTRACT OF VOIT'S REPORT, BY ANDRÉ SANSON.)

BESIDES the elements of nutrition which we consume at every meal, there is also a number of other elements which serve to make the food savory and appetizing. These latter do not strictly come within the definition of nutritive substances, and are properly denominated condiments. Though not in themselves nutritious, the condiments are nevertheless necessary to nutrition. Their importance, however, as constituents of food, has not hitherto been duly appreciated. We must determine with exactitude the action both of the various elements of nutrition and of the condiments, and employ, to express this difference, well-defined terms, if we would avoid all confusion in treating the subject. Before we state what is the action of the salts and of the extractive elements of nutrition, as condiments, we must first consider the action of condiments in general. It is commonly supposed that they excite in the palate agreeable sensations, and so produce simply an excitation which, however, serves no useful purpose; and that, when once they enter into the blood, they bring about in it abnormal states and unnatural excitation. However, they are not regarded as hurtful.

Condiments act principally upon the nervous system. Some of them, for instance, excite the nerve termini of the mucous membrane of the digestive canal, whence the excitation or stimulus passes to certain centres in the intestine, or to more remote centres in the spinal cord, the brain, etc. Others of them, having been absorbed in the blood, reach the central organ of the nervous system, and act upon it. Passing beyond all these nerve-centres, their influence may extend farther, and may, through the intestinal canal, affect portions of the system which have no direct relation to digestion.

Bearing all this in mind, we perceive that the term *condiment* is commonly used in too restrictive a sense, being applied to but a few of the substances which act upon the system in the manner above indicated. There is no reason why we should give the name of condiments only to those substances which produce agreeable and useful stimulation in the nervous system, either by exciting the palate or by entering into the blood. The site of the excitation is immaterial, and cannot determine whether a substance is or is not properly a condiment. The first effects produced by sundry agents not commonly regarded as condiments—tea and coffee, for example—are at bottom the same as those produced by the condiments. As for those substances which produce their effects only when they have entered into the blood, and which have nothing to do with digestion, these have been regarded as condiments if they are absorbed by the intestinal canal, as caffeine; or by the nasal mucous membrane, as the nicotine of snuff. To be consistent, we must give the same name of condiment to sundry substances which are not at all *eaten*. This will readily be admitted with regard to the sense of smell, since many dishes, instead of pleasing by their flavor, please rather by their agreeable odor. The volatile elements of food, by gratifying the sense of smell, become true condiments. The same is to be said of other volatile elements which are not derived from articles of food, such as the fragrance of flowers, etc.

The excitation of the organs of taste or of smelling produces, in certain determinate portions of the brain, corresponding agreeable sensations. The process is essentially the same in the case of sensations of hearing or of seeing. Hence we might reckon among condiments the vibrations of the ether, and those of sound. However wide the difference between the pleasure we experience in the contemplation of a Madonna by Raffaelle, the hearing of one of Beethoven's symphonies, inhaling the fragrance of a rose, and tasting a savory fruit, still these have all something in common. External causes will always produce a movement in the nerves, and this will be transmitted to certain points of the central organ, where it will give rise to sensations; and thence again there may be transmitted to still other centres other nerve-influences, which will produce simultaneous action in other points.

The term *condiment*, as commonly used, is taken in too restricted a sense in another point of view. An agent acting upon the mucous membrane of the mouth, stomach, or intestine, may produce in the nervous system important effects as regards digestion, and yet we may have no sensation of this either through taste or through smell, its parts not entering into communication with the central organ of sensation.

Having thus given a notion of what he understands by condiments, the author lays some stress upon the foregoing considerations, in order to show that a substance may be rigorously denominated a *condiment*, without exercising any agreeable effect upon the organs of taste. Still the chief condiments do undoubtedly produce this effect. A mixture of pure albumen, fat, starch, salts, and water, would suffice for alimentation, and yet it would be a satisfactory ration only in case of extreme want. In any other case we should regard it as unpalatable, and should refuse to partake of it. All alimentary substances, even those which come from the vegetable kingdom, are combined with substances which, though not nutritious, still have a flavor, and the former are not easily digested unless they first gratify the palate. Substances without flavor, or which are repulsive to the palate, are nauseating, and cause vomiting. There exists, therefore, a functional relation between the central organ of taste and the stomach. If the former acts upon the latter adversely, it may also act favorably upon it. In like manner, too, the central organ of taste is influenced by the stomach. Satiety deprives food, which once was agreeable to us, of its power of gratifying the palate.

Several condiments act upon the stomach, or on the intestine, after having first produced an agreeable sensation of taste. The excitation to which they give rise does not extend to the central organ, there to produce the same sensation. They are limited to the stomach and to the intestine, and serve to favor digestion and absorption. The gastric juice, we know, is not secreted continually, but only when there is something in the stomach. When the mucous membrane of that organ is excited by the contact of a quill, for instance, or of a glass rod, the gastric juice begins to flow, and the vessels of the mucous membrane become charged with blood. The presence of food produces the same effect. But there are other excitations which appear to act even more powerfully on the stomach. If we introduce a drop of alcohol or ether, or a solution of common salt, into the stomach of a living animal, the juice will flow from the glands, just as the same effect is produced by the thought of some savory dish. We may observe this when we offer a hungry dog a piece of meat. It is for this reason that we frequently add to our food substances strongly salted or aromatized, as, for instance, a caviare, or a glass of some spirituous liquor, such as sherry. The same effect may even be produced by the very sight of the label borne by such articles. When meat is roasted at a hot fire, it brings about this same result in the best and simplest manner; and most of the flavors and pleasing odors of food have the same effect. Hence we see their importance as means of promoting digestion.

The extract of meat belongs to the class of condiments. It first gratifies the palate, and then produces important results in the stomach. This is not due to the nutritive salts it contains, nor to any special effect it produces on absorption or nutrition. If an animal gets for food only extract of meat, it will succumb more quickly than if no food at all were given, as was demonstrated by Kemmerich in the case of a dog. We may account for this either on the supposition that the salts accelerate the transformation of albumen, or that the potash of the extract acts injuriously on the heart. Therefore, when vessels, fortresses, armies, and hospitals, are supplied with this meat-extract, they obtain what we must regard as an excellent *condiment;* but that will not supply the place of a single grain of the nutritive elements; and in this regard it is analogous to table-salt, coffee, tobacco, etc. Nevertheless, we cannot question the beneficial effect of a good meat-broth upon the stomach, whether in health or in sickness. Especially does it produce a good effect in the case of convalescents whose stomach is in a chronic state of debility. They cannot retain common food, except it is given to them in the shape of broth. Just as the excitation of the mucous membrane of the mouth has an effect upon the stomach, so, probably, the stomach acts upon the intestine. Thus, for instance, soon after the stomach is filled, we find the pancreas addressing itself to its function.

There are some condiments the effects of which are not at first local. They act only after having been absorbed, and their action is then perceptible in the central nervous system. This is the case, for instance, with coffee, tea, tobacco, alcoholic drinks, etc., the general action of which is well known. It has been supposed that we have here an arrest of decomposition, an economy of nutritive material. In fact, we have only another mode of arrangement or of change in the inward phenomena. The amount of work of which a man is capable depends very much upon his momentary disposition. With equal nutritive transformations, and with equal production of living force, the man who undertakes a work under favorable moral conditions will perform it more easily than another who happens to be oppressed and weighed down by some affliction. A stroke of the whip causes a horse to surmount an obstacle, before which he would have stood still without that stimulus; and yet the latter does not communicate to him any force; it only induces him to exert the force he already possessed. It is thus that condiments act upon certain determinate parts of our nervous centre, and so enable us to attain our ends. We may regard as of similar nature to this the action of opium or of musk, under the influence of which a man, who before was perfectly powerless, appears to get new life, without any demonstrable elementary change having taken place in his body. The same is to be said of the influence of alcohol, and of common salt, leaving out of the account their local action in the mouth and stomach.

Does the same hold good for extract of meat? None of the known organic elements of this extract have an action analogous to that of caffeine, nicotine, or alcohol. Still it is certain that the potash which it contains brings about results which are essentially general. It renders the nerves and the muscles more excitable, and produces an acceleration of the contractions of the heart. Kemmerich was at first disposed to attribute the exciting and quickening action of the extract to the potash which it contains; and he has shown that meat-extract, reduced to ashes, produces a fatal effect when administered in the same quantity which is fatal before it is so reduced. He has demonstrated that a dose of chloride of potassium, containing the same quantity of potash which is contained in a half-pound of meat, accelerates the beating of the heart in a healthy subject. Yet, notwithstanding this, we are not to overlook local action, and suppose with Kemmerich that the extract of meat might give place to a small quantity of potash, and still leave the food equally nutritious.

We might accordingly attribute to the extract of meat the same property which characterizes animal food, viz., the production of an extraordinary degree of energy and vigor. Here Voit observes that this property does not belong to the extractive elements, but rather to the albuminoid materials, the proportion of which contained in animal food exceeds that contained in vegetables, as compared with the non-nitrogenized elements. Indeed, if we feed a carnivorous animal on a small quantity of meat, with a large amount of fat and meat-extract, he loses his natural liveliness. The same theory holds good for man, when fed on vegetable diet and the extract of meat. His vigor is far less than when meat forms the basis of his food. But on the other hand, if we give to an herbivorous animal food rich in albuminoid principles, if, for instance, we give to a horse an abundance of oats, the result will be the same as when a carnivorous animal is given animal food.

The action of meat-extract on the animal economy is, therefore, simply that of a condiment. Liebig attributes to it no other action, though the matter has frequently been involved in confusion. This action is, however, very important and beneficial. It is also possessed by certain vegetable extracts. Thus soups of high flavor and very strengthening may be made with the extract of the tomato, which has an acid reaction.

The foregoing remarks give only a partial view of the important function of condiments in promoting nutrition. Neither man nor animals take their food without some condiment. The simplest food always possesses some quality which serves as its condiment. It is only in virtue of this that vegetables gratify the palate. Thus in fruits for example, there are acids, volatile oils, etc. Most of the condiments are derived from the vegetable kingdom. Every people has its own favorite condiment. Every one likes to find an agreeable flavor in his food, and we have it prepared in such a way as to acquire the peculiar flavor we like. For the same reason we like variety in articles of food. In time the persistent impression of one flavor produces disgust, and so what once was savory now becomes unpleasant. Therefore, if one were to be confined for a considerable time to a fixed diet, he would not thrive upon it, no matter how rich it might be in the elements of nutrition, for the reason that the influence of the condiment would be nullified.

There are, besides, many other influences which act upon digestion, but of which we commonly think little. In taking food we strive to combine various enjoyments, so that many organic manifestations may conspire together to promote the action of the digestive apparatus. The organ of smell is situated near that of taste. Those dishes which contain volatile elements are rather smelt than tasted. We give an agreeable smell to some articles of food by adding to them others which are fragrant. Dishes to which we are unaccustomed we partake of with repugnance, and generally they cannot be retained. We also give to dishes agreeable forms, and set them on the table with some regard to their appearance, and this makes them "appetizing." If they are served up without any regard to such considerations, they excite only repugnance. The frame of mind in which one may happen to be is also a matter of importance. If our thoughts are preëngaged, or if we are in trouble, we have no desire for food. The presence of a sprightly child, or of friends, at the board, is a true condiment. How different is the process of digestion when a meal is taken in full view of a pleasing landscape, or behind the bars of a prison-cell!

We are continually exposed to a multitude of excitations or influences from without. These give us sensations which are not alone agreeable, but also useful and necessary. Thus alone can we *live.* Though by many persons the limits of moderation are overstepped in seeking this kind of gratification, and they are made thus hurtful, it does not thence follow that they are to be avoided. If some men make an abusive use of food, we are not therefore to conclude that the proper course is to abstain altogether from food, any more than we should conclude, from the fact that the feasts of Lucullus are every day repeated, that therefore, instead of palatable food, whether animal or vegetable, one should eat only a tasteless mixture of albuminates, fat, starch, etc. There is danger of excess in every action we perform, but a man of sense will always respect the law which determines for him what is beneficial and wnat hurtful.—*Revue Scientifique.*

ENGLISH AGAINST THE CLASSICS.

BY A SCOTCH GRADUATE.[1]

NOT long ago, the Lord Rector of the University of Aberdeen submitted to the University Court a scheme for reducing the value of Latin composition. In a lecture recently given at Edinburgh upon education, Prof. Jowett condemned the existing methods of classical instruction, and asserted that Latin and Greek might be learned in two-thirds of the time now bestowed upon them. And the other day, Mr. Froude, addressing the students of St. Andrew's on the occasion of his installation as their Lord Rector, in place of Greek recommended French, or German, or Chemistry, or Norman-French, or Chinese, or Russian, according to the wants of the individual. Such explosions of discontent keep the question of classical education in a lively condition.

In fact, complaints against the classics have grown so common of late that people begin to be weary of the question before any thing has been done to settle it. The cry that we have had enough of discussion about classics, and the sneer that every scribbler must have his fling at classics nowadays, are taken up with such heartiness by those interested in keeping things just as they are, that it is difficult sometimes to get a hearing.

To vindicate the right of speech on a question that deserves every ventilation, it may be sufficient to say that, if there were *more doing*, there might be *less talking*. It is contrary to all experience to suppose that, if there were a cessation of the talking, the authorities might in course of time begin to act. The importunate widow in the parable knew better than that. Believing that it is wise to discuss such a

[1] The present article is abridged from a pungent pamphlet reissued by D. Appleton & Co., and entitled "Classical Studies as Information or as Training." Should it be thought that what it says of the neglect of English applies to the state of things abroad, not here, we suggest a recent testimony upon this point. Dr. Manly, President of Georgetown College, Ky., in a commencement address, delivered last June, on Collegiate Reform, speaking of the branches of study that should be added to the course, said:

"Of these, one of the most important is the English language. The study of English grammar, commonly made a botch of in our schools, is usually entirely ignored in our colleges. Dogberry's philosophy appears to prevail, that "to read and write comes by nature." The student is presumed to be a "good English scholar" when he arrives at college; a very violent presumption, by the way, whether we consider either the chance he has had to learn, or the proofs he usually gives that he has learned. And even as to graduates, male and female, I scarcely venture to tell, what I have had abundant opportunities of knowing, in other States besides this, of the blunders they make in spelling, in pronunciation, in the plainest matters of propriety, and the simplest principles of grammar. And yet I do not hesitate to affirm that intrinsically and for its own merits, and then certainly more especially for us, who are to use it all our lives, there is no language the world ever saw more abnndantly deserving, or more amply repayiug, careful study than this same English tongue."

question to the utmost, and that the public should be grateful for the smallest contributions to the discussion, the writer of the present essay ventures to add his mite.

It will be found that in most cases the services claimed for the ancient languages are valuable services, and that, if a knowledge of these tongues could render one-tenth of the services alleged, it would be a serious crime to utter a word against their continuance as the staple of education. But what if, under the present mode of teaching classics, many of the alleged services are not rendered? And what if it be the case that, where certain services are rendered, or might be rendered, by a knowledge of classics, they are rendered, or might be rendered, in so far as they are desirable, more economically by other means? I propose to consider some of the arguments offered in defence of the classics, and to show that it would be better to replace Latin and Greek studies by the systematic study of English as the basis of a liberal education.

Among the arguments for the study of the classical languages, it is frequently urged that without it we cannot understand our own language. The English Schools Inquiry Commissioners for 1868 reported that "Latin has entered so largely into English that the meaning of a very large proportion of our words is first discovered to us on learning Latin, and to a no less degree has it entered into English literature, so that many of our classical writers are only half intelligible, unless some Latin precede the reading."

This argument is unsubstantial. Perhaps one man in a thousand of our countrymen has some smattering of Latin, fresh or faded; say one man in a hundred: do the Commissioners mean to aver that ninety-nine men in every hundred of us have not discovered the meaning of "a very large proportion" of what we say?

It is useless to reason with men capable of putting on record, or of accepting, such a proposition. It is useless to point out, what seems obvious enough, that the meaning of a word is determined not by its derivation, but by usage.

If anybody, after ten minutes' reflection, continues in such a belief, he had better have recourse to practical experiment. Let him call a servant a "slave," a sturdy rustic a "pagan," a Presbyterian father of a family a "pope." He will thus be delivered from his error very effectually, if not so agreeably as he might desire.

The same argument is put on a somewhat grander scale. Mr. Clark contends that, "whatever the subject-matter may be, no man can expound it with scientific precision unless he is acquainted with the etymologies and mutual relations of the terms he employs."

English Philology is doubtless an interesting study. Like other artists, the verbal artist takes a pleasure in the makers and the materials of his instruments. And some time might not unprofitably be devoted to the sources of the language, and the leading rules of verbal change. That is all that can be said for the study of philology, and it is no small recommendation. To go Mr. Clark's length is a mistake. The meaning of *root* words, and the history of their transformation down to the present time, are no more essential to clear and effective composition than an historical knowledge of tools is essential to good carpentry; and the reason is manifest. The meaning of a word is determined not by its derivation but by usage. We can no more know the meaning of a word from the meaning of its etymon than we can know the size of a river at its mouth by going to its source.

Philological knowledge, however delightful, being a luxury, and therefore a secondary object, my space will not permit me to expatiate upon it. I make a brief statement.

The enormous acquisition of Latin and Greek is both insufficient and unnecessary.

It is insufficient. A thorough knowledge of Greek and Latin clearly will not help us in such parts of our vocabulary as are not derived from those sources.

It is unnecessary and even useless. The *roots* in English are computed at 500. The only rational way to study our philology is, to take up these roots, and trace their ramifications, so far as these have been ascertained. A collateral study would be the importation of words from various sources: for this purpose it would be ridiculous to master the syntax and literature of the various original languages. The main groups are determined by simple rules.

The philological argument assumes yet another form. The Latin scholar is supposed to have a peculiar advantage in scientific terminology.

Mr. Torr, a Lincolnshire farmer, examined before the Commissioners, says: "All botany and all chemistry have a sort of Latin derivation. There is a sort of knowledge of Latin in every thing. For instance, a man could not go into chemistry or botany without knowing the derivation and *finale* of every word."

In this matter, many argue as if the meanings of the original words were learned without an effort. The real state of the case is obvious enough. If the meaning of the original is adopted without change in the derivative, it can be learned as easily in English as in Latin. If the meaning of the original is not retained in the derivative, a knowledge of the one will be no aid toward the knowledge of the other.

Where several words come from the same root, let the common element be explained. If philology were really taught in our schools, as it might be were less time occupied with classics, the root-words in scientific nomenclature would be no less familiar to the average boy than they are at present to the best classical scholar.

We are told, furthermore, that English grammar cannot be taught without Latin grammar. "All masters," say the Commissioners, "appear to be agreed that nothing teaches English grammar so easily, or so well, as Latin grammar; and next to that they would place the teaching of some other foreign grammar, such as French." Mr. Clark, who carries all the favorite arguments for classics to such a height that he may be suspected of a covert design to make them ridiculous, alleges that "a youth who has mastered the Latin grammar, and learned to apply its rules, speaks and writes English without a fault, albeit innocent of Lindley Murray."

Is this argument verified by experience? On this point I might appeal to the individual reader. But we have definite testimony. We have the evidence of Mr. Dasent, who "has had considerable experience as an examiner" for military and civil service appointments. So far from certifying that Latin scholars "speak and write English without a fault," Mr. Dasent says: "I have known young men who write very good Latin prose, indeed, and very good Latin verse. I know what good Latin prose and Latin verse are, and I have known the same young men utterly incapable of writing a letter in their own language, or a decent essay." And again, "I think I know good writing when I see it, and I must say that some, who had great classical reputation, have been the worst English writers I have known. I have observed this over and over again. I have known men recommended solely in consequence of their university reputation, and I have found that they have been signal failures in English writing—splendid scholars, but utterly incapable of expressing themselves in their own tongue. They have no choice of words, and very often have a heavy, cumbrous way of expressing themselves." What could be stronger than this? Coming as it does from one of the few men qualified by experience to pronounce an opinion, this evidence is not to be lightly set aside.

Does the argument in question stand the test of reason? It is a common rejoinder to whatever is said against the existing system of education, that educational results are impalpable. Now, this is not one of the impalpable cases: a certain definite acquisition, the command of the literary usages of our language, is said to be conferred; the alleged possessors are tried and found wanting. However, for fear the evidence should not be considered wide enough, and the report of the Commissioners be adduced as counter-evidence, let us take the only other way of determining the point—let us apply the test of reason. We shall find that Latin grammar, so far from being the only means of teaching English grammar thoroughly, teaches hardly any English grammar. And not only so: what little English grammar it does teach indirectly, had better be taught directly.

How much English grammar is acquired through Latin grammar? The names of the parts of speech, and nothing else. Latin agrees with English in employing similar parts of speech. A Latin sentence, like an English sentence, is made up of nouns, adjectives, verbs, conjunctions, etc. Now, a boy that understands what a noun is, or an adjective, or a conjunction, in a Latin sentence, will probably know what name to give to words performing similar functions in an English sentence. If he knows that "cum" is called a preposition, and that "cum" means "with," he will probably be able to say that "with" is a preposition.

A pupil acquainted with English grammar, before commencing with Latin, has the same advantage toward knowing Latin grammar. If he has been taught to call "with" a preposition, and that "with" stands for "cum," he will probably be able to tell that "cum" is a preposition.

In the above I make a very full concession. It is extremely doubtful whether an ordinary boy would recognize an inflected part of speech in English, from knowing a similar part of speech in Latin. How many boys, if told that "bona" is an adjective, would make out that "good" receives the same grammatical name?

There is no further coincidence between English grammar and Latin grammar. The two languages have very different modes of inflection, whether for noun or for pronoun, or for verb, or for adjective, or for adverb; different concord, different government, different order; and, of course, different derivation and different composition. In all these respects—that is, in all the important or practical part of grammar—the usages of the two languages are wholly different. We cannot know English declensions from Latin declensions, English conjugations from Latin conjugations, English syntax from Latin syntax. Would a boy know that the past participle of *have* is *had*, from knowing that the supine of *habeo* is *habitum;* or, knowing the one, would he more easily remember the other? What boy, familiar with Latin declensions and conjugations, would discover by his unaided reason that there were such things as declensions and conjugations in English? Mr. Dasent's evidence clinches this. He bears witness of good Latin scholars that "they did not know even that there was any syntax or construction of the English language."

We are driven to conclude that this too common argument is an example of the error deplored by Mr. Mill—an example of using words without thinking of their meaning. Nobody, after remembering that Grammar is an account of the usages of a language, would be guilty of saying that the best way to get acquainted with the usage of one language is to study the usage of another.

It may be said that the knowledge of another grammar than our own helps our acquaintance with our own grammar, by way of contrast. True, but foreign usages may be illustrated well enough for this purpose with our own vocables. Take, for example, the inflections of Latin and Greek: what hinders the English teacher from showing that, in those ruder and less flexible tongues, relational particles were stuck on at the end of a word, instead of being placed before the word in a separate form? That, instead of saying "He struck with a sword," a Roman would say "Sword-with-struck-he"—a partial advance on the agglutination of more savage dialects, where, instead of "He saw a pig on the road," we should have one word, "Road-pig-saw-he."

A classical education is also said to be the best training in English composition. This argument, in so far as the end alleged is gained through grammar, I have already shown to be groundless. I have still to deal with the direct exercise in English composition obtained in classical translation.

It is to be observed that this value is not special to Latin or Greek, but is common to all foreign languages. Further, if the idea of Mr. Mill and of some others were carried out, and we were able to read foreign tongues as we read our own, we should not translate at all, and could have no conceivable exercise in English composition. If we are exercised at all in English composition by foreign translation, it must be under some such system as the present mode of classical instruction. Is it impossible to write good English without a knowledge of classics? I need only repeat the stock answer. Some of the greatest names in our literature have won their reputation without a knowledge of classics.

Does the power of composing good English *always follow upon* a good knowledge of classics? Mr. Dasent's evidence, quoted before, gives to this question as explicit a denial as could be desired.

How far, then, is translation an exercise in English composition? Let us consider translation in detail. The pupil has to master the construction, that is, to recall the meaning of the relational particles and endings. He has to muster, partly from memory, partly from his dictionary, the English equivalents for the foreign words, settling which is the word for the occasion. Finally, he has to range the English words in the form of a sentence. This last is the exercise in English composition.

What proportion of the whole time given to translation does this exercise occupy? Sometimes hardly any time at all. The pupil prepares the meanings of the words, and blurts them out anyhow. In the most favorable cases, the time spent on this operation must be comparatively small. The other operations are much more arduous, and must occupy at least five-sixths of the whole time.

What is the nature of the composition done in this sixth of the translating time? Is it calculated to train in good English composition? On the contrary, literal translation is often insisted upon; that is to say, the pupil is drilled in unidiomatic English. This is worse than no English drill at all for purposes of English composition: its only effect in that direction must be to foster a habit of writing bad English.

Where the arrangement of the English words is made in accordance with English usage, this sixth of the translating process becomes an exercise in the amendment of unidiomatic English. But the result is little more profitable than in the other case, for two reasons: One is, that the preliminary mustering of the main English words, and the puzzling over the constructions, absorb so much of the pupil's attention that the finished English rendering is little thought of. The other and principal reason is, that the English version, where attended to—as it must be in a good translation—is remembered only in connection with the Latin, and is not readily remembered when a natural object has to be described. A good translator has no facility in original composition, unless he has practised the art of composition by itself: the words used in translation do not occur as symbols for natural things, but only as equivalents for the Latin expressions. It was quite to be expected that Mr. Dasent would find good Latin scholars "utterly incapable of expressing themselves in their own language." The wonder would be if they found time to learn how to lay out felicitously their own thoughts and sentiments, while they acquired the art of felicitously translating the more or less skilful expression of the thoughts and sentiments of others.

Does the classical scholar acquire an abundance of words or skill in selecting the right words? In translating, he must cast about over various words of cognate meaning for the word that will suit the passage. Does he thereby learn a wide command of synonymes, and a dexterity in seizing the aptest word to convey his meaning? He learns a command of synonymes, undoubtedly. But where does he get them? Not in Latin; but in his own remembered store, and in the pages of the English lexicographer, his starting-point being some English equivalent of a Latin word. As a learner of synonymes, he does no more, and can make no more progress, than the non-classical pupil that ransacks his memory and his dictionary with a similar object. He does not learn to seize the aptest words to convey his meaning. What he learns is, to seize the aptest words to represent particular Latin words in particular contexts—an entirely different thing. Mr. Dasent's evidence on this matter is very pointed. It is his express complaint of good Latin scholars, that "they have no choice of words" in English.

Does classical composition train in English composition? In translating English into Latin or Greek, the pupil must acquire a certain familiarity with a certain number of English words. If the English be good, so much the better for the pupil. If he is taught to twist and turn it about, so as to make idiomatic Latin out of idiomatic English, so much the better for him. But the advantage is no greater than he would have by keeping passages of good English some time in his memory for any purpose whatsoever.

Let us now consider what can be made of English as an instrument of education.

Passages of English, more or less unsuited for children and often selected without method, are part of existing school-drill. This might be supplemented by attention to elocution, and practice in committing to memory, exercises that children are peculiarly apt for. Such exercises have the advantage of keeping the pupil occupied with the words of his own language, and storing him with a fund of expression.

Looking out the meanings is also a valuable exercise in greater or less present practice. In the hands of a skilful teacher this might lead to a wide command of synonymes. The highest form of this exercise would be the precise discrimination of synonymes. The want of some such early training is very marked in current literature. It is strange that men should know, or at least have spent much of their school-time in learning, the conjectured shades of meaning in Latin or Greek words, while they ride rough-shod over the delicacies of their own vocabulary.

Again, if Philology is to be studied, apart from Comparative Philology, it might be expected that boys should be taught the origin and changes in form and meaning of words they use daily, rather than crammed with the history of words they never use in after-life, and never view with any thing but a pedantic interest at the best.

A beginning might be made in philology at an early stage. The sources of words are determined by simple rules: it would be an easy task for beginners to apply these rules in referring words to their source, to decide whether words were taken from Latin, or Saxon, or Norman-French. A good exercise would be to Saxonize a whole Latinized paragraph, and inversely.

In discussing other studies in English I shall make a distinction between analytical processes and synthetical processes. Both occur in dealing with what usage permits—the province of Grammar—and also in dealing with what, within the compass of permissible usage, is best suited for its purpose—the province of Rhetoric. Analysis is otherwise known as construing, or parsing; synthesis, as constructing, or composing.

In the meagre share of our school-time now allotted to the teaching of English, very little is done toward the practice of these operations. This is all the more to be deplored, because the analysis of sentences and the principles of composition are not taught in connection with Latin or Greek. It is a great waste of energy to learn meanings and shades of meaning of so many vocables destined to total neglect as soon as they have been learned: the evil is aggravated when so much lumber is acquired without reference to principles applicable to all verbal compositions.

The grammatical analysis of sentences has lately been introduced into our schools. But the complaint is made that boys, though they soon learn to repeat glibly enough the hard terms used in that process, often fail to understand them. Now, what is the cause of this? It is due to two causes, both arising from the consumption of so much time on Latin and Greek. Too little time is left for this analysis: none but teachers know the quantity of iteration and exemplification necessary to get an abstract notion into a boy's head. And there is no time at all for an exercise without which analysis can never be vividly understood, the opposite process of synthesis. Before a boy can be fully awakened to the gist of the terms of analysis, he must have applied them again and again to themes of his own composing, and there will be no time for such an exercise until there is an end of the classical supremacy.

The purification of the language from blunders is an urgent necessity. A good way of habituating the pupil to recognized usage would be to keep him working at collections of grammatical blunders. Were English made the systematic study that Latin has been, we should in this way effect, in the course of a generation or two, a great purification of our language. We have a good many collections of genuine idioms with examples of their violation; but we want a great many books of this kind—contributions from many workers in the same field. Latin is well provided for in this way. One cannot help regretting that so much time has been thrown away upon settling pure Latin usage that might have been spent so much more profitably in the purification of our own tongue.

So much for familiarizing the pupil with the parts of a sentence and correct grammatical usage. Practical teachers will recognize in what has been exhibited a wide field for school-study. Others will understand the amount of exercise involved, when they reflect upon the time now spent upon introductory exercises to Latin, of a much less extensive range than those I have indicated.

A knowledge of admissible forms of expression is more than Mr. Dasent seems to have found in several "good Latin scholars." But a youth that is master of this accomplishment is but indifferently equipped for recording and communicating his thoughts. Much imperfect expression passes current. A thing may be put a hundred ways, all conformable to grammar, yet one, and perhaps not many more than one, accords with the laws of good composition.

Can the principles of good composition be taught? Is rhetoric—the knowledge of good and bad in expression, viewed with reference to certain ends—a possible accomplishment for the school-boy? According to De Quincey, the end of rhetoric, as conceived by the ancients, was either ornament or fraud, figurative decoration or sophistry—a conception of rhetoric not so very rare in our day. The one end was served by the branches of rhetoric conversant with Tropes, Figures, and Emotional Qualities of Style; the other by the various maxims of Persuasive Art, consisting for the most part of shrewd devices for securing plausibility. I believe something more might be made of those branches of education than mere garnishing and trickery; still they are, perhaps, too advanced for the school-room. Be that as it may, there are other parts of rhetoric that have a prior claim, because of more general value. De Quincey's account of ancient rhetoric is a fair enough summary; but of late years the canons of rhetoric have taken a wider scope. In Prof. Bain's "Rhetoric" or English "Composition," written with the scientific exhaustiveness and originality characteristic of the author, we have a great advance upon Aristotle. In addition to the old material completed and methodized, we have a body of rules bearing upon the order of words, the principles of the construction of sentences and of paragraphs, the principles of description, narration, and exposition. Of these subjects, the first four are admirably suited for the school-boy, description more than narration or exposition—although these also might be valuable—because it is regulated by a compact, complete, and easily-managed body of maxims.

What is there, then, to prevent this department of English composition from being practised in our schools, instead of composition in a dead language, where the sole ambition is to be grammatical? A variety of objections might be urged, which I proceed to discuss one by one. They will be found to disappear on consideration:

1. It may be said that *such studies are not ample enough* to keep our school-boys busy, and so fail in the most fundamental requisite of a school-study. How to arrange words, how to form sentences and paragraphs, how to make an easily conceivable description—why should not that be learned in a few lessons? If so, why are years spent in teaching our boys to avoid a few stock pitfalls in Latin composition? The reason is obvious. The rules or principles you may learn in a few lessons: you may not be perfect in the practice of these rules after years of study. The same thing is seen in every art. The pugilist or fencer soon learns the guards theoretically: it is a long time before he can promptly parry the hit or thrust of an adversary. The musician knows all the notes, and where he should place his fingers to bring them out, long before he can play at sight. We can all of us remember what we should have done: the opportunity is often past before we remember what we should do. In English composition, as in every thing else, theory and practice are two very different things. Take, for example, two points: how to place qualifying clauses in the most advantageous light for the words they qualify, and how to apportion the emphatic places of a sentence. These are embodied in Prof. Bain's work, and treated of in isolation, the one by Mr. Herbert Spencer, the other by Mr. Matthew Arnold. The principles are within the comprehension of any boy of ordinary intelligence. And yet they may be practised for years by a grown man without insuring infallibility in rapid composition. Here is a wide field for educational exercises, a field wide as the writings of the language, beginning with easy examples and reaching on to the more difficult. No expensive apparatus is required; wherever you have sentences written in English, you may fall to work. And the principles I have mentioned are but samples.

The difficulty is not to get work to overtake, but to overtake much of the work that waits for us.

2. It may be said that studies of this kind are mere elegant trifling. Admitted that classical studies are of no practical value except for discipline: admitted that these English studies contain all the elements of discipline; the one is as useless subsequently as the other; there is no reason for substituting the one for the other. I say that English studies have at least the advantage of keeping the pupil occupied with the words and correct usages of *his own language*, and that this, were there nothing else, is sufficient cause for change. But I say, further, that these studies can be so directed as to cultivate clearness and force of expression. Perhaps you deny this: you hold that clearness and force are natural gifts. That clearness and force are natural gifts, and that a teacher cannot communicate brains, nobody will care to dispute; but, that the devices and appliances for giving clearness and force to what they say can be communicated to boys of natural aptitude by a skilled teacher, I hold to be beyond question. All would not learn to compose English well, any more than all learn to compose Latin well; but some would learn; and no more can be said for any system of instruction.

3. It may be said that, granting careful tuition a help to acquiring clearness and force of expression, a good style can be formed only by familiarity with the best writers. I answer that this is no objection to the scheme we have considered. We made provision for the analytical as well as the synthetical study of English, rhetorical parsing as well as rhetorical practice. What I insist upon is, that we must have principles of good and bad in expression drilled into our boys, principles to be borne in mind both in analysis and in synthesis, in reading authors as well as in our own composition. Otherwise, how are we to know what to adopt and what to reject in an author, what to imitate and what to avoid; and how shall we escape the errors of Latinists that worship the conceits of Cicero, and adore the Patavinities of Livy? I quote from Dryden a striking confirmation: "Thus difficult it is to understand the purity of English, and critically to discern, not only good writers from bad, and a proper style from a corrupt, but also to distinguish that which is pure in a good author, from that which is vicious and corrupt in him. And for want of all these requisites, or the greatest part of them, most of our ingenious young men take up some cried-up English poet for their model; adore him and imitate him, as they think, without knowing wherein he is defective, where he is boyish and trifling, wherein either his thoughts are improper to his subject, or his expressions unworthy of his thoughts, or the turn of both is inharmonious."

4. It may be said that, granting the necessity of reading admired authors critically, that is, upon principles of good and bad, there are no good authors in English, and that the pupil should go with his

principles to classical Greek and Latin. Supposing there were no good authors in our tongue, the amendment of the bad would be as valuable an exercise as the recognition of the good. However, we should be glad to think with Macaulay: "It may safely be said that the literature now extant in the English language is of far greater value than all the literature which three hundred years ago was extant in all the languages of the world put together."

5. It may be said that, if composition were managed according to rule, there would be no scope for variety. That depends upon the nature of the body of rules. If the rule is absurdly narrow, obedience to it will result in a dead monotony. For example, on the unity of the sentence, Irving lays down that "different thoughts ought to be separated in the expression by being placed in different periods"—a rule that would reduce all composition to the movement of a jig. On the contrary, Prof. Bain recognizes that the matter of a sentence is determined by the rest of the composition, and gives the limitations of the absolute rule of unity. A principle of this kind, so far from inducing monotony, tends to assist variety: the writer is compelled to think of the matter of his sentences, and, in all probability, will thereby be prevented from the natural tendency to run them all together on the same model. Even if the rule were absolute, it would still be valuable, provided its reasons were assigned. The dull pupil would be dull all the same: the eager pupil, if he found the restrictions irksome, would either overthrow the reasons, or cast about for all variety within the letter of the law. Cut a root that intrudes into your garden, and the stump sends out twenty suckers for the one. You produce the same effect when you stop short an inquiring boy with a rule: the dull boy, a dead root, is little affected for good or for evil, but the clever boy is put upon his mettle, and becomes twice as active as before.

6. It may be said that *writing by rule, like walking on stilts*, must be a very cramped and constrained movement. The awkwardness in both cases is removed by practice.

7. It might be said that we should have *nobody to teach the new subject.* Such an evil would rapidly disappear. Many teachers are already competent, and all could without difficulty keep ahead of their first batch of pupils.

8. It will be said that no material for school-exercises has been accumulated, and that taking up an author at random would be unprofitable. It is not so; a good deal of such material has been accumulated. The reason why so little, comparatively, has been done, is plain enough. Our school-rooms have been occupied by a foreign invader, and the makers of school-books have been retained in alien service. For generations our boys have been condemned to anomalies in Greek and Latin gender, declension, and conjugation, Greek accents, Latin quantities, stiff constructions in Virgil, obscure allusions in Juvenal, various readings in Æschylus, years of study at things of no human use

or interest; and generation after generation of school-masters and book-compilers have been tortured to supply the means of torture. If the same amount of ingenuity had been expended upon English, our young writers might have been saved many a throe of composition, and our language many an ugly blemish. No one can tell how much the language might have been improved, and its superior modes and characteristics rendered habitual to the mass of our countrymen.

What I proposed to examine was whether classical studies should cease to be the staple of a liberal education, should in public institutions for general instruction form the basis of all scholarly acquirements. We seem to have reached the conclusion that Latin and Greek in that capacity should be replaced by English. There is no reason why such a change should involve the entire cessation of Latin and Greek studies. It would simply make Latin and Greek as other foreign languages are. It would make them optional, as Hebrew, Sanscrit, German, French. It would prevent the distorted view that we take of their importance, from their anomalous place in our education. It would enable us to survey them in their true light, as two—perhaps an important two, but still only two—of the great family of languages. Our conclusion is not that the study of Latin and Greek should be discontinued, but that, whatever acquisitions be intended for the school-boy, the foundation of them all should be, not a knowledge of Latin and Greek, but a competent knowledge of his own language.

THE TRANSIT OF VENUS.

By HEZEKIAH BUTTERWORTH, Esq.

SOME of the world's greatest benefactors have worked with young minds, and one of the most remarkable discoveries of astronomical science was made by a company of English students in the best days of youth. We refer to the transit of Venus across the disk of the sun.

Our readers have doubtless noticed that Congress [1] has already made provision for the scientific observation of the transit in 1874. The subject will soon engage the attention of astronomers, for the phenomenon furnishes us with the most important elements of astronomical knowledge. By the visible movement of the planet across the sun's centre, we are enabled to determine the sun's horizontal parallax, or the difference between the real and apparent position of the sun,[2] and thereby to correctly calculate the distance of the earth and

[1] Congress has appropriated $150,000 to aid the observations, and has placed the United States Navy at the disposal of Messrs. Pierce, Henry, and Sands, to be employed for the purpose.

[2] The parallax of the sun, moon, or any planet, is the distance between its true and

the planets from the sun, and the magnitude of the heavenly bodies. No person now living ever saw the transit, nor will any of the present inhabitants of the earth, who see the wonderful visions of 1874 and 1882, ever behold them again.

The transits of Venus occur alternately at intervals of eight, one hundred and five and a half, and one hundred and twenty-one and a half years. The last transit took place in 1769,[2] before the American Republic had an existence, the next will occur in 1874, and the last that we shall ever see, in 1882. Nearly a century and a quarter will then pass away, to that strange-looking date 2004, ere the beautiful planet will impart her revelation to the astronomer on the sun's reflected image.

About the year 1635 there might have been found, in an obscure village near Liverpool, a young enthusiast of science, who, like Ferguson, turned away from the ordinary pastimes of youth to study the sublimities of the celestial scenery. He was beloved by all for his amiable disposition and his stainless life. Before he reached the age of eighteen he had mastered all the known problems of astronomical knowledge.

His name was Jeremiah Horrox. His father was a man of moderate means, but sympathized with his son's studious turn of mind, and, before the year 1633, placed him at Emanuel College, Cambridge.

The stormy times of the English Revolution were approaching. During the period in which the court and Parliament were occupied in the disputes that lost the first Charles his throne, four men (three of them were youths, and all of them intimately acquainted with each other) were employed in advancing the theory and practice of astronomy. They were, William Wilbon, William Gascoygne, James Crabtree, and Jeremiah Horrox, the subject of this sketch.

Possessing a sensitive, responsive nature, and always happier in loving companionship, the boy-astronomer Horrox made of James Crabtree, a youth in years but a sage in knowledge, a bosom-friend.

Horrox had but scarcely passed into his teens, before he became interested in the fact that the tables of Kepler indicated the near approach of the transit of Venus across the disk of the sun. It was a sight that no human eye had ever seen, and one which, if any human

apparent place in the heavens, the true place of any celestial object being that in which it would appear if seen from the centre of the earth.

[2] The year 1769, the birth-year of Humboldt, Cuvier, and Napoleon, is marked in the calendar of science by unusual achievements in the infant branches of experimental investigation. Chemistry had emerged from the mystical stage of alchemy, and was planted upon its firm inductive basis. Bergmann had just made the first analysis ever made of mineral waters. Black, Cavendish, and Priestley, had commenced investigations into the nature of different kinds of air; and, in 1769, Scheele first discovered the existence of phosphate of lime in bones. The experiments of Bakewell in sheep-breeding, the first step in the art of improving stock, which has been carried to such perfection during the last hundred years, also date their success from 1769.—Ed.

eye could see, would confirm all the deductions of the great German and Danish astronomers.

Often at night, as the boy Horrox stood before moonrise, gazing at the stars, and saw Venus—the Lucifer and Hesperus of the old classic poets—burning with a clear, steady flame, and casting a dim shadow over the vernal and midsummer fields, the thought would come to him that perhaps he, first among all the dwellers on the face of the earth, might see the planet, like a celestial messenger, darkening the solar centre.

The thought grew upon him, and haunted his waking dreams. In the hours that others spent in relaxation from toil, he studied and ciphered to see if the problems by which Kepler had fixed the date of the event had been accurately solved. The marvellous boy found an inaccuracy in the tables. Again and again he recast the figures of the great astronomer, with the same result. He calculated and recalculated the problems, until he himself wrought out a table by which it appeared that the next transit would take place on December 4, 1639.

We read of student-heroes, but what a proposition was this for a boy to demonstrate! Would the calculation indeed be verified by the event itself? Would the vision withheld from philosophers and sages, from the gray dawn of time, be first revealed to the eye of a boy—an humble boy?

Gassendi had noted the transit of Mercury a few years previously, the first that had ever been seen, and men of learning were discussing the discovery. Horrox aspired to follow up the triumph of Gassendi. He had proved the deductions of Kepler to be inaccurate, and he knew that he alone possessed the true knowledge of the phenomenon.

The imaginative years of youth flew by; his college-days passed, bringing him to the verge of manhood, and the looked-for time drew near.

Horrox met his young companions in science at times, and compared his astronomical observations with theirs, but to only one of them, his chosen friend Crabtree, did he confide the discovery that he had made of the near approach of the transit.

The memorable year arrived at length, and the memorable day came round. It was the Sabbath, a bright, shining day, clear and cool. In a room nearly dark sat the young astronomer, now twenty years of age. Engaged in devout thoughts, he awaited the fulfilment of his sublime dream. On a table before him lay a white sheet of paper on which to receive the sun's reflected image, over which the shadow of the planet would move like a dark spot, if indeed the boy's calculation were correct.

The sun mounted the deep-blue sky. The paper lay spotless before the expectant youth; no shadow broke the rim of its circle, and the hour for religious worship came.

The youth hears the call of the church-bells. Shall he heed it?

Before he shall return from the house of God, a cloud may overcast the sky, and the celestial disclosure may be lost for a century!

He asks his conscience what he must do. The inward voice seems to tell him that the Creator himself is more worthy of worship than the phenomena he has instituted of admiration. He resolved, if need be, to lose the vision, and keep his eye single to the glory of God alone.

When he returned from the service, he went to the darkened room. The sun was still shining clearly. He approached the paper. It was there—the round shadow on the luminous image.

He sat down, overcome with the fulness of his emotions. The shadow crept slowly along the bright centre, like the finger of the Invisible. Then he knew that the great principles of astronomy were true, and he saw that a new revelation of scientific truth awaited mankind.

There are moments in human experience that repay the toils and struggles of a lifetime. Such were those of Galileo when he raised the newly-made telescope to the heavens; such were those of Rittenhouse, when, a century after the discovery of Horrox, he saw the shadow of Venus again crossing the disk of the sun; and such were those that the boy-astronomer himself felt as he watched the dark spot—the mighty shadow of a planet in the far abyss of space—almost imperceptibly stealing across the circumference of the reflected circle on the paper. The sublimity of the youth's vision was as grand as the moral greatness of his soul.

His friend Crabtree, to whom he had communicated the secret, made the same discovery, by the same means, in a different place of observation.

The report of the discovery awakened a new interest in astronomical science throughout the world. Horrox was censured by men of culture for suspending his observations during the Sabbath service. He answered: "I observed the sun from sunrise to nine o'clock; again a little before ten, and lastly at noon, and from one to two o'clock—*the rest of the day being devoted to higher duties!*"

His work was ended. He fell a martyr to science, at the age of twenty-two. His companions in astronomical study also perished at an early age, two of them in the civil wars, and one of these at Marston Moor, fighting in defence of the crown.

The twilight of his young life was serene and cloudless. As his bodily strength decayed, he felt that his soul would soon rise in triumph over the glittering orbs on high, and join the pure in heart.

Nearly one hundred and thirty years passed before the transit of Venus was again visible. A transit had indeed occurred in 1761, but it did not fall within the observation of the astronomer.

The transit in 1769 was eagerly looked for because it was predicted. Expeditions were fitted out by the British, French, and Russian Governments, that it might be observed from widely-distant quarters of the globe. These went to Cape Wardhus, Kola, Cajaneburg, Otaheite, Fort Prince of Wales on the northwest of Hudson's Bay, St. Joseph and Santa Anna in California. The ingress of the planet was seen at almost all the observatories of Europe, the egress at Petersburg, Yakutsk, Uanilla, Batavia, Pekin, and Orenburg.

One of the principal observers, and perhaps the astronomer whose published observations were most highly valued, was David Rittenhouse. He, too, became an astronomer in boyhood, and used to calculate eclipses on the fences and on his plough-beam, when he stopped to rest in the field.

He, too, expectantly awaited the phenomenon, studying the theories and deductions that it involved by day and dreaming of them by night. He was assigned by the American Philosophical Society to Norriton, Pennsylvania, as his place of observation.

Rittenhouse possessed a highly-imaginative and sensitive nature; and when he saw, on the calm June day, the planet like a shadow, creeping, as it were, slowly along the edge of the solar disk, he became for some moments unconscious, overawed by the sublimity of the vision.

The transit of Venus, in 1874, occurs after an interval of one hundred and five and a half years.

TRANSITS.

1639, December 4th (N. S.) 1761, June 5th	$121\frac{1}{2}$ years.
1761, June 5th 1769, June 3d	8 years.
1769, June 3d 1874, December 8th	$105\frac{1}{2}$ years.

Venus, being the second planet from the sun, and the larger of the two inferior planets having their orbits within that of the earth, appears to the earth the most luminous of all the planetary stars, her light at the period of her greatest splendor being so intense as to cast a shadow. She is seen in her full orbit beauty in regions under the equator at the period of her greatest elongation. Her telescopic appearance is interesting, lofty mountains breaking her luminous circle. During her transits her atmosphere is distinctly visible.

Extensive preparations are making, in England and on the Continent, for observing the transit in 1874 and 1882, which will afford the means of the most careful and accurate results.

ON THE DERIVATION OF AMERICAN PLANTS.

By Prof. ASA GRAY.[1]

THE session being now happily inaugurated, your presiding officer of the last year has only one duty to perform before he surrenders the chair to his successors. If allowed to borrow a simile from the language of my own profession, I might liken the President of this Association to a biennial plant. He flourishes for the year in which he comes into existence, and performs his appropriate functions as presiding officer. When the second year comes round he is expected to blossom out in an address and disappear. Each president, as he retires, is naturally expected to contribute something from his own investigations, or his own line of study; usually to discuss some particular scientific topic. Now, although I have cultivated the field of North American botany with some assiduity for more than fifty years, have reviewed our vegetable hosts, and assigned to no small number of them their name and their place in the ranks, yet, so far as our own wide country is concerned, I have been, to a great extent, a close botanist. Until this summer I had not seen the Mississippi, nor set foot upon a prairie. To gratify a natural interest, and to gain some title for addressing a body of practical explorers, I have made a pilgrimage across the continent; I have sought and viewed in their native haunts many a plant and flower which, for me, had long bloomed unseen, or only in the *Hortus siccus*. I have been able to see for myself what species and what form constitute the main features of the vegetation of each successive region, and record—as the vegetation unerringly does—the permanent characteristics of its climate. Passing on from the eastern district, marked by its equally-distributed rainfall, and therefore naturally forest-clad, I have seen the trees diminish in numbers, give place to wide prairies, restrict their growth to the borders of streams, and then disappear from the boundless drier plains; have seen grassy plains change into brown and sere desert—desert in the common sense, but hardly anywhere botanically so—have seen a fair growth of coniferous trees adorning the more favored slopes of a mountain-range, high enough to compel summer showers; have traversed that broad and bare elevated region shut off on both sides by high mountains from the moisture supplied by either ocean, and longitudinally intersected by sierras which seemingly remain as naked as they were born; and have reached at length the westward slopes of the high mountain-barrier, which, refreshed by the Pacific, bear the noble forests of the Sierra Nevada and the Coast Range, and among

[1] Retiring Address of Prof. Gray before the American Association for the Advancement of Science, upon resigning the presidency, at the late meeting in Dubuque, Iowa, August 21, 1872.

them trees which are the wonder of the world. As I stood in their shade, in the groves of Mariposa and Calaveras, and again, under the canopy of the commoner redwood, raised on columns of such majestic height and ample girth, it occurred to me that I could not do better than to share with you, upon this occasion, some of the thoughts which possessed my mind. In their development they may perhaps lead us up to questions of considerable scientific interest.

I shall not detain you with my remarks (which would now be trite) upon the rise or longevity of these far-famed *Sequoia* trees, or of the sugar-pines, incense-cedar, and firs, associated with them, of which even the prodigious bulk of the dominating *Sequoia* does not sensibly diminish the grandeur. Although no account and no photographic representation of either species of the far-famed *Sequoia* trees can give an adequate idea of their singular majesty—still less of their beauty—yet my interest in them did not culminate merely nor mainly in consideration of their size and age. Other trees in other parts of the world may claim to be older. Certain Australian gum-trees (*eucalypti*) are said to be taller. Some, we are told, rise so high that they might even cast a flicker of shadow upon the summit of the Pyramid of Cheops. Yet the oldest of them doubtless grew from seed which was shed long after the names of the pyramid-builders had been forgotten. So far as we can judge from the actual counting of the layers of several trees, no *Sequoia* now alive can much overdate the Christian era. Nor was I much impressed with an attraction of man's adding. That the more remarkable of these trees should bear distinguishing appellations seems proper enough. But the tablets of personal names which are affixed to many of them in the most visited groves—as if the memory of more or less notable people of our day might be made more enduring by the juxtaposition—does suggest some incongruity. When we consider that a hand's-breadth at the circumference of any one of the venerable trunks so placarded has recorded in annual lines the lifetime of the individual thus associated with it, one may question whether the next hand's-breadth may not measure the fame of some of the names thus ticketed for adventitious immortality. Whether it be the man or the tree that is honored in the connection, probably either would live as long in fact and in memory without it.

One notable thing about these *Sequoia* trees is their isolation. Most of the trees associated with them are of peculiar species, and some of them are nearly as local. Yet every pine, fir, and cypress in California is in some sort familiar, because it has near relations in other parts of the world. But the redwoods have none. The redwood—including in that name the two species of "big trees"—belongs to the general cypress family, but is *sui generis*. Thus isolated systematically, and extremely isolated geographically, and so wonderful in size and port, they, more than other trees, suggest questions. Were they created, thus local and lonely, denizens of California only;

one in limited numbers in a few choice spots on the Sierra Nevada, the other only along the Coast Range from the bay of Monterey to the frontiers of Oregon? Are they veritable Melchisedeks, without pedigree or early relationship, and possibly fated to be without descent? Or are they now coming upon the stage (or rather were they coming but for man's interference) to play a part in the future? Or are they remnants, sole and scanty survivors of a race that has played a grander part in the past, but is now verging to extinction? Have they had a career, and can that career be ascertained or surmised, so that we may at least guess whence they came and how and when? Time was, and not long ago, when such questions as these were regarded as useless and vain—when students of natural history, unmindful of what the name denotes, were content with a knowledge of things as they now are, but gave little heed as to how they came to be so. Now such questions are held to be legitimate, and perhaps not wholly unanswerable. It cannot now be said that these trees inhabit their present restricted areas simply because they are there placed in the climate and soil of all the world most congenial to them. These must indeed be congenial, or they would not survive. But when we see how Australian *eucalyptus* trees thrive upon the California coast, and how these very redwoods flourish upon another continent; how the so-called wild-oat (*Avena sterilis* of the Old World) has taken full possession of California; how that cattle and horses, introduced by the Spaniard, have spread as widely and made themselves as much at home on the plains of the La Plata as on those of Tartary, and that the cardoon thistle-seeds, and others they brought with them, have multiplied there into numbers probably much exceeding those extant in their native land; indeed, when we contemplate our own race, and our own particular stock, taking such recent but dominating possession of this New World; when we consider how the indigenous flora of islands generally succumbs to the foreigners which come in the train of man; and that most weeds (i. e., the prepotent plants in open soil) of all temperate climates are not "to the manor born," but are self-invited intruders, we must needs abandon the notion of any primordial and absolute adaptation of plants and animals to their habitat which may stand in lieu of explanation, and so preclude our inquiring any further. The harmony of Nature and its admirable perfection need not be regarded as inflexible and changeless. Nor need Nature be likened to a statue, or a cast in rigid bronze, but rather to an organism, with play and adaptability of parts, and life and even soul informing the whole. Under the former view, Nature would be "the faultless monster which the world ne'er saw," but inscrutable as the Sphinx, whom it was vain, or worse, to question of the whence and whither. Under the other, the perfection of Nature, if relative, is multifarious and ever renewed; and much that is enigmatical now may find explanation in some record of the past.

The larger part of the genera of our own region which I have enumerated as wanting in California are present in Japan or Mantchooria, along with many other peculiar plants divided between the two. There are plants enough of the one region which have no representatives in the other. There are types which appear to have reached the Atlantic States from the South, and there is a larger infusion of subtropical Asiatic types into temperate China and Japan; among these there is no relationship between the two countries to speak of. There are also, as I have already said, no small number of genera and some species, which, being common all round or partially round the northern temperate zone, have no special significance because of their occurrence in these two antipodal floras, although they have testimony to bear upon the general question of geographical distribution. The point to be remarked is that a very large proportion of the genera and species which are peculiar to North America as compared with Europe, and largely peculiar to Atlantic North America as compared with the California region, are also represented in Japan and Mantchooria, either by identical or by closely-similar forms. The same rule holds on a more northward line, although not so strikingly. If we compare the plants, say of New England and Pennsylvania (latitude 45° 47′), with those of Oregon, and then with those of Northeast Asia, we shall find many of our own curiously represented in the latter, while only a small number of them can be traced along the route even so far as the western slope of the Rocky Mountains. And these repositories of Eastern-American types in Japan and neighboring districts are in all degrees if likewise. Sometimes the one is undistinguishable from the other; sometimes there is a difference of as great but hardly of as tangible character; sometimes the two would be termed marked varieties if they grew naturally in the same forest, or in the same region; sometimes they are what the botanists call representative species, the one answering closely to the other, but with some differences regarded as specific; sometimes the two are nearly of the same genus or not quite that, but of a single or very few species in each country, when the point which interests us is that this peculiar limited type should occur in two antipodal places and nowhere else. It would be tedious, and, except to botanists, abstruse, to enumerate instances, yet the whole strength of the case depends upon the number of such instances. I propose, therefore, if the Association does me the honor to print this discourse, to append in a note a list of the more remarkable ones. But I would mention two or three cases as specimens. Our *Rhus toxicodendron*, or poison-ivy, is exactly repeated in Japan, but is found in no other part of the world, although a species like it abounds in California. Our other species of *Rhus* (*R. venenata*), commonly called poison-dogwood, is in no way represented in Western America, but has so close an alliance in Japan that the two were taken for the same by Thunberg and Linnæus, who called them both *R. vernix*. Our

Northern fox-grape, *Vitis labrosca*, is wholly confined to the Atlantic States, except that it reappears in Japan and that region. *Wistaria* was named for a woody leguminous climber, with showy blossoms; native of the Middle Atlantic States. The other species which we prize so highly in cultivation, *W. sinensis*, is from China, as its name indicates, or perhaps only from Japan, where it is certainly indigenous. Our yellow-wood (*cladrastis*) inhabits a very limited district on the western slope of the Alleghanies. Its only and very near relative (*maackia*) is in Mantchooria. The *hydrangeas* have some species in our Alleghany region. All the rest belong to the Chino-Japanese region and its continuation westward. The same may be said of the *Syringas* (*Philadelphus*), except that there are one or two nearly the same in California and Oregon. Our blue choste (*cantophyllum*) is confined to the woods of the Atlantic States, but has lately been discovered in Japan. A peculiar relative of it, *diphyllæ*, confined to the higher Alleghanies, is also repeated in Japan, with a slight difference, so that it may largely be distinguished as another species. Another relative is our twin-leaf (*Jeffersonia*) of the Alleghany region alone. A second species has lately turned up in Mantchooria. A relative of this is *podophyllum*, our mandrake, a common inhabitant of the Atlantic United States, but found nowhere else. There is one other species of it, and that is in the Himalayas. Here are four most peculiar genera of one family, each of a single species in the Atlantic United States, which are duplicated on the other side of the world, either in identical or almost identical species, or in an analogous species, while nothing else of the kind is known in any other part of the world. I ought not to omit ginseng, the root so prized by the Chinese, and which they obtained from their northern provinces and Mantchooria. We have it also from Corea and Northern Japan. The Jesuit fathers identified the plant in Canada and the Atlantic States, brought it in the Chinese name by which we know it, and established the trade in it, which was for many years most profitable. The exportation of ginseng to China probably has not yet entirely ceased. Whether the Northeastern Asiatic and the Atlantic American ginsengs are exactly of the same species or not is somewhat uncertain, but they are hardly if at all distinguishable. There is a shrub—*ellittia*—which is so rare and local that it is known only at two stations on the Savannah River, in Georgia. It is of peculiar structure, and was without near relative until one was lately discovered in Japan (in Triwitalavia) so like it as hardly to be distinguishable, except by having the parts of the blossom in threes instead of fours. We suppose *ellittia* had happened to be collected only once, a good while ago, and all knowledge of the limited and secluded locality was lost; and meanwhile the Japanese form came to be known. Such a case would be paralled with an actual one. A specimen of a peculiar plant was detected in the herbarium of the elder Michaux, who collected it (as his autograph ticket shows) somewhere in the high Alleghany Mountains more than eighty years ago. No one has seen the living plant since, or knows where to find it, if haply it still flourishes in some secluded spot. At length it is found in Japan; and I had the satisfaction of making the identification. One other relative is also shown in Japan; and another has just been detected in Thibet. Whether the Japanese and the Alleghanian plants are exactly the same or not, it needs complete specimens of the two to settle. So far as we know, they are just alike. And even if some difference came to be known between them, it would not appreciably alter the question as to how such a result came to pass.

Each and every one of the analogous cases I have been detailing—and of which I could adduce very many more—raises the same question, and would be satisfied with the same answer. These singular relations attracted my curiosity early in the course of my botanical studies, when comparatively few of them were known, and my serious attention in later years, when I had numerous and new Japanese plants to study in the collections made (by Morris, Williams, and Morrow) during Commodore Perry's visit in 1853, and especially, by Mr. Charles Wright, in Commodore Rodgers's expedition in 1855. I then discussed this subject somewhat fully, and translated the facts within my reach. This was before I ever had developed the rich fossil botany of the arctic zone, before the immense antiquity of existing species of plants was recognized, and before the publication of Darwin's now famous volume on the "Origin of Species" had introduced and familiarized the scientific world with those now current ideas respecting the history of species, with which I attempted to deal in a moderate and feeble way. My speculation was based upon the former glaciation of the northern temperate zone, and the inference of a warmer period preceding (and, perhaps, following). I considered that our own vegetation, or its proximate ancestry, must have occupied the arctic and sub-arctic regions in Pliocene times, and that it had been gradually pushed southward as the temperature lowered and the glaciation advanced even beyond its present habitation; that plants of the same stock and kindred, probably ranging round the arctic zone as the present arctic species do, made their forced migration southward upon widely-different longitudes, and receded more or less as the climate grew warmer; that the general difference of climate which marks the eastern and the western sides of the continents—the one extreme, the other mean—was doubtless even then established, so that the same species and the same sort of species would be likely to secure and retain foothold in the similar climates of Japan and the Atlantic United States, but not in intermediate regions of different distribution of heat and moisture; so that different species of the same genus as in *torreya*, or different genera of the same group, as Redwood, *taxodium* and *glyptostribus*, or different associations of forest-trees, might establish themselves each in the region best suited to their particular requirements, while they would fail to do so in any other. These views implied that the sources of our actual vegetation and the explanation of these peculiarities were to be sought in and presupposed an ancestry in Pliocene or still earlier times, occupying the high northern regions. And it was thought that the occurrence of peculiarly North American genera in Europe, in the Tertiary period (such as *taxodium*, *carya*, *liquidamber*, *sassafras*, *negundo*, etc.), might best be explained on the assumption of early interchange and diffusion through Northern Asia, rather than by that of the fabled Atlantis. The hypothesis supposed a gradual modification of species in different directions under altering conditions, at least to the extent of producing varieties, sub-species, and representative species, as they may be variously regarded; likewise the single and local origination of each type, which is now almost universally taken for granted.

The remarkable facts in regard to the Northeast American and Northeast Asiatic floras, which these speculations were to explain, have since increased in number, more especially through the admirable collections of Dr. Maximowits in Japan and adjacent countries, and the critical comparisons he has made and is still engaged upon. I am bound to state that in a recent general work by a distinguished botanist, Prof. Guisebach of Göttingen, these facts have been emptied of all special significance,.and the relations between the Japanese and the Atlantic United States floras may be said to be more intimate than might be expected from the situation, climate, and present opportunity of interchange. This extraordinary conclusion is reached by regarding as distinct species all the plants common to both countries between which any differences have been discerned, although such differences would probably count for little if the two grew in the same country, thus transferring many of my list of identical to that of representative species, and by simply eliminating from consideration the whole array of representative species—i. e., all cases in which the Japanese and the American plant are not exactly alike. As if, by pronouncing the cabalistic word *species* the question was settled, or rather the greater part of it remanded out of the domain of science, as if, while complete identity of forms implied community of region, any thing short of it carried no presumption of the kind—so leaving all these singular duplicates to be wondered at, indeed, but wholly beyond the reach of inquiry. Now, the only known cause of such likeness is inheritance, and as all transmission of likeness is with some difference in individuals, and as changed conditions have resulted, as is well known, in very considerable differences, it seems to me that if the high antiquity of our actual vegetation could be rendered probable, not to say certain, and the former habitation of any of our species, or if very near relatives of them in high northern regions could be ascertained, my whole case would be made out.

The needful facts, of which I was ignorant when my essay was published, have now been for some years made known, thanks mainly to the researches of Heer upon ample collections of arctic fossil plants. These are confirmed and extended by new investigations, the results of which have been indicated to me by the latter. The *taxodium*, which everywhere abounds in the Miocene formations in Europe, has been specifically identified, first by Goeppert, then by Heer, with our common cypress of the Southern States. It has been found, fossil in Spitzbergen, Greenland, and Alaska, in the latter country along with the remains of another form, distinguishable, but very like the common species; and this has been identified by Lesquereux in the Miocene of the Rocky Mountains. So there is one species of tree which has come down essentially unchanged from the Tertiary period, which for a long while inhabited both Europe and North America, and also at some part of the period the region which geographically connects the two (once doubtless much more closely than now), but survives only in the Atlantic United States and Mexico. The same *Sequoia* which abound in the same Miocene formations in North Europe has been now abundantly found in those of Iceland, Spitzbergen, Greenland, Mackenzie River, and Alaska. It is named *Sequoia langsdupii*, but is pronounced to be very much like *Sequoia sempervirens*, our living redwood of the Californian coast—to be the ancient representative of it. Fossil specimens of a similar, if not the same, species have been recently detected in the Rocky Mountains by Hayden, and determined by our eminent paleontological botanist, Lesquereux, and he assures me that he has the common redwood itself from Oregon, in a deposit of Tertiary age. Another *Sequoia* (*Sequoia sternbergii*), discovered in Miocene deposits in Greenland, is pronounced to be the representative of *Sequoia gigantea*, the big tree of Californian sierra. If the *taxodium* of the Tertiary time in Europe and throughout the arctic regions is the ancestor of our present bald cypress, which is assumed in regarding them as specifically identical, then I think we may with our present light fairly assume that the two redwoods of California are the probable descendants of the two ancient species which so closely resemble them. The forests of the arctic zone in Tertiary times contained at least three other species of *Sequoia*, as determined by their remains, one of which, from Spitzbergen, also much resembles the common redwood of California. Another, "which appears to have been the commonest coniferous tree on Disco," was common in England and some other parts of Europe. So the *Sequoias*, now remarkable for their restricted station and numbers, as well as for their extraordinary size, are of an ancient stock; their ancestors and kindred formed a large part of the forests which flourished throughout the polar regions, now desolated and ice-clad, and which extended into low latitudes in Europe. On this continent one species at least had reached to the vicinity of its present habitat before the glaciation of the region. Among the fossil specimens already found in California, and which our trustworthy paleontological botanist has not yet had time to examine, we may expect to find evidence of the early arrival of these two redwoods upon the ground which they now, after much vicissitude, scantily occupy. Differences of climate, or circumstances of migration, or both, must have determined the survival of *Sequoia* upon the Pacific; very similar would seem to have been the fate of a more familiar gymnospermous tree, the ginko or *salistiria.* It is now indigenous to Japan only. Its ancestor, as we may fairly call it, since, according to Heer, "it corresponds so entirely with the living species that it can scarcely be separated from it," once inhabited Northern Europe and the whole arctic region round to Alaska, and had even a representative farther south in our Rocky Mountain district. For some reason, this and *glystrophobes* survived only on the shores of Eastern Asia. *Libocearus*, on the other hand, appears to have cast in its lot with the *Sequoias.* Two species, according to Heer, were with the ancient ones in Spitzbergen. Of the two now living, one *L. decurrens*—the incense-cedar—is one of the noblest associates of both the present redwoods; the other is far south in the Andes of Chili. The genealogy of the *torreyas* is more obscure; yet it is not unlikely that the yew-like trees, named *taxides*, which flourished with the *Sequoias* in the Tertiary arctic forests, are the remote ancestors of the three species of torreya, now severally in Florida, in California, and in Japan. As to the pines and firs, these were more numerously associated with the ancient *Sequoias* of the polar forests than with their present representatives, but in different species, apparently more like those of Eastern than of Western North America. They must have encircled the whole polar zone then as they encircle the present temperate zone now.

I must refrain from all enumeration of the angiospermous or ordinary deciduous trees and shrubs, which are now known by their fossil remains to have flourished throughout the polar regions when Greenland better deserved its name, and enjoyed the present climate of New England and New Jersey. Then Greenland and the rest of the north abounded with oaks, representing the several groups of species which now inhabit both our eastern and western forest districts; several poplars are very like our balsam-poplar or balm-of-Gilead-tree; more beeches than there are now, a hornbeam, and a hop-hornbeam, some birches, a persimmon, and a plane-tree, near representatives of those of the Old World, at least of Asia, as well as of Atlantic North America, but all wanting in California; one *juglans*, like the walnut of the Old World; two or three grape-vines are near our Southern fox-grape or muscadine, the other near our Northern frost-grape; a *tilia*, very like our basswood of the Atlantic States, only a *liquidamber;* a magnolia, which recalls our *Magnolia grandiflora;* a *liriodendron*, sole representative of our tulip-tree; and a sassafras very like the living tree. Most of these, it will be noticed, have their nearest or their only living representatives in the Atlantic States, and, when elsewhere, mainly in Eastern Asia. Several of them, or of species like them, have been detected in our Tertiary deposits west of the Mississippi by Newberry and Lesquereux. Herbaceous plants, as it happens, are rarely preserved in a fossil state, else they would probably supply additional testimony to the antiquity of our existing vegetation, its wide diffusion over the northern and and more frigid zone, and its enforced migrations under changes of climate. Supposing, then, that our existing vegetation, as a whole, is a continuation of that of the Tertiary period, may we conclude that it absolutely originated then? Evidently not. The preceding Cretaceous period has furnished to Caruthers in Europe a fossil print like that of the *Sequoia gigantea* of the famous groves, associated with pines of the same character as those that accompany the present tree; has furnished to Heer, from Greenland, two more *Sequoias*, one of them identical with a Tertiary species, and one nearly allied to *Sequoia languidrupii*, which in turn is a probable ancestor of the Californian redwood; has furnished to Lesquereux, in North America, the remains of another ancient *Sequoia*, a *glyptotrobus;* a *liquidamber*, which well represents our sweet-gum-tree; oaks, analogous to living ones, leaves of a plane-tree, which are also in the Tertiary, and are scarcely distinguishable from our own *Platanus Occidentalis;* of a magnolia- and tulip-tree; and "of a sassafras undistinguishable from our living species."

I need not continue the enumeration. The facts will justify the conclusion which Lesquereux—a very scrupulous investigator—has already announced, that "the essential types of our actual flora are marked in the Cretaceous period, and have come to us after passing, without notable changes, through the Tertiary formations of our continent." According to these views, as regards the plants, at least, the adaptation to successive times and changed conditions has been maintained, not by absolute reversals, but by gradual modifications. I, for one, cannot doubt that the present existing species are the lineal successors of those that garnished the earth in the old time before them, and that they were as well adapted to their surroundings then as those which flourish and bloom around us are to their conditions now. Order and exquisite adaptation did not wait for man's coming, nor were they ever stereotyped. Organic Nature, by which I mean the system and vitality of living things, their adaptation to each other and to the world, with all its apparent and indeed real stability, should be likened, not to the ocean, which varies only by tidal oscillations from a fixed level to which it is always returning, but rather to a river so vast that we can neither discern its shores nor reach its sources, whose onward flow is no less actual because too slow to be observed by the ephemera which hover near its surface or are borne upon its bosom. Such ideas as these, though still repugnant to some, and not long since to many, have so possessed the minds of the naturalists of the present day that hardly a discourse can be pronounced or an investigation prosecuted without reference to them. I suppose that the views here taken are little, if at all, in advance of the average scientific mind of the day. I cannot regard them as less noble than those which they are succeeding. An able philosophical writer, Miss Frances Power Cobbe, has recently and truthfully said:

It is a singular fact that when we can find out how any thing is done, our first conclusion seems to be that God did not do it. No matter how wonderful, how beautiful, how intimately complex and delicate has been the machinery which has worked, perhaps for centuries, perhaps for millions of ages, to bring about some beneficent result, if we can but catch a glimpse of the wheels, its divine character disappears.—("Darwinism in Morals," in *Theological Review, April*, 1871.)

I agree with the writer that this first conclusion is premature and unworthy; I will add deplorable. Through what faults or infirmities of dogmatism on the one hand, and skepticism on the other, it came to be so thought, we need not here consider. Let us hope, and confidently expect, that it is not to last; that the religious faith which survived, without a shock, the notion of the fixity of the earth itself, may equally outlast the notion of the absolute fixity of the species which inhabit it; that, in the future, even more than in the past, faith in an order which is the basis of science will not (as it cannot reasonably) be dissevered from faith in an Ordainer, which is the basis of religion.

VISUAL IMAGES IN DARKNESS.

THERE is a chapter in Sir John Herschel's volume of "Lectures on Scientific Subjects" which treats of certain peculiar forms of ocular spectra, under the above title.

The spectra here alluded to—those which present themselves to us, independently of the will, in darkness or when the eyes are closed—are familiar to us all; but it appears to me that the subject has certain bearings which have been hitherto overlooked, and which merit a passing notice.

In the first place, I must beg permission to quote Sir John's own words respecting the most frequently-occurring forms—those possessing perfect geometrical regularity:

"I find them," he says, "to be formed in darkness, and, if the darkness be complete, equally with open or closed eyes.

"The forms are not modified by slight pressure on the retina, but their degree of visibility is much and capriciously varied by that cause. They are very frequent; in the majority of instances, the pattern presented is that of lattice-work, the longer axis of the rhombs being vertical. Sometimes, however, the larger axes are horizontal. The lines are sometimes dark on a light ground, and sometimes the reverse. Occasionally at their intersection appears a small, close, and apparently complete piece of pattern work, but always too indistinct to be clearly made out.

"Occasionally the latticed pattern is replaced by a rectangular one, and within the rectangles occurs in some cases a filling-up of a smaller lattice-pattern or of a lozenge of filigree-work, of which it is impossible to seize the precise form, but which is evidently the same in all the rectangles.

"Occasionally, too, but much more rarely, complex and colored patterns like those of a carpet appear, but *not* of any carpet distinctly remembered or lately seen; and in two or three instances in which this has been the case the pattern has not remained constant, but has kept changing from instant to instant, hardly giving time to apprehend its symmetry and regularity, before being replaced by another; that other, however, not being a sudden transition to something totally different, but rather a variation on the former."

Thus far I have spoken of rectilinear forms; with myself, however, curvilinear forms more frequently present themselves. These so closely resemble the spectra which Sir John describes as having presented themselves to him when under anæsthetic influence, that I again quote his words:

"The indication," he says, "by which I knew it" (the chloroform) "had taken effect consisted of a kind of dazzles, immediately followed by the appearance of a very beautiful and perfectly symmetrical Turk's-cap pattern formed by the intersection of a great many circles outside and tangent to a central one. It lasted long enough for me to contemplate it so as to seize the full impression of its perfect regularity, and to be aware of its consisting of exceedingly delicate lines, which seemed, however, to be not single but close assemblages of colored lines not unlike the delicate fringes formed along the shadows of objects by minute pencils of light. The whole exhibition lasted, so far as I could judge, hardly more than a few seconds."

On the administration of chloroform a second time, after an interval of many months, "the Turk's-cap pattern again presented itself on the first impression, which I watched with some curiosity; but it was not quite so complete as, nor was it identical with the former. In the intersections of the circles with each other I could perceive small lozenge-shaped forms or minute patterns, but not clearly enough to make them well out. On both these occasions the colors were lively and conspicuous. . . . Since that time circular forms have presented themselves, spontaneously, of the shadowy and obscure class. On one occasion circular were combined with straight lines, forming a series of semicircular arches, supported by, or, rather, prolonged beneath into, vertical columns, while another series of arches and uprights, darker than the general ground, appeared, intersecting the former, so as to have the dark uprights just intermediate between the bright ones of the first set. On the second occasion the pattern consisted of a very slender and delicate hoop, surrounded with a set of circles of the same size, as tangents to the centre circle and to one another. On the third occasion the whole visual area was covered with separate circles, each having within it a four-sided pattern of concave circular arcs. All these phenomena were much fainter than in the chloroform exhibition."

The accuracy of these descriptions will be readily admitted, as far as my own observations have enabled me to judge. I am, however, disposed to believe that the forms under which the spectra present themselves vary persistently in different individuals to a considerable extent.

A question now naturally arises: What are these spectra, and how are they formed?

An eminent scientific authority has suggested to me that they are *possibly* referable to that obscure mental process which Dr. Carpenter has termed "*unconscious cerebration.*" (*See* "Human Physiology.") But, allowing this to be the case, the questions put by Sir John Herschel still remain unanswered:

"Where do the *patterns* or their prototypes in the intellect originate?

"If it be suggested that a kaleidoscopic power of forming regular patterns, by the combination of casual elements, exists in the sensorium, how is it that we are unconscious of the power—unable to use it voluntarily—only aware of its being exerted at times in a manner in which we have actually no part but as spectators?"

I cannot help thinking that more than one of the most ancient types of symbolism upon which so much learning and ingenuity have been expended in endeavors to invest them with mystical meanings, or to trace their origin in the forms of the organic world, *may* have been first suggested by these hitherto-unnoticed spectra.

But besides these geometrical forms, there are others, which I must again describe in Sir John Herschel's words:

"I fancy," he writes, "that it is no very uncommon thing for persons in the dark, and with their eyes closed, to see, or seem to see, faces and landscapes. I believe I am as little visionary as most people, but the former case very frequently happens to myself. The faces present themselves voluntarily, are always shadowy and indistinct in outline, for the most part unpleasing, though not hideous, expressive of no violent emotions, and succeeding one another at short intervals of time, as if melting into each other. Sometimes ten or a dozen appear in succession, and have always, on each separate occasion, something of a general resemblance of expression, or some peculiarity of feature common to all, though very various in individual aspect and physiognomy. Landscapes present themselves much more rarely, but *more distinctly*, and, on the few occasions I remember, have been highly picturesque and pleasing, with a certain, but very limited power of varying them by an effort of will, which is NOT the case with the other sort of impressions. Of course," he adds, "I am now speaking of waking impressions, in perfect health, and under no sort of excitement."

There is, of course, as Sir John Herschel observes, *one marked distinction* between these spectra and the *abstract* forms referred to at the beginning of this paper: "The human features have nothing abstract in their form, and they are so intimately connected with our mental impressions that the associative principle may easily find, in casual and irregular patches of darkness caused by slight local pressure on the retina, the physiognomic exponent of our mental state. Even landscape scenery, to one habitually moved by the aspects of Nature in association with feeling, may be considered in the same predicament. We all know," he adds, "how easy it is to imagine faces in casual blots, and to fancy pictures in the fire."

However this may be, I am inclined to think that we have here an, as yet, unacknowledged source of many widely-prevailing conceptions of the "world unseen."

If we are to believe with the eminent German mythologist, Dr. Swartz, that there was a time, strange as it may now appear, "when men had not yet learned to suspect any collusion between their eyes and their fancy;" when fast-scudding clouds were flying horses or fleeting swans; when the rolling masses of vapor in the west, as the day declined, were mountains in the far-off cloud-land—not in the sense of poetic figments, but in sober reality—we can scarcely doubt but that the shadowy resemblances of which we have just spoken would be, in like manner, regarded as real existences.

Even stopping short of this extreme view of the case, I think it is difficult to suggest a more probable origin for that universally-prevailing belief, which peoples the darkness with shadowy forms—the thousand fleeting shapes which

"Make night hideous;"

or of that equally wide-spread faith in the existence of hidden realms of enchantment, of which we have types in the mystic caves of Eastern story, and the glimpses of fairy-land in our own folk-lore.

It will be observed that the phenomena above described present themselves in *health*, and in the *absence* of *all* excitement.

Where these two conditions are wanting, both voluntary and involuntary spectra present themselves with greater frequency and distinctness. Medical works abound in such cases, and Sir J. Herschel gives several suggestive examples from his own personal experience, which space forbids my quoting here.

There is, however, one point to which he refers which should not be overlooked. Whatever views we may be disposed to entertain respecting either the mental conditions in which these phenomena originate, or the external agencies by which these conditions are produced or modified, there is reason to believe that the appearances themselves ARE really formed upon the retina of the eye, and THUS they may be fairly placed in the category of "THINGS ACTUALLY seen."—*Science Gossip.*

COAL AS A RESERVOIR OF POWER.

BY ROBERT HUNT, F. R. S.

THE sun, according to the philosophy of the day, is the great storehouse of Force. All the grand natural phenomena are directly dependent upon the influence of energies which are poured forth without intermission from the central star of our system. Under the influences of light, heat, actinism, and electricity, plants and animals are produced, live, and grow, in all their infinite variety. Those physical powers, or, as they were formerly called, those imponderable elements, have their origin in one or other of those mysterious zones which envelop the orb of day, and become evident to us only when mighty cyclones break them up into dark spots. Is it possible to account for the enormous amount of energy which is constantly being developed in the sun? This question may be answered by saying that chemical changes of the most intense activity are discovered to be forever progressing, and that to these changes we owe the development of all the physical powers with which we are acquainted. In our laboratory we establish, by mechanical disturbance, some chemical phenomenon, which becomes evident to our senses by the heat and light which are developed, and we find associated with them the principle which can set up chemical change and promote electrical manifestations. We have produced combustion, say, of a metal, or of a metallic compound, and we have a flame of a color which belongs especially to the substance which is being consumed. We examine a ray of the light produced by that flame by passing it through a prism, and this analysis informs us that colored bands, having a fixed angle of refraction, are constant for that especial metal. Beyond this, research acquaints us with the fact that, if the ray of light is made to pass through the vapor of the substance which gives color to the flame, the lines of the spectrum which were chromatic become dark and colorless. We trap a ray of sunlight and we refract it by means of a spectroscope—an instrument giving results which are already described in this journal[1]—when we detect the same lines as those which

[1] *Popular Science Review*, vol. i., pp. 210–214.

we have discovered in our artificial flame. We pursue this very interesting discovery, and we find that several metals which give color to flame, and produce certain lines, when subjected to spectrum analysis, are to be detected in the rays of the sun. Therefore our inference is, that some substances, similar to the terrestrial bodies, with which we are familiar, are actually undergoing a change in the sun, analogous to those changes which we call combustion; and, more than this, we argue that the high probability is, that all solar energies are developed under those conditions of chemical change—that, in fact, the sun is burning, and while solar matter is changing its form, Force is rendered active, and as ray-power passes off into space as light, heat, etc., to do its work upon distant worlds, and these forms of Force are expended in doing the work of development *on* those worlds. This idea—theory—hypothesis—call it what we may—involves of necessity the waste of energy in the sun, and we must concede the possibility of the blazing sun's gigantic mass becoming eventually a globe of dead ashes, unless we can comprehend some method by which energy can be again restored to the inert matter. Certain it is that the sun has been shining thousands of years, and its influence on this earth we know to have been the production of organized masses, absorbing the radiant energies, in volumes capable of measurement. On this earth, for every equivalent of heat developed, a fixed equivalent of matter has changed its form; and so likewise is it with regard to the other forces. On the sun, in like manner, every cubic mile of sunshine represents the change of form of an equivalent of solar matter, and that equivalent of matter is no longer capable of supplying Force, unless by some conditions, beyond our grasp at present, it takes up again that which it has lost. That something of this kind must take place is certain. The sun is *not burning out.* After the lapse of thousands of years we have the most incontrovertible evidence that the light of to-day is no less brilliant now than it was when man walked amid the groves of Eden. We may venture farther back into the arcana of time, and say that the sun of the past summer has shone with splendor equal to the radiant power which, myriads of ages ere yet man appeared on this planet, stimulated the growth of those luxuriant forests which perished to form those vast beds from which we derive our coal. Not a ray the less is poured out in any hour of sunshine; not a grain-weight of matter is lost from the mass of the sun. If either the sunshine were weakened, or the weight of the vast globe diminished, the planets would vary in their physical conditions, and their orbits would be changed. There is no evidence that either the one or the other has resulted. Let us see if we can guess at any process by which this stability of the solar system is maintained.

It was first shown by Faraday, in a series of experimental investigations which may be regarded as the most beautiful example of inductive science with which the world has been favored since Bacon promulgated his new philosophy, that the quantity of electricity contained in a body was exactly the quantity which was necessary to decompose that body. For example, in a voltaic battery—of zinc and copper plates—a certain fixed quantity of electricity is eliminated by the oxidation of a portion of the zinc. If, to produce this effect, the oxygen of a given measure of water—say a drop—is necessary, the electricity developed will be exactly that which is required to separate the gaseous elements of a drop of water from each other. An equivalent of electricity is developed by the oxidation of an equivalent of zinc, and that electricity is required for the decomposition of an equivalent of water, or the same quantity of electricity would be equal to the power of effecting the recombination of oxygen and hydrogen, into an equivalent of water. The law which has been so perfectly established for electricity is found to be true of the other physical forces. By the combustion—which is a condition of oxidation—of an equivalent of carbon, or of any body susceptible of this change of state, exact volumes of light and heat are liberated. It is theoretically certain that these equivalents of light and heat are exactly the quantities necessary for the formation of the substance from which those energies have been derived. That which takes place in terrestrial phenomena is, it is highly probable, constantly taking place in solar phenomena. Chemical changes, or disturbances analogous to them, of vast energy, are constantly progressing in the sun, and thus is maintained that unceasing outpour of sunshine which gladdens the earth, and illumines all the planets of our system. Every solar ray is a bundle of powerful forces; light, the luminous life-maintaining energy, giving color to all things; heat, the calorific power which determines the conditions of all terrestrial matter; actinism, peculiarly the force which produces all photographic phenomena; and electricity regulating the magnetic conditions of this globe. Combined in action, these solar radiations carry out the conditions necessary to animal and vegetable organization, in all their varieties, and *create* out of a chaotic mass forms of beauty rejoicing in life.

To confine our attention to the one subject before us. Every person knows that, to grow a tree or a shrub healthfully, it must have plenty of sunshine. In the dark we may force a plant to grow, but it forms no woody matter, it acquires no color; even in shade it grows slowly and weak. In sunshine it glows with color, and its frame is strengthened by the deposition of woody matter eliminated from the carbonic acid of the air in which it grows. A momentary digression will make one point here more clear. Men and animals live by consuming the products of the vegetable world. The process of supporting life by food is essentially one of combustion. The food is burnt in the system, developing that heat which is necessary for life, and the living animal rejects, with every expiration, the combinations, principally carbonic acid, which result from this combustion. This carbonic acid is inhaled by the plant; and, by its vital power, excited by sunshine, it is decomposed; the carbon forms the ligneous structure of the plant, and the oxygen is liberated to renew the healthful condition of the atmosphere. Here we see a sequence of changes analogous to those which have been shown to be a law of electricity.

Every equivalent of matter changing form in the sun sends forth a measured volume of sunshine, charged with the organizing powers as potential energies. These meet with the terrestrial matter which has the function of living, and they expend themselves in the labor of producing a quantity of wood, which represents the equivalent of matter which has changed form in the sun. The light, heat, chemical and electrical power of the sunshine have produced a certain quantity of wood, and these physical energies have been absorbed—used up—in the production of that quantity. Now, we learn that a cube of wood is the result of a fixed measure of sunshine; common experience teaches us that, if we ignite that wood, it gives out, in burning, light and heat; while a little examination proves the presence of actinism and electricity in its flame. Philosophy teaches us that the powers set free in the burning of that cube of wood are exactly those which were required for its growth, and that, for the production of it, a definite equivalent of matter changed its form on a globe ninety millions of miles distant from us.

Myriads of ages before man appeared—the monarch of this world—the sun was doing its work. Vast forests grew, as they now grow, especially in the wide-spread swamps of the tropics, and, decaying, gathered into thick mats of humus-like substance. Those who have studied all the conditions of a peat-morass, will remember how the ligneous matter loses its woody structure in depth—depth here representing time—and how at the bottom a bituminous or coaly matter is not unfrequently formed. Some such process as this, continued through long ages, at length produced those extensive beds of coal which are so distinguishingly a feature of the British and American coal-fields. At a period in geological time, when an Old Red Sandstone land was washed by ocean-waves highly charged with carbonic acid, in which existed multitudinous animals, whose work in Nature was to aid in the building up masses of limestone-rock, there prevailed a teeming vegetation from which have been derived all the coal-beds of the British Isles. Our space will not allow of any inquiry into the immensity of time required for the growth of the forests necessary for the production of even a single seam of coal. Suffice it to say that, within one coal-field, we may discover coal-beds to the depth of 6,000 feet from the present surface. The section of such a coal-field will show us coal and sandstone, or shale, alternating again and again—a yard or two of coal and hundreds of feet of shale or sandstone—until we come to the present surface· every one of those deeply-buried coal-beds having been at one time a forest, growing under the full power of a brilliant sun, the result of solar forces, produced then, as now, by chemical phenomena taking place in the sun itself. Every cubic yard of coal in every coal-bed is the result of a very slow, but constant, change of a mass of vegetable matter; that change being analogous to the process of rotting in a large heap of succulent plants. The change has been so slow, and continued under a constantly-increasing pressure, that but few of the gaseous constituents have escaped, and nearly all those physical forces which were used in the task of producing the woody matter of the plant have been held prisoners in the vegetable matter which constitutes coal. How vast, then, must be the store of power which is preserved in the coal deposits of these islands!

We are now raising from our coal-pits nearly one hundred and ten millions of tons of coal annually. Of this quantity we are exporting to our colonial possessions and foreign parts about ten million tons, reserving nearly a hundred million tons of coal for our home consumption. Not many less than one hundred thousand steam-boilers are in constant use in these islands, producing steam—to blow the blast for smelting the iron-ore—to urge the mills for rolling, crushing, and cutting with giant power—to twirl the spindle—and to urge the shuttle. For every purpose, from rolling cyclopean masses of metal into form to weaving silky textures of the most filmy fineness, steam is used, and this steam is an exact representative of the coal employed, a large allowance being made for the imperfections of human machinery. This requires a little explanation. Coal is a compound of carbon, hydrogen, oxygen, and nitrogen, the last two elements existing in quantities so small, as compared with the carbon, that they may be rejected from our consideration. The heat which we obtain in burning the coal is almost all derived from the carbon; the hydrogen in burning produces some heat, but for our purpose it is sufficient to confine attention to the carbon only.

One pound of pure coal yields, in combining with oxygen in combustion, *theoretically*, an energy equal to the power of lifting 10,808,000 pounds one foot high. The quantity of heat necessary to raise a pound of water one degree will raise 772 pounds one foot. A pound of coal burning should yield 14,000 units of heat, or $772 \times 14{,}000 = 10{,}808{,}000$ pounds, as above. Such is the theoretical value of a pound of pure coal. Many of our coal-seams are about a yard in thickness; several important seams are much thicker than this, and one well-known seam, the thick coal of South Staffordshire, is ten yards in thickness. This, however, concerns us no further than that it is useful in conveying to the mind some idea of the enormous reservoir of power which is buried in our coal formations. One square yard of the coal from a yard-thick seam—that is, in fact, a cubic yard of coal—weighs about 2,240 pounds avoirdupois; the reserved energy in that cube of coal is equal to lifting 1,729,200 pounds one foot high. We are raising every year about 110,000,000 tons of coal from our coal-beds, each ton of coal being about a square yard. The heat of that coal is equal to a mechanical lifting power which it is scarcely possible to convey to the mind in any thing approaching to its reality. If we say it is 190,212,000 millions we merely state an incomprehensible number. We may do something more than this, if we can convey some idea of the magnitude of the mass of coal which is raised annually in these islands.

The diameter of this globe is 7,926 miles, or 13,880,760 yards; therefore the coal raised in 1870 would make a solid bar more than eight yards wide and one yard thick, which would pass from east to west through the earth at the equator. Supposing such a mass to be in a state of ignition, we can perhaps imagine the intensity of its heat, and its capability, if employed in converting water into steam, of exerting the vast force which we have endeavored to indicate. It was intimated last year in the House of Commons by a member of the coal commission that the decision of that body, after a long and laborious inquiry, would be that there existed in our coal-fields a supply for about one thousand years at our present rate of consumption. We have therefore to multiply the above computation by 1,000 to arrive at any idea of the reserved power of our British coal-fields. What must it have been ere yet our coal deposits were disturbed! At the time of the Roman occupation coal was used in this country. In the ruins of Roman Uriconium coal has been found. Certainly up to the present time a quantity of not less than three thousand million tons of coal has been dug out of our carboniferous deposits and consumed. All this enormous mass of matter has been derived from vegetable organizations which have been built up by sunshine. The sun-rays which compelled the plants to grow were used by the plant, absorbed, imprisoned in the cells, and held there as an essential ingredient of the woody matter. The heat, light, actinism, and electricity, which are developed when we burn a lump of coal, represent exactly the quantity of those forces which were necessary to the growth of the vegetable matter from which that coal was formed. The sunshine of infinitely remote ages becomes the useful power of the present day.

Let it not, however, be supposed that we employ all the heat which is available in our coal. All our appliances, even the very best, are so defective that we lose far more than we use. A pound of pure coal should evaporate thirteen pounds of water; in practice a pound of coal does not evaporate four pounds, even in the most perfectly-constructed steam-boilers, with the most complete steam-engines, such as have been constructed for pumping water for the Chelsea and the other water-works upon the Thames.

Numerous attempts have been made to burn our coal so as to secure a more effective result than this. There has been some advance, the most satisfactory being in the regenerative furnace of Mr. Siemens.

In this system the solid fuel is converted into crude gas; this gas is mixed with a regulated quantity of atmospheric air, and then burnt. The arrangements are essentially *the gas-producer*, or apparatus for converting the fuel bodily into the gaseous state; then there are *the regenerators.* These are sunk chambers filled with fire-bricks, piled in such a manner that a current of air or gas, passing through them, is broken into a great number of parts, and is checked at every step by the interposition of an additional surface of fire-brick; four of these chambers are placed below each furnace. The third essential is the *heated chamber*, or furnace proper. This, the furnace-chamber, communicates at each extremity with two of the regenerative chambers, and, in directing currents of gas and air upward through them, the two gaseous streams meet on entering the heated chamber, where they are ignited. The current descends through the remaining two regenerators, and heats the same in such a manner that the uppermost checkerwork is heated to nearly the temperature of the furnace, whereas the lower portions are heated to a less and less degree, the products of combustion escaping into the chimney comparatively cool. In the course of, say, one hour, the currents are reversed, and the cold air and gas, ascending through the two chambers which have been previously heated, take up the heat there deposited, and enter into combustion at their entrance into the heated chamber, at nearly the temperature at which the products of combustion left the chamber. It is not difficult to conceive that by this arrangement, and with its power of accumulation, any degree of temperature may be obtained in the furnace-chamber, without having recourse to purified gas, or to an intensified draught. Where the temperature of the melting-chamber has certainly exceeded 4,000 degrees of Fahrenheit, the products of combustion escape into the chimney at a temperature of only 240 degrees. The practical result of this regenerative system is stated to be, that a ton of steel requires by the ordinary method about three tons of Durham coke—which, being estimated as coal, will be about four tons—to melt it, whereas, in Siemens's furnace, the melting is effected with twelve hundred-weight of ordinary coal. This economy is produced by reserving the heat, by means of the regenerator, which is ordinarily allowed to escape by the chimney.

Another plan for consuming coal with economy has been recently introduced by Mr. T. R. Crampton, and is now in use at the Royal Arsenal, Woolwich, and at the Bowling Iron Works, in Yorkshire. Instead of converting coal into gas, as in the Siemens process, the coal is reduced by Mr. Crampton to a very fine powder, and then blown into the heated chamber by means of a fan-blast. By this arrangement the perfect combustion of the coal is produced, and a heat of the highest intensity can be obtained. The utilization of this heat, without waste, when it is produced, is an important question still requiring careful attention. There are several other experiments being carried

WILLIAM BENJAMIN CARPENTER, LL. D., F. R. S.,

President of the British Association for the Advancement of Science.

out with a view to the economical use of coal, but the two to which we have alluded give up to the present time the best results. Still, with these we allow more than one-half of the heat latent in the coal to escape us. The subtle element eludes our grasp—our charms are powerless to chain the sprite; he will not be bound to labor for us, but passes off into space, regardless of the human Prospero whose wand of science he derides.

In conclusion, our philosophy has enabled us to determine the heat-value of our coal-fields, and to prove that all this heat has a solar origin. Our science has shown us that, although we can eliminate all this heat, we cannot use it. There is an immense quantity constantly passing into space as radiant heat which we cannot retain.

The circle of action between the vegetable and the animal world is a beautiful and a remarkable provision. The animal burns carbon and sends into the air carbonic acid (a compound of carbon and oxygen); the vegetable breathes that carbonic acid and decomposes it; the carbon is retained and the oxygen liberated in purity, to maintain the life and fire-supporting principle of the atmosphere. Changes similar to these may be constantly going forward in the sun, and producing those radiations which are poured forth in volumes, far beyond the requirements of all the planets of our system. Although there is probably some circle of action analogous to that which exists upon this earth, maintaining the permanency of the vegetable and animal world, still there must be a waste of energy, which must be resupplied to the sun.

May it not be that Sir Isaac Newton's idea—that the comets traversing space gather up the waste heat of the solar system, and eventually, falling into the sun, restore its power—is nearer the truth than the more modern hypothesis, that meteorites are incessantly raining an iron shower upon the solar surface, and by their mechanical impact reproducing the energy as constantly as it is expended?—*Popular Science Review.*

SKETCH OF DR. CARPENTER.

By DANIEL DUNCAN, A. M.,

PROFESSOR OF LOGIC IN THE UNIVERSITY OF MADRAS.

WILLIAM BENJAMIN CARPENTER was born in Exeter, October 29, 1813. His father, Dr. Lant Carpenter, was a dissenting minister, favorably known as a writer on theological subjects. More widely known, however, as a zealous worker in the cause of juvenile reformation, is his sister, Miss Mary Carpenter. Only his earliest childhood was spent in Exeter, for in 1817 the family removed to Bristol. Like several distinguished Englishmen of the present day, among whom are to be named Mr. John Stuart Mill and Mr. Herbert Spencer, Dr. Carpenter's subsequent achievements cannot be traced to the training received at any of the public schools; since his early instruction was carried on entirely under his father's roof. Besides the ordinary branches of an English lad's education, he devoted himself to physics and chemistry, for which he already showed a special taste and aptitude. His wish was to become a civil engineer, but, no suitable opening presenting itself at this time in that profession, he yielded to the desire of his family that he should study medicine. Mr. J. B. Estlin, a general practitioner of high standing in Bristol, and brother-in-law of Dr. Pritchard the ethnologist, having offered to take him as a pupil and apprentice to the medical profession, an engagement to this effect was entered into. This was in 1828. Besides receiving private instructions, Mr. Carpenter attended lectures at the Bristol Medical School, and at the Bristol Philosophical and Literary Institution, and had hospital practice at the Bristol Infirmary. In the winter of 1832, the state of Mr. Estlin's health rendering it desirable that he should make a voyage to the West Indies, Mr. Carpenter accompanied him to St. Vincent, where he stayed several months, and also visited the island of Grenada.

On his return to Bristol, Mr. Carpenter resumed his medical studies and practice. In 1834 he went to London, where he prosecuted his studies at University College and Middlesex Hospital. It was at this time, while attending the lectures of Dr. Grant on Comparative Anatomy, that he imbibed that special love for the subject which has resulted in the production of those volumes on Physiology by which he is most generally known. Having passed his examination at the College of Surgeons and the Apothecaries' Hall, he went in 1835 to Edinburgh, where he devoted himself to professional studies, under the able guidance of the distinguished men who at that time upheld the fame of Edinburgh University as one of the first medical schools in Europe. While here, he was elected the first of the four annual presidents of the Royal Medical Society.

After having spent two sessions in Edinburgh, Mr. Carpenter accepted the lectureship on Medical Jurisprudence in the Bristol Medical School, and at the same time commenced general practice in Bristol, intending to devote what spare time he might have to scientific pursuits. About this time he became a frequent contributor to various periodicals. Among the first of these contributions was a paper, "On the Voluntary and Instinctive Actions of Living Beings," published in the *Edinburgh Medical and Surgical Journal*. In the *British and Foreign Medical Review*, of which he eventually became the editor, his papers are remarkable alike for number and for varied contents. The first, which appeared in the July number of 1837, was on "Vegetable Physiology." This was succeeded in the following year by a critique on that portion of Whewell's "History of the Inductive Sciences" which relates to physiology; and by an article on his favorite subject, "The Physiology of the Spinal Marrow," where the writer discusses the doctrine of reflex action which Dr. Marshall Hall had recently propounded as new. These are tolerably good beginnings for a young man of twenty-four years.

An impulse and direction were given to Mr. Carpenter's studies about this time, by his becoming possessed of a microscope, which a prize of thirty pounds, gained at Edinburgh University in 1837, for the best essay of that year, enabled him to purchase. He had already formed, and begun to execute, his design to write the now famous treatise entitled "General and Comparative Physiology," the first edition of which appeared in 1838. The scientific reader will not need to be told the general character of this work; and any account of it, to be of use to the non-scientific reader, would transgress the limits of this biographical sketch. Dr. Carpenter confesses that the course of study he had to go through in bringing out the work was of immense service to him, though it was rather detrimental than otherwise to success in the practice of his profession.

Up to this time the subject of this memoir had not received the degree of M. D. According to one of the regulations of the University of Edinburgh, a three-years' attendance was requisite for graduation; and when Mr. Carpenter accepted the post of lecturer at the Bristol Medical School he had only completed his second year. Now, however, a change in the rules enabled him to graduate in 1839 by an additional residence of three months. His thesis on the occasion of taking his degree—"On the Physiological Inferences to be deduced from the Structure of the Nervous System of Invertebrated Animals"—gained for its author one of the gold medals annually distributed. The views advanced by the essayist, though meeting with some opposition for a time, were at once adopted by Prof. Owen and others, and have since passed into general acceptance among scientific men.

The scientific aspects of medicine having from the beginning possessed attractions superior to the strictly practical, Dr. Carpenter resolved to devote himself wholly to the study of physiology, the delivering of lectures, private tuition, and writing. On being appointed Fullerian Professor of Physiology in the Royal Institution, he resigned his post in the Bristol Medical School, and came, in 1844, to London, where he has resided ever since. Hitherto he had been engaged chiefly in reducing to system the results of the investigations of others; as in his "Comparative Physiology," and "Human Physiology," the latter of which first appeared during this year. But about this time he began to be known as an original investigator, in connection with his researches into the microscopic structure of the shells of *Echinodermata*, *Mollusca*, *Crustacea*, etc. He was elected a Fellow of the Royal Society in 1844, and in the following year he obtained a lectureship at the London Hospital. A lectureship in geology was bestowed on him, by the trustees of the British Museum, in 1847, and in the same year he became one of the examiners of the London University. He also succeeded Dr. Forbes as editor of the *British and Foreign Medical Review*, to which he had been a constant contributor for years, and which was now amalgamated with the *Medico-Chirurgical Review*, under the title *British and Foreign Medico-Chirurgical Review*. Besides editorial supervision, he continued to contribute articles to this periodical, on a wide range of subjects. In 1849 he was appointed Professor of Medical Jurisprudence at University College, a post which he held for ten years.

Some six or eight years had already elapsed from the time when Mr. Grove first promulgated his views on the now well-known doctrine of the "Correlation of Physical Forces." As indicated by the title of his treatise, Mr. Grove did not attempt to show the equivalence of the so-called "vital force" with the physical forces; but confined himself to proving the mutual convertibility of the *physical* forces—motion, heat, electricity, light, magnetism, etc. In a memoir communicated to the Royal Society in 1850, Dr. Carpenter carried the argument further; he attempted to bring the "vital force" also within the generalization, proving that it has its origin in solar light and heat, and not, as is commonly believed, in a power inherent in the germ.

The reader will form an idea of the success of Dr. Carpenter's two principal works from the fact that, as early as in 1851, a third edition of the "Comparative Physiology," and a fourth of the "Human Physiology," were called for. Very high authorities have expressed their appreciation of these works, and the debt which recent physiology owes to them. Among these authorities may be mentioned Sir Benjamin Brodie, who, in his presidential address at the annual meeting of the Royal Society in 1861, said that Dr. Carpenter's works "have served, more perhaps than any others of their time, to spread the knowledge of those sciences, and promote their study among a large class of readers;" and that, "while they admirably fulfil their purpose as systematic expositions of the current state of knowledge on the subjects which they comprehend, they afford evidence throughout of much depth and extent of original thought on some of the great questions of physiology." The field where, perhaps, Dr. Carpenter has been most successful, is that border-land between the physical and the psychical, between matter and mind—the nervous system and its functions. He has also given his thoughts on another topic of present interest, in an article on the "Varieties of the Human Race;" where he argues strongly on physiological and psychological grounds for the specific unity of mankind.

In 1852 Dr. Carpenter relinquished the editorship of the *Medico-*

Chirurgical Review, on being appointed principal of University Hall—an institution for the reception of students at University College, similar to the halls at Oxford and Cambridge. By this change he was enabled to devote more time to scientific pursuits.

Of these pursuits a very important one was the study of the Australian and Philippine *Foraminifera;* the results of which were given in memoirs to the Royal Society, between 1856 and 1860. In these papers, says Sir B. Brodie in the address already referred to, Dr. Carpenter "described some remarkable types which were previously quite unknown; he gave a detailed account of the very complex organization existing alike in the foregoing and in types previously well known by *external* configuration; he demonstrated the entire fallacy of the artificial system of classification hitherto in vogue, the primary divisions of which are based on the plan of growth; he laid the foundation of a natural system, based on those characters, in the *internal* structure and conformation of the shell, which are most closely related to the physiological conditions of the animal; and, finally, by the comparison of very large numbers of individuals, he proved the existence of an extremely wide range of variation among the leading types of *Foraminifera*, often reassembling under a single species varying forms, which, for want of a sufficiently careful study, had not merely been separated into distinct species, but had been arranged under different genera, families, and even orders."

Another important series of subjects that engaged Dr. Carpenter's attention about this time was the phenomena of mesmerism, hypnotism, electro-biology, etc. The result of his investigations will be found in the *Quarterly Review* for October, 1853. In this paper he endeavors to explain the phenomena by *the automatic action of the mind under the influence of suggestion, the will being in abeyance.* The same explanation he considers applicable to all the phenomena of spiritualism, with the exception of those which are referable either to trickery or self-deception.

A detailed account of Dr. Carpenter's contributions to the general body of scientific knowledge would be out of place here. Let it suffice to say that he continued to prosecute with success his researches into the microscopic structures of organisms. In 1856 he published "The Microscope and its Revelations." New editions of his two great works on physiology being again urgently demanded, there was entailed upon him immense labor in reorganizing them and bringing them up to the highest level of that rapidly-advancing science. So great, indeed, has been the toil required to keep the successive editions of the "Human Physiology" (which is at present in its eighth edition) abreast of the times, that the author has of late years been compelled to hand over to others this important duty, while he himself has devoted all his spare time and energy to original investigation in certain departments of zoology.

In this self-imposed task it would still have been impossible for Dr. Carpenter to accomplish any thing very noteworthy, had he continued to be distracted by the multifarious engagements which occupied so much of his time during the first ten or twelve years of his stay in London. But, fortunately for him and for science, he was appointed, in 1856, registrar of the University of London. Though the duties of this office have considerably increased since he entered upon them, they still leave him many intervals of leisure for his favorite pursuits, while the salary attached to it is such as enables him to forego other engagements.

The Royal Medal awarded to Dr. Carpenter in 1861, by the Council of the Royal Society, was a well-earned recognition of the important services he has rendered to the cause of truth. And he has continued to lay us under additional obligations. For to him, as to other devoted students of Nature, the conquest of one field is but the prelude to yet further conquests. He has latterly been much occupied with a subject of special interest; to wit, the investigations connected with the deep-sea dredging expeditions, carried on in one of her Britannic Majesty's ships, and conducted by him, Mr. J. Gwyn Jeffreys, and Prof. Wyville Thompson. Though no final conclusions have as yet been arrived at, it seems to be clearly indicated that there is a vast sheet of the lowest type of animal life, which probably extends over the whole of the warmer regions of the sea. And there can be little doubt that, conducted by such experienced naturalists, these expeditions will result in correcting and enlarging our present knowledge regarding the distribution of life on the globe.

Dr. Carpenter is a man of much versatility of scientific attainment, of a philosophical cast of mind, inclining him to take broad views, with a good capacity of original investigations (although this is seen more in the speculative and generalizing field than in special experimental researches), and, withal, he is an unusually clear and able scientific writer. His election to the presidency of the British Association, at its Edinburgh meeting last year, was one of the highest honors that British science has to bestow. To guide the deliberations of the largest and ablest scientific body in the world, and to occupy the chair formerly filled by such men as Herschel, Whewell, Airy, Rosse, Stokes, Grove, Hooker, Huxley, and Thompson, is a tribute to Dr. Carpenter's worth and character which is doubtless as gratifying as it is just and deserved.

EDITOR'S TABLE.

PROFESSOR TYNDALL.

THIS distinguished scientific philosopher, it is expected, will soon arrive in this country to give several courses of lectures in the chief Atlantic cities. Many of our people have read and admired his books, and become deeply interested in his themes, and those who can will no doubt gladly avail themselves of this opportunity to witness his beautiful experiments, and listen to his eloquent expositions. Dealing as he does with the various branches of physical science, and the familiar agencies and operations of Nature in their latest philosophical interpretations, his lectures will be of a high order of interest, and arrest the attention of our most thoughtful and intelligent citizens.

The indebtedness of the people of the United States to European thinkers for works of genius and learning in all departments of literature and science is acknowledged, but we owe to Europe another debt for lending us now and then the living use of her great men. We are thus enabled to know not only what manner of books they write, but what manner of men they are, and to be brought immediately under the vital magnetic influence of their personalities. It was a great gain to American science when Prof. Agassiz left his foreign home and took up his abode in this country. His works would, of course, have produced an important influence, but that would have been as nothing to what he has been able to accomplish by his actual presence with us. Not only in his extensive original investigations by which our knowledge of Nature has been enlarged, and not only by the stimulus which he has given to multitudes of young men in the study of natural history, has he been of great service, but also by his public lectures, in all parts of the country, which have helped to increase the popular appreciation of these subjects.

A generation has now passed away since Dr. Lardner lectured in the principal towns in the United States to large and interested audiences, and the impulse he gave to the public mind in creating an interest upon these topics will produce its salutary effects for years to come. His general field of science was the same as that of Prof. Tyndall, but physics has made a long stride in the last thirty years. New departments of transcendent interest have been wholly created within this period. Dr. Lardner died the same year that Kirchhoff and Bunsen startled the world by the announcement of Spectrum Analysis. This was not only a new and splendid revelation which has thrown a flood of light upon many obscurities of Nature that science had never before dreamed of penetrating, but it was a new and powerful instrument of research of permanent value in the work of future discovery. Moreover, since the time of Lardner, new views of the energies of Nature of a most fundamental character have been arrived at. The doctrine of the correlation and conservation of force—"the highest law in physical science," says Dr. Faraday, "which our faculties permit us to perceive"—has been announced, elucidated, and established within the last generation. Dr. Lardner was too early for this subject; he belonged to the preceding epoch. As Dr. Whewell wrote the history of the science of heat without referring to the discoveries of Rumford in the last century — discoveries which involved a complete revolution in our views of the nature of that agent as well as of dynamic philosophy—so Dr. Lardner went over the ground of physics in his five-years' lectures in this country in complete obliviousness of the new point of view that had even then been assumed by investigators of his own and other countries.

But Prof. Tyndall belongs to the later era: he has done his share in bringing it about, and is among its ablest representatives. Besides his original contributions to the more recent phases of science, by his genius for lucid and eloquent statement he has done perhaps more than any other man to put the new doctrines into popular and attractive form. In his classical volume entitled "Heat as a Mode of Motion," he takes the point of view definitely assumed by Rumford, and has worked out the science of thermotics on a modern basis and in harmony with the later views of the nature of force or energy. As all who have read his works are aware, Tyndall is more than a mere specialist; he is a broad thinker—a philosopher of science. No man is more painstaking or scrupulous in elaborating isolated facts with accuracy, but that does not content him, nor is he satisfied with the narrow theories that have been applied to them; but he strives after those wider and deeper explanations by which diverse phenomena are brought into harmonized relations. The various physical forces are interesting to him in their pure phenomenal workings, but they have a larger interest as clews to the constitution of matter. Physics has two great departments. Molar Physics treats of the movements and mechanical properties of masses, as the revolutions and attractions of the celestial orbs, or the laws of motion in terrestrial bodies. Molecular Physics, on the other hand, deals with the subtler forces of magnetism, heat, light, electricity, and affinity, by which the inner nature of matter is affected and its profoundest changes brought about. It is this division or aspect of physics that has mainly engaged the attention of Prof. Tyndall. His first scientific reputation was made by researches in the field of magnetism, and his original papers upon this subject have recently appeared in an elaborate volume. Glacial phenomena have also been favorite objects of study with him. Involving as they do the molecular mutations of water, through the vaporous, liquid, and solid conditions, on a grand and impressive scale, they afford a fine exemplification of the play of molecular forces of which Prof. Tyndall has availed himself, both to extend our knowledge of the subject and to enlist the interest of the public in some of the most beautiful and wonderful operations of Nature. The first book by which Prof. Tyndall became widely known was his "Glaciers of the Alps," now long out of print; and his latest work, to be immediately published, is on the "Forms of Water," in clouds, rain, rivers, ice, and glaciers. Much of his time during the last dozen years has been devoted to the revision and extension of his early opinions upon these subjects. The courses of lectures which he is to give in this country will be eminently valuable as reflecting the latest views that have been formed in a field of science that has undergone a great change within a recent period. We shall be able to listen to the authentic teachings of a master in science, and one who is, moreover, a master in the art of popular exposition.

THE PRESIDENTIAL ADDRESSES.

In our present number will be found the addresses of the presidents of the two scientific associations held in August, the one in Dubuque, Iowa, and the other in Brighton, England. They are entitled to consideration from the positions of their respective authors, the weight and dignity of the bodies addressed, and the interest of the topics discussed. The presidency of these bodies is held as an eminent honor among men of science, to be filled but once in a lifetime, and then by gentlemen of the highest scientific ability. These addresses are read with interest throughout the scientific world, and they naturally call forth the best exertion that their authors are capable of making. In the present case the speakers have taken up the subjects to which their lives have been devoted, and upon which they are prepared to discourse with authority. This, however, is more especially the case with Prof. Gray. An accomplished botanist, who is, moreover, much of a philosopher, and can work at causes and effects in Nature as well as at identifying and labelling specimens, he has grappled with the profoundest question in his own domain, the origin, descent, and modifications of vegetable forms on this continent, and has handled it with a clearness, originality, and richness of illustration, which cannot fail to increase his already high reputation. Dr. Carpenter has won his best fame in the field of physiology, although cultivating successfully various branches of natural history. As is shown in the biographical notice which we publish, he has paid special attention to the physiology of the nervous system, and has worked out a mental philosophy on the basis of cerebral physiology. One of the doctrines to which he has paid much attention, and which he claims to have developed and extended so as to make it his own, was set forth by him in the lecture which we published last month, on the "Unconscious Action of the Brain." But while Dr. Carpenter has been an assiduous student of mind from this point of view, and is entitled to speak with authority upon the questions it involves, in the present address he has gone quite beyond this subject, and plunged into the utmost intricacies of metaphysics. His address contains much that is instructive in regard to the methods of science in interpreting Nature; and in addition to this he makes a vigorous attack on the new philosophical school that has lately grown up into strength within the circles of science. His argument is generally regarded as a protest and a reaction against recent and as many think mischievous scientific tendencies.

It is curious to note the course of thought for the past few years, in these two Associations, dedicated to the "advancement" of ideas, as that course is evinced by the leanings of the presidential speeches. Those of the American presidents have been cautious and timid, and they seem to have hesitated about committing themselves to "advanced" views. Prof. Gray is the first who has ventured officially to avow Darwinian doctrines. On the other hand, the later presidents of the British Association, Grove, Hooker, and Huxley, have been representatives of these doctrines. This year, however, the tendencies in both bodies would seem to be reversed—the American president breaking away from the conservatism of his predecessors, and the British president putting on the breaks to check the radical movement in his own body.

Yet Dr. Carpenter has neither arrayed himself against the doctrine of "Darwinism," nor is his scientific orthodoxy by any means above suspicion. He was among the first to assert and elaborate the great doctrine of the correlation of physical and vital forces, and, in the fifth edition of his "Principles of Physiology," he carried out the argument by including the mental forces in the correlated group. This doctrine was denounced as heretical and dangerous by Dr. Barnard, in his address before the American Association at Chicago, and, if we remember rightly, so great was the scare in England at the position taken by Carpenter, which was reprobated as rank materialism, that a paper had to be circulated, and eminent names obtained, certifying that it was all right, and that Dr. Carpenter was quite sound and safe in his views. As regards the present address, its main point involves the explicit acceptance of the view currently designated as "Darwinian."

The metaphysical conflict into which the doctor has thrown himself has reference to the mode of origin of our ideas. One school affirms that they are not a part of the order of Nature, that is, they do not come into existence by natural processes of growth and development. They are held to be intuitive, and formed directly by the Creator in a supernatural or extra-natural sphere. The opposite school maintains that ideas are not a part of the preconstituted original furniture of our minds, but grow and arise by experience in the regular order of Nature. Thus the intuitional hypothesis and the experience hypothesis are antagonist doctrines. Dr. Carpenter here proposes a compromise by calling in the principle of hereditary influence, or the power of habit to originate intuitive ideas in the course of generations. But, strange to say, Dr. Carpenter puts forth this view as his own, without recognizing that it is an old and fundamental doctrine of Herbert Spencer. It will surprise many that, upon so conspicuous and important an occasion, a theory of such undoubted moment in philosophy could have been put forth by Dr. Carpenter without the scrupulous recognition of its true authorship. Mr. Spencer's doctrine, long maintained, and fully elaborated in his system of Synthetic Philosophy, is that intuitions originate by slowly-organized experiences in the race, which are confirmed and accumulated through hereditary transmission as a part of the working of the great principle of Evolution. Dr. Carpenter indorses this view, and cites Mr. Mill as having recently given his adhesion to it, and his position is therefore substantially the same as that of Prof. Gray and the developmental school. But, in common with many others who hold to this theory, he strongly urges that it does not exclude the conception of efficient causation or of a supreme cause by which Nature is controlled, and, like Dr. Gray, he takes broad issue with the atheists. His view is summed up in the following closing passage of the address: "The science of modern times, however, has taken a more special direction. Fixing its attention exclusively on the *order* of Nature, it has separated itself wholly from theology, whose function it is to seek after its *cause*. In this, science is fully justified, alike by the entire independence of its objects, and by the historical fact that it has been continually hampered and impeded in its search for the truth as it is in Nature, by the restraints which theologians have attempted to impose upon its inquiries. But when science, passing beyond its own limits, assumes to take the place of theology, and sets up its own conception of the *order* of Nature as a sufficient account of its *cause*, it is invading a province of thought to which it has no claim, and not unreasonably provokes the hostility of those who ought to be its best friends. For, while the deep-seated instincts of humanity and the profoundest researches of philosophy alike point to mind as the one and only source of power, it is the high prerogative of science to demonstrate the *unity* of the power which is operating through the limitless extent and variety of the universe, and to trace its *continuity* through the vast series of ages that have been occupied in its evolution."

HERBERT SPENCER AND DR. CARPENTER.

Since the foregoing remarks were put in type, we have heard again from the other side, and find that Dr. Carpenter's error has received prompt and thorough correction. The *Daily Telegraph* closed a long editorial on Dr. Carpenter's address with a reference to the doctrine of modification of mental faculties through organized and transmitted experiences, and said: "It certainly is a striking theory, and for that reason the speaker might have been expected to avoid the pretence of treating it as if it were originally his own. The honor of opening up this new line of speculation belongs to Mr. Herbert Spencer more than to any other man, and yet not a word of recognition was paid to that eminent thinker. If we are to accept the doctrine, let us begin to practise justice on all occasions, so that posterity may have all the advantage, and that future presidents may display an instinctive equity in their addresses."

This called out the following from Dr. Carpenter:

To the Editor of the Daily Telegraph.

Sir: Observing that, in the comments on my Presidential Address which are contained in your leading article this morning, you impute it to me that I have adopted and put forth as my own a doctrine which really belongs to Mr. Herbert Spencer, I think it due to myself to state that, as you will see by the slip I enclose from the *Brighton Daily News*[1] of yesterday, I had supplied—before the delivery of my address—a reference to him, which had been inadvertently omitted from the copies issued by Messrs. Taylor and Francis to the London press, but which I at once transmitted also to the Association printers, to be included in all future copies.

I use the words "first explicitly put forth," because the germ of the doctrine is contained in a paper by Mr. T. Andrew Knight "On the Transmission of Acquired Peculiarities," published in the "Philosophical Transactions" for (I believe) 1837. His views had been introduced into my own "Physiological Treatises" long before my friend Mr. Herbert Spencer began his valuable labors.

Your obedient servant,

WILLIAM B. CARPENTER.

British Association, Brighton, *August 16th.*

[1] "This doctrine was first explicitly put forth by Mr. Herbert Spencer, in whose philosophical treatises it will be found most ably developed."

Whereupon the President is again corrected by Mr. Spencer himself:

To the Editor of the Daily Telegraph.

Sir: Allow me to correct an error respecting date, into which Dr. Carpenter has naturally fallen from his unacquaintance with writings of mine earlier than those he names. It is true that "The Principles of Psychology," in which Mind is dealt with as a product of evolution, and in which the inheritance of accumulated effects of experience is recognized, not simply as producing "acquired peculiarities," but as originating the mental faculties themselves, emotional and intellectual, including the "forms of thought," was not published till 1855. But the doctrine which in that work took a developed and systematic form was set forth in an undeveloped form in works I published long before. Throughout "Social Statics," issued in December, 1850, it is taken as a cardinal principle: sundry leading ethical and political conclusions there drawn depend on the postulate that through inheritance there is a cumulative effect produced by the moral activities on the moral faculties—the discipline of social life gradually developing men into greater fitness for the social state (*see* pp. 33, 65, 413–441, first edition). Further back still is this idea traceable. Through a series of letters on "The Proper Sphere of Government," which I first published in 1842, and republished as a pamphlet in 1843, there runs a belief in human progression as wrought out by natural causes; and along with this there is shown, in its partial applications, the belief that in all creatures, man included, there goes on, through successive generations, a continuous adjustment of faculties, mental as well as bodily, to environing conditions.

While I have pen in hand, let me thank you for supplying the reference which, by the mischance Dr. Carpenter names, was omitted from the reports of his address in the daily papers. I am so much accustomed to see views of mine ascribed to others (as in this week's *Saturday Review*, p. 208, as well as in this week's *Spectator*, p. 1030), and I am so little accustomed to see a rectification made by any one on my behalf, that the close of your article on Friday produced in me the effect of a surprise.

HERBERT SPENCER.

Athenæum Club, *August 18th.*

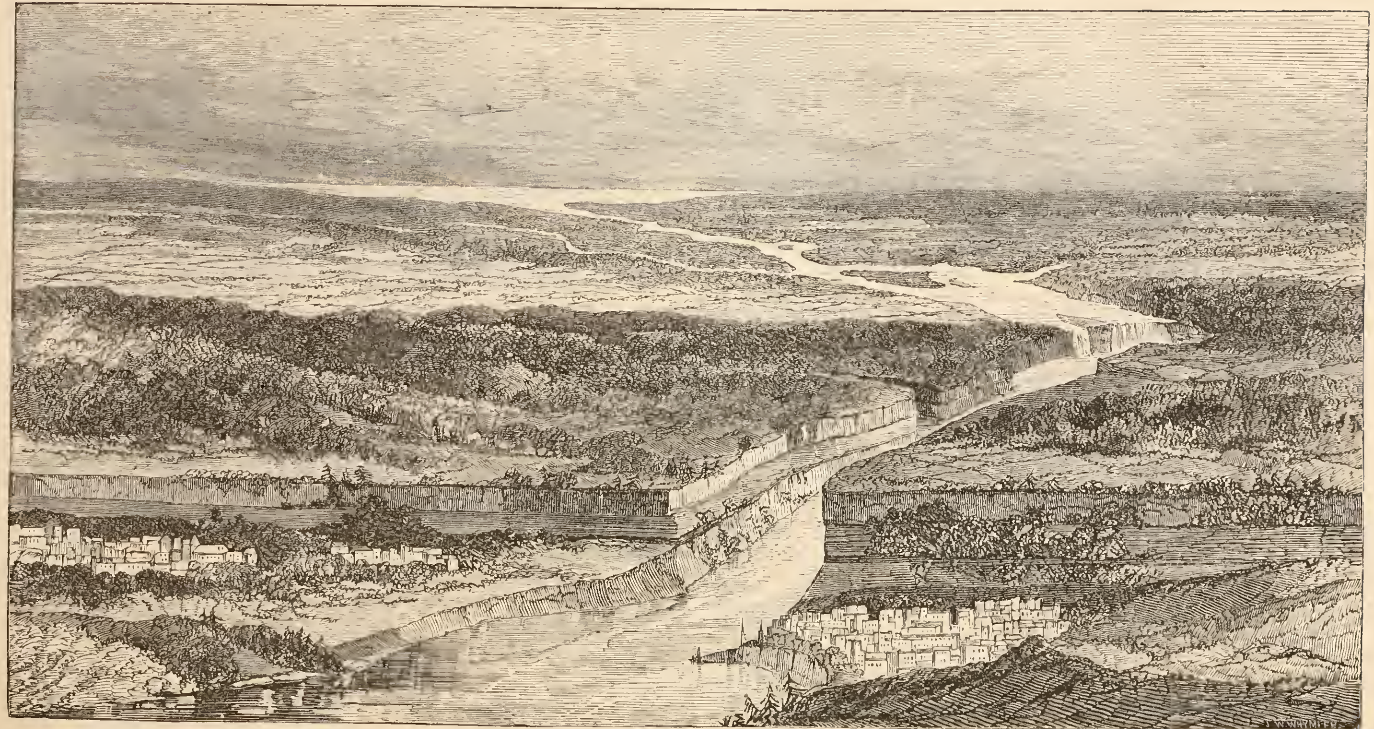
LITERARY NOTICES.

The Physiology of Man. By Austin Flint, Jr., M. D. Vol. IV. The Nervous System.

The comprehensive work on Human Physiology, by Dr. Flint, approaches its completion; 2,000 pages of it are done, and another volume of perhaps 500 more will finish the treatise. This is the most considerable effort yet made by an American in physiology, and the work, by its extent and thoroughness, will prove an honor to American science. Although covering extensive ground, and dealing with a wide range of topics, Dr. Flint's work is by no means a mere compilation. Its author is a working physiologist; a careful and industrious experimenter, he has done much, both in the way of original investigation, and in testing and verifying the investigations of others. The first volume of the series treats of Blood, Circulation, and Respiration; the second of Alimentation, Digestion, and Absorption; the third of Secretion, Excretion, Nutrition, Animal Heat, Movements, Voice, and Speech; and the fourth of the interesting and complicated subject of Nervous Structure and Nerve-actions. This is the most obscure and difficult of all the branches of physiology, and it is consequently that division of the science in which clear and definite knowledge being most wanting, its place is supplied by speculation and hypothesis. Dr. Flint has been very careful to guard against the danger that here arises, and to limit his exposition to those facts and conclusions which may be regarded as fairly and decisively settled. In his preface, he says: "The present volume treats of the physiological anatomy and the functions of the nervous system, as they appear to a practical physiologist, accustomed to accept nothing that is not capable of positive demonstration or well-sustained inference. Adhering conscientiously to the positive method of study, the author has endeavored to present an account of the nervous system which, though it will undoubtedly be extended by future investigations, is made up mainly of statements of facts that will probably not undergo serious modification as we advance in our knowledge of the subject. He has considered the properties and functions of the cerebro-spinal and sympathetic nervous systems mainly from this point of view; and has touched but slightly upon psychology, which has long been considered a science by itself. The special senses have been deferred, to be taken up in the fifth and last volume of the series." Dr. Flint's work is written in a remarkably clear and agreeable style; and, although he would probably not himself claim that it is a popular treatise, as it must needs deal with many things that are unfamiliar to the common mind, and clothed in scientific language, yet his pages are nevertheless in a high degree attractive to all intelligent persons who are interested in the higher problems and processes of life. His work will be as valuable for reading and reference in the libraries of laymen as in those of the professional student, and for this purpose we know of no work upon physiological science that equals the present. It is just the treatise for reference in school libraries. Our popular physiological text-books are necessarily very meagre and often unsatisfactory, and it is therefore desirable that some larger work should be at hand for consultation. Flint's "Physiology of Man" will be well suited for this purpose, not only from its fulness and authenticity, but also from the convenience of its form, which is in several handy volumes, instead of an unwieldy single volume.

Niagara: its History and Geology, with Illustrations. By George W. Holley. New York: Sheldon & Co.

An instructive description of Niagara and its surroundings, not a mere traveller's guide to its sights and curiosities, but an account of it as a great natural phenomenon, was much needed, and the want has been well supplied by the neat little handbook just issued by Sheldon. The author observes in his preface that, of all places so extensively known, Niagara Falls is probably the least known; the mass of people being quite satisfied with it as a grand spectacular sensation. To the geologists, however, it has ever been an interesting study, while the number of those who share their interest, who care to *understand* it as well as to *see* it, to know something of its past and future as well as of its present, must


LAKE ERIE.
THE FALLS.
Lime-
stone,
Shale.
LEWISTON.
NIAGARA RIVER.
QUEENSTOWN.

constantly increase, and these will find much to satisfy them in Mr. Holley's book. He has collected a great deal of historical information in regard to its early observations, gives full descriptions of its aspects and surroundings, makes a very clear statement of its geological character, and enlivens the whole with anecdotes, accounts of accidents, adventures, escapes, and personal sketches of men variously associated with its history. The earliest printed description of the cataract is now nearly two hundred years old. It was made by Father Hennepin in the winter of 1678–'79, and is a curious mixture of sober truth and childish exaggeration. He says: "Betwixt the lakes Ontario and Erie, there is a vast and prodigious cadence of water, which falls down after a surprising and astonishing manner, insomuch that the universe does not afford its parallel. 'Tis true that Italy and Switzerland boast of some such things, but we may well say they are sorry patterns when compared with this of which we now speak. . . . It (the river) is so rapid above the descent, that it violently hurries down the wild beasts, while endeavoring to pass it, . . . they not being able to withstand the force of its current, which inevitably casts them headlong above six hundred feet high. This wonderful downfall is composed of two great cross-streams of water and two falls, with an isle sloping along the middle of it. The waters which fall from this horrible precipice do foam and boil after the most hideous manner imaginable, making an outrageous noise, more terrible than that of thunder; for when the wind blows out of the south their dismal roaring may be heard more than fifteen leagues off."

MISCELLANY.

Bowlders of the Long Island Drift.—In a paper read before the Natural History section of the Long Island Historical Society, Mr. E. Lewis, Jr., gives an interesting account of the bowlders of the Long Island drift, treating especially of their size as compared with those of New England. On the north shore of the island, where the banks and headlands are rapidly wasted by the waves, bowlders, varying in size from a few inches to twenty feet in diameter, are thickly scattered about. Indeed, north of the central ridge of hills they are found everywhere, in some cases at an elevation of 300 feet above the sea-level. On Montauk Point, and in the neighborhood of the Hamptons, they are also abundant; and the immense deposits of sand along the southwestern shores were largely formed no doubt from bowlders and other materials of the drift, that have been ground up and deposited by the waves. This process is still going on, enormous quantities of bowlders and pebbles along the banks about Montauk being daily undermined and reduced to sand by the action of the surf. So far as observed, the bowlders are without sharp outlines, and many of them are exceedingly smooth. Those on the surface in the vicinity of Montauk have a blotched appearance, due to the presence of feldspar, and show evident traces of disintegration and decay. The excessive humidity of the air in this region is thought to contribute to this result.

Many of the bowlders are of large size, the largest being varieties of gneiss. Several have been carefully measured by Mr. Lewis. One on Strong's Neck, in Suffolk County, measures above the ground 22 by 26 feet, and is 25 feet high, giving a solid contents of about 14,000 cubic feet. At least half of this rock is believed to be below the surface. East of this are three masses of gneiss, which may have been originally one. If so, the volume of the mass could not have been less than 40,000 cubic feet; and if but two were originally united, of which there is reasonable certainty, the volume would have been about 27,000 cubic feet. Near Montauk are two masses of dark gneiss, one of which is, above the surface, 126 feet in circumference and 27 feet high, being somewhat cone-shaped. The other is about half this size. Not far from these is the finest though possibly not the largest specimen of gneiss upon the island. It is somewhat irregular in shape, compact in structure, and has a solid contents above the ground of 19,000 cubic feet. There are sections where bowlders, small and large, lie in masses that form continuous ledges.

The bowlders of Long Island, like those

of New England, indicate the enormous transporting power that was concerned in their removal. Long Island lies between 40° 34′ and 40° 10′ north latitude, and the 39th parallel is supposed to be nearly the southern limit of the drift; and, as a rule, toward its southern limit the drift is composed of small masses of material, but the dimensions of the Long Island bowlders prove that there may be exceptions to this.

The bowlders of the island and of New England appear to be similar in kind, dimensions, and distribution, and are believed by Mr. Lewis to have the same general origin. They also indicate but little diminution of the transporting power which distributed the bowlders of New England, and which so thoroughly modified its surface.

A New Entozoon from the Common Eel.—In the *American Naturalist* Dr. Samuel Lockwood describes a new parasite which he discovered embedded in the fat, or adipose tissue, on the entrails of the common eel. It has a proboscis which it can protrude from, or entirely retract into, its worm-like body, as into a conical sheath. This proboscis when extended is in the form of a cone, and is surrounded by rings of hooklets. At the extremity or point of this cone-like proboscis is a minute pore, which probably serves the purpose of a mouth. It is this spiny-armed organ which the animal forces by a slow motion into the fat, in and upon which it subsists. When the cone-like proboscis is withdrawn into the body of the animal, the forward end has a truncated appearance, and the entozoon is about one-eighth shorter than when the proboscis is extended. At this time the creature is less than a line in length. Dr. Lockwood has named the object *Koleops anguilla*. The first word, as denoting the habits of the animal, signifies *sheathed-head*, and the second, as denoting its habitat, is the technical name for the eel. Aside from the fact that this discovery has a general interest as an item of knowledge respecting the internal parasites of animals, it has a special interest to the helminthologist, as it makes the second genus of an order until now limited to one genus. On this point it is better to give the author's own words. Comparing this species with the *Echinorhyncus gigas*, long known to the student of the Entozoa, Dr. Lockwood says: "As to their ordinal relations, both are members of Owen's second class of the Entozoa, embracing the Sterelmintha or Solid Worms; and both evidently belong to Duvaine's Type IV., Acanthocephala or Spiny Heads, and to Randolph's Order IV., which bears the same name. Now, in this order there is but one genus, namely, Echinorhyncus, already mentioned; therefore we put in the order a new genus, to which we give the name *Koleops*, meaning *sheathed-head*, and species *anguilla*, because found in the common eel." Besides an extended description, the *Naturalist* gives good illustrative figures of the subject.

Insects and Flowers.—We are indebted to the report in the *World* for the synopsis of a paper read by Prof. C. V. Riley at the Dubuque scientific meeting, "On a New Genus in the Lepidopterous Family Tineidæ, with Remarks on the Fructification of Yucca"—one of the lily family.

Prof. Riley said that Dr. Engelmann, of St. Louis, had this year discovered that our yuccas must rely on some artificial agency for fertilization. The flowers are peculiarly constructed, so that it is impossible for the pollen to reach the stigma, it being glutinous and expelled from the anthers before the blossoms open. Prof. Riley, in investigating this subject, discovered that there was a small white moth that did the work, and he demonstrated on the black-board how marvellously the little insect was adapted to the purpose. This little moth, which he calls *Pronuba yuccasella* (yucca's go-between), was hitherto unknown to entomologists, and forms the type of a new genus. It is very anomalous from the fact that the female only has the basal joint of the maxillary palpus wonderfully modified into a long prehensile spined tentacle. With this tentacle, she collects the pollen and thrusts it into the stigmatic tube, and, after having thus fertilized the flower, she consigns a few eggs to the young fruit, the seeds of which her young larvæ feed upon. He stated that the yucca was the only entomophilous plant known which absolutely depended for fertilization on a single species of insect, and that insect so remarkably modified for the purpose. There was a beautiful adaptatiou of meaus to an end, and a mutual interdependence between the plant and the animal. Prof. Riley then explained succinctly how, on Darwinian grounds, even this perfect adaptation was doubtless brought about by slow degrees. He alluded, in closing, to a practical phase of the subject. The plant and its fructifier are inseparable under natural conditions, and the fructifier is found in the native home of the plant. In the more northerly parts of the United States aud in Europe, where our yuccas have been introduced, and are cultivated for their showy blossoms, the insect does not exist, and consequently the yuccas never produce seed in those places. The larva of pronuba eats through the yucca-capsule in which it fed, enters the ground, and hibernates there in an oval silken cocoon. In this state the insect may easily be sent by mail from one part of the world to another, and our own florists may, by introducing it, soon have the satisfaction of seeing their American yuccas produce seed, from which new plants can be grown.

This paper was extremely interesting to every one present, and those who discussed it pronounced it in every respect admirable. Dr. Asa Gray, thau whom no one in the country is better able to form a sound opinion upon such a subject, complimented Prof. Riley on his discovery, and the lucidity of his explanation before the section.

Binary Stars.—The same journal gives a sketch of a paper on this subject by Prof. Daniel Kirkwood, of which the following is a summary:

At the meeting of the Royal Astronomical Society of London, on May 18, 1872, it was announced by Mr. Wilson that a discussion of all the observations of the double star Castor, from 1719 to the present time, had led to the remarkable conclusion that the components are moving in hyperbolas, and, consequently, that their mutual relations as members of a system are but temporary. The fact, if confirmed, will be regarded with great interest, and its discovery will doubtless be followed by a minute and vigilant scrutiny of other binary systems.

But, while such a relation as that discovered by Mr. Wilson had not been previously suspected, its existence was certainly not altogether improbable. As the sun in his progressive motion through space compels such cometary matter as may come withiu the sphere of its influence to move about him in parabolas or hyperbolas, so two bodies of the same order of magnitude may be brought by their proper motions within such proximity that their mutual attraction shall cause each to move about the other in a hyperbolic orbit. Such instances, however, would seem to be exceptions to the general rule, as the motion of most binary stars is undoubtedly elliptic. (This fact has been explained in 1864 by the author on the basis of the nebular hypothesis.)

The components of Castor are of the magnitudes three and three and a half respectively. If we suppose that each before the epoch of their physical conuection was the centre of a planetary system, the results of perturbation must have been extremely disastrous. The two stars were at their least distance in 1858.

This alleged discovery of a temporary physical connection between two fixed stars suggests a number of interesting inquiries. In the infinitely varied and complicated movements of the sidereal systems, different bodies may be brought into such juxtaposition as to change not only the direction of their motions, but also the orbits of their dependent planets. Some stars, at the rate of motion indicated by the spectroscope, would pass over an interval equal to that which separates us from the nearest neighboring systems in 20,000 years. In view of these facts, the conjecture of Poisson, that the temperature of the earth's surface at different epochs has depended upon the high or low temperature of the portions of space through which the solar system has passed, may not be wholly improbable.

A possible origin of binary systems is also iudicated by Mr. Wilson's discovery. The cometary eccentricity of the orbits of these bodies is well known. In some cases the estimated distance between the components at the time of their periastral passage is less than half the radius of the earth's orbit. Now, if at the epoch of the first nearest approach the radius of either star's nebulous envelop was greater than the distance between the centres of the two bodies, the atmospheric resistance would tend to transform the parabola or hyperbola, in which the body was moving, into an ellipse. Each subsequent return would shorten the period, until, in the process of cooling, the stellar atmosphere had so far contracted as no longer to involve any part of its companion's.

It would be an interesting question whether some of the double stars, whose apparent distance apart has seemed too great to justify the hypothesis of a physical connection, may not afford other instances of motion, either as parabolas or hyperbolas.

School-Life and Eyesight.—In a communication to the *Mechanics' Magazine*, Prof. Liebreich describes the injuries to the eye incident to school-life, pointing out their causes, and the means to be adopted to avoid them. The changes in the functions of the visual organ, developed under the influence of school-life, are three in number: First, decrease of the range of vision; second, decrease of the acuteness of vision; third, decrease of the endurance of vision.

Decrease of the range, short-sightedness (myopia), is developed almost exclusively during school-life—rarely afterward, and very rarely before that time. There is often an inherited predisposition to become short-sighted, and this is developed during school-life, more or less, according to certain external conditions. It is a common notion that short-sighted eyes are the most durable. This is founded on the fact that such eyes can see near objects distinctly without the aid of glasses, at an age when normal eyes require the assistance of convex lenses. But this is no proof of their durability. On the contrary, a high degree of short-sightedness is a diseased condition, caused by anatomical changes in the membranes of the eye, which involve a greater tendency to serious complication than the normal eye. Short-sightedness exerts an injurious influence on the general health by inducing the habit of stooping; and, from a national point of view, its increase is to be considered a serious evil.

Decrease of acuteness of vision (amblyopia) is a serious condition, generally the result of positive disease of the eye, which may exceptionally be induced at school. Amblyopia of one eye only, is, however, often produced by unsuitable arrangements for work, which disturb the common action of the two eyes, and weaken the eye which is excluded from use.

Decrease of endurance (asthenopia) is a frequent affection, that has destroyed many a career, prevented the development of many a fine intellect, and deprived many of the fruits of their laborious exertions. It arises principally from two causes: the first is a congenital condition, called hypermetropia, which can be corrected by convex glasses, and which cannot, therefore, be laid at the door of school-life; the second is a disturbance in the harmonious action of the muscles of the eye—a defect which is difficult to cure, and which is generally caused by unsuitable arrangements for work.

These three anomalies all arise from the same circumstances, viz., insufficient or ill-arranged light, or from a wrong position during work. Where the light is insufficient, or badly arranged, we are obliged to lessen the distance between the eye and the book while reading or writing; and we must do the same if the desks and seats are not of the right shape and size, and suitably located. When the eye looks at a very near object, the accommodating apparatus, and the muscles which turn the eye, are brought into a condition of extra tension, and this is to be considered as the principal cause of short-sightedness and its increase. If the muscles of the eye are not strong enough to resist such tension for any length of time, one of the eyes is left to itself; and, while one eye is being directed on the object, the other deviates outwardly, receives false images, and its vision becomes indistinct (amblyopia). Or, perhaps, the muscles resist these difficulties for a time, become weary, and thus is induced the diminution of endurance (asthenopia).

In order to prevent these evils, the light must be sufficiently strong, and fall on the table from the left-hand side, and, as far as possible, from above. The children ought to sit straight, and not have the book nearer to the eye than ten inches at least. Besides this, the book ought to be raised 20° for writing, and about 40° for reading.

Ordinarily, minor considerations, such as the most compact disposition of the seats, or placing the pupils so that the teacher may the most readily look into their faces, govern the arrangements of the class-room, and, when any attention is paid to the matter of light, it is often to the detriment rather than the benefit of the class. For example: one of the rules laid down by the Educational Department in London, for the guidance of architects, is, that "the windows should be so placed that a full light should fall upon the faces both of the teachers and the children." Light coming from the right hand is not so good as that from the left, because the shadow of the hand falls upon that part of the paper at which we are looking. Light from behind is still worse, because the head and upper part of the body throw a shadow on the book or paper; but the light that comes from the front, and falls on the face, is by far the worst of all; for it not only defeats the object desired—illuminating the faces of the children—but is most hurtful to the eye. Instinctively desirous of avoiding the unpleasantness of the full glare, the children will assume all sorts of positions, which turn their faces from the master. In reading, they turn the head round the vertical axis, generally toward the right, in order to let the light fall on the book, which, when held straight before them, is completely in shadow; while, in writing or reading (the book being on the table), they bend their heads as low as possible, in order to shade their eyes by the projection of the forehead.

The best light for the school-room is from above; but, when this cannot be obtained, the desks should be so arranged, in connection with the windows, that the light shall fall upon the book or paper from the left.

Where light from gas or other artificial source is used for evening work, it should be made as steady as possible, and the lights so placed that they will not come opposite the eye, as in this situation they are dazzling and injurious. Ground-glass globes ought not to be used, for, though valuable in an ordinary room, where they tend to diffuse the light more equally, they give an indistinct light for work, and thus put a greater strain upon the eye. And, for the same reason, ground or ribbed glass should not be employed for the lower portions of windows, as the optical effect of such glass in that position is decidedly hurtful.

Jute.—This remarkable fibre, which formerly was only used for the coarsest purposes, has of late become invaluable. It makes a serviceable substitute for hair in chignons, and is now used extensively as a "mix" in silk. Owing to its kindly way of taking the dye, and the gloss which it sustains, a large quantity can be used in silk, and yet defy detection, except by an expert. It is, in consequence, highly desirable that it should be produced in our country, if possible. Some experiments by agriculturists are under way, which seem to promise success. Mr. F. T. D. Lacroix, of New Iberia County, Louisiana, has, on his plantation, several rows of the jute-plant, the seed of which was sent to him by the Department of Agriculture. The plants are very vigorous, and the indications are that jute will thrive in that climate. It bears some resemblance to flax in appearance, as it is said to in fibre.

A City's Waste.—Mr. Lepmann, director of the Central Trial Station, in Bavaria, speaks thus of the loss of fertilizers in Munich, a city of 177,000 inhabitants. He makes the sum of fertilizing elements wasted in the human excrements of the city for one year, 1,857,714 pounds of nitrogen, of which the commercial value is 866,934 gulden; 611,054 pounds of phosphoric acid, value 122,210 gulden; 372,375 pounds of potash, value 49,650 gulden; total value 1,038,794 gulden, equal to about $500,000. This sum would be still further increased by adding to it the value of the humus-forming constituents of the excrements wasted. To make up for that waste, he states that the amount of guano furnished by Peru yearly for the German fields is about 1,000,000 cwt.

Mr. Lepmann states that Germany now possesses a system by which he is confident this enormous waste may be entirely prevented, called there the Tonnen (barrel) system. The city of Gratz, containing 80,000 inhabitants, has this system in use in every house, and has thus demonstrated the practicability of using it in large cities. As an illustration of the profit to be derived from human excrement when fairly tested as a fertilizer, Mr. Lepmann refers to the fact that, between the years 1850 and 1864, the price of that obtained from the barracks increased forty-five fold.

Mental Exertions governed by Law.—Prof. Heinrichs read a paper at the Dubuque scientific meeting, "On the Law of Probability as applied to the Determination of Mental Exertions." The following is a summary:

All phenomena in the physical world, exhibited by individuals of a mass subject to certain given influences, are regulated by the so-called law of probability. This has long been practically used by the various insurance companies, which employ millions of dollars a year; however uncertain the health of any given individual, the number of individuals dying each year in a mass of a hundred thousand individuals is perceptibly constant. So also the height of the stature of the individual in a greatly-varying quantity; but the number of individuals in an army having a certain definite height is very nearly constant, and determined by the law of probability. The application of this law of probability to the affairs of the individual man may be studied in the works of Quetelet. By several of our modern chemists the same law has been applied to the various chemical processes. If the laws which regulate mental work and mental phenomena are not radically different from those which we study in the physical world proper, then the law of probability ought to be equally applicable to the mental stature of man, as we long ago have found it to be applicable to the bodily stature of the same. By very careful determination of the relative grade of the individuals composing the large classes which have been instructed in the elements of physics at the State University of Iowa, the author has, during the past three years, had abundant means to test the applicability of the law of probability to mental exertions. The student's standing is determined by adding the numerical values of his credit for oral examination on the subject studied to the grade expressing his daily recitation and his practical work in the laboratory. Since these three quantities are determined independently of one another, and often by different persons (the class being instructed by the professor and two assistants), we have some guarantee against the accumulation of personal errors in this determination. Thus, in a class of sixty-seven students in the elements of physics, the following table shows the observed number of students per hundred who have obtained the standing given, also the calculated number of students who, according to the law of probability, should have obtained the same degree. It will be seen that the two numbers agree very closely:

NUMBER OF STUDENTS IN 100.

Standing.	Observed.	Calculated.
100	3.0	3.0
98	4.5	5.0
95	7.5	7.5
92	10.5	10.0
89	13.5	11.8
86	10.5	12.5
83	10.5	12.5
80	13.5	11.8
77	7.5	10.0
74	7.5	7.5
71	6.0	5.0
68	3.0	3.0
65	3.0	1.6

Dr. Hooker and the Kew Gardens.—The English papers have latterly had much to say of the difficulty between Dr. Hooker, Superintendent of the Kew Botanical Gardens, and Mr. Ayrton, a member of the Government, and Superintendent of Public Works. The Kew Gardens are part of an old royal park situated a few miles out of London, and have been developed to their present great extent and remarkable beauty, as well as in their scientific richness, mainly through the labors of the celebrated botanist Sir William Hooker, and of his son, Dr. Joseph Dalton Hooker, the present director. Without the genius, learning, enthusiasm, and, it may be added, the liberal pecuniary aid of these gentlemen, the Gardens would probably never have been created. They have been called into existence mainly through their agencies, and are now the pride of the nation, and are visited and enjoyed by many thousands of people each year, while they are of immense value to students as a vast scientific treasure-house of the vegetable kingdom. But Ayrton, who has control of the Public Works, in which the Kew Gardens are included, a surly, grouty, ill-mannered, and meddlesome old politician, seems to have taken every occasion to make himself disagreeable to Dr. Hooker by impertinent interference with his management, aud various kinds of insulting treatment. Dr. Hooker eudured it as long as he could, but his position at length became so uncomfortable that he felt himself compelled either to resign or to appeal to the government to keep its bully somewhere within the bounds of deceut behavior. When the facts became known, a committee of the most eminent scientific men of England, including Lyell, Tyndall, Busk, Huxley, Darwin, and others, drew up an elaborate statement of the case, and appealed to Mr. Gladstone to check the outrageous course of Ayrton, and make it possible for Dr. Hooker to continue his relations to the establishment. This waked up the press, who were not slow to ventilate the case, and the subject was at length brought before Parliament. The effect has been that the crabbed Superintendent of Works has received a sharp and thorough public rebuke, which will probably exert a salutary influence upon his future behavior.

The Work of the Coast Survey.—We copy from the *Tribune* the following notices of papers which were read at the late scientific meeting:

Prof. Benjamin Peirce, Superintendent of the United States Coast Survey, gave an exceedingly interesting account of the measures taken by that Bureau with reference to stations for astronomical observations at great heights, such as Sherman, on the Rocky Mountaius. Prof. Young, of Dartmouth College, was selected by Prof. Peirce as the proper astronomer to determine the best position for astronomical observations. Iu a higher position you get rid of absorption of light by getting rid of half the atmosphere. This problem Prof. Young was specially adapted to investigate, as his knowledge of spectrum analysis is superior to that of any other man in this country. Prof. Young reports the whole number of lines in the chromosphere seen from Sherman as 150, which is three times as great a number as have been observed before. This fact alone shows that higher points should be resorted to for astronomical observations. Telescopes will hereafter be placed at points higher than ever before—in Europe probably on the Alps. The next element of success depends upon the steadiness of the atmosphere. It can be said in reference to this, that a star has been recognized at these high altitudes as having a companion, or being a double star, not previously known as such. An observer on the Pacific coast reports to Prof. Peirce that he can see the companion of the star Polaris from a high point on the Sierra Nevada. It is well known that this is a test of great nicety, requiring the utmost purity of atmosphere. As to the character of the observations for precision, there are not yet sufficient observations to determine it. The evidence is already at hand to show that at some of these elevated points an observatory should be established. The best work in astronomy is done in the few best nights at any place, and by these alone the value of the position must be determined.

Prof. J. Lawrence Smith adverted to the extreme brilliaucy of stars in those regions. West of Sherman the air is so dry that even the lips of observers crack, and their health is otherwise affected. He thought that more exact observations upon the planets and satellites would be made from those lofty points which would add as much of interest to this departmeut of astronomy as did the recent discoveries in stellar analysis. It was resolved that Prof. Peirce should be added to the committee to press this matter of elevated astronomical stations upon the Government of the United States.

Prof. Peirce showed that the uecessities of the Coast Survey extended its operations to all parts of the Uuited States. No science could be divided and separated so as to stand alone. If one begins by measuring his town-lots, the method involves geometry and astronomy, geology and surveying, including ultimately the coast survey. To prove the paths by which vessels cau best traverse the ocean, to test the best methods by which $2,000,000,000 of values shall be carried from the West to the East, from the East across the Atlantic, or from the shores of China and Japan to the Pacific coast, and thence across the country, was the business of the Coast Survey. All the United States is deeply interested in every part of this subject. Every ship that is lost by imperfectly-surveyed harbors is a loss to the whole country. A few great harbors—New York, Boston, Savannah, San Francisco—are vital points of commerce. The merchants of those cities are ever ready, by extending wharves and pushing out piers, to gain individual advantages while ruining the harbors. The Coast Survey is the bulwark against these encroachments. This matter should be in the hands of the General Government, and Congress should pass laws to prevent these injuries. If the coast survey were thorough, and maps were fully representative of ascertained facts, a pilot would scarcely be necessary, but yet never could be entirely dispensed with, especially in bad weather. The worst rocks have generally been discovered by the misfortune of striking upon them. Under such circumstances the pilot becomes a more accurate observer than the plummets of the Coast Survey. This was curiously illustrated by instances where pilots had taken out parties engaged in coast survey, and asked to have a plummet dropped at a spot apparently out at sea with nothing to guide it, and the surveying parties have found this strange instinctive knowledge of the pilot fixed the very spot of a dangerous sunken rock which could never have been found otherwise. The pilots discovered that, by putting down every rock that they knew of, they made maps that frightened the captains of vessels into employing them. Hence these practical observers have added immensely to the number of facts accumulated by the Coast Survey.

Prof. Peirce explained why he considered it unnecessary to carry out at present so thorough a survey of the Pacific as has been made of the Atlantic coast. The needs of the commerce of the coast is the standard by which the work of the survey is determined. He took occasion to mention that the Hassler Expedition was at the expense of private individuals, principally of Boston, and was not at the expense of the Government. Different States obtained the benefit of the coast survey by the determination of fixed points for their own interior topographical and geological surveys. A general geodetic connection has been effected in these observations, so that the whole United States will benefit by them; and the points will be taken so as eventually to procure a complete survey of the whole continent, passing through each State and the large cities. It is a work that may take a century. It is the hope of Prof. Peirce that this survey will not only be the best in the world, but that its details will be such that before long there will be no necessity for railroad surveys—the facts will be spread everywhere. As to the higher operations of the Coast Survey, their ultimate expression will be an accurate determination of the figure of the earth. Its actual figure as an ellipsoid of revolution is not yet actually known. It is one of an infinite number of possible figures, each nearly an ellipsoid of revolution. This question may ultimately be determined by observations on this continent. Observations here are more successful and free from local irregularities than in Asia or Europe. Yet there are some such local irregularities here—notably one near Boston, where there is some strange deviation of density from the surrounding country.

THE FEMALE THE BETTER HALF.

If there were able debaters among the members of the Association present, opportunity has certainly not been wanting in which to develop their ability. Think, for instance, of what a magnificent subject for discussion was offered by Prof. Hartshorne, of Pennsylvania, in a paper on the relation between organic vigor and sex, in which he espoused the theory that the births of females were an indication of excess of formative force, and of males of a deficiency, on the part of the parents; and that female offspring was an index of the highest vigor. He began by alluding to certain papers which Prof. Meehan, a botanist of celebrity, had submitted to the Association, wherein it was set forth that the highest types of vegetation among the larch and coniferous trees were of the female kind. He specifies that the larch, while in its highest luxuriance, and during many years, produces only female flowers; but in its decline it at length produces male flowers, and it shortly afterward dies. Prof. Hartshorne extended this theory to animal life, and undertook to show that, whenever or wherever there was excess of formative power, its tendency was to the production of female offspring. He illustrated his belief by the development of bees, the birth of the queen-bee being the highest, of the drone the lowest result, and preceded by respectively high and low circumstances of nutrition. Sometimes a working-bee — which, being an imperfect female, is of course incapable of impregnation—will give birth to parthenogenetic offspring. Such offspring is always male. The eggs of the queen-bee that hatch males have not been fertilized; and, should she never have been impregnated and lay eggs, they will hatch only drones. In respect to the aphides (plant-lice), it is noticeable that, while their food is sufficient and of nutritious quality, their offspring is exclusively females, propagated parthenogenetically; but soon after the supply of food, owing to a change of season or circumstances, is diminished, young male aphides appear. Among the higher order of animals Prof. Hartshorne found an argument in the sex of double monsters. Stating that the birth of double monsters was due to fissure of the ovum and excess of formative power, he asserted that it is well known that in the majority of instances these monsters were of the female sex. He brought forward the vital statistics of different nations and their varying proportion of male and female births in support of his position, attributing the differences to increasing or diminishing vitality; and even the continually lessening reproductive powers of American women formed one of the illustrations of this theory.

SYMPATHETIC VIBRATIONS.

Prof. Joseph Lovering, of Cambridge, Mass., gave an interesting address on vibration, illustrated by an experiment. It was presumed that the members were more or less familiar with Milde's experiment with a tuning-fork and vibrating thread. This optical method of Milde is very much improved by using a large bar of iron and perpetuating the motion by means of magnetic excitement, the vibration being thus maintained for any length of time. A cord 20 or 30 feet in length is thus thrown into vibration. When the first suspension bridge was building in England, a fiddler offered to fiddle it away. Striking one note after another, he eventually hit its vibrating note, or fundamental tone, and threw it into such extraordinary vibrations that the bridge-builders had to beg him to desist. Only recently a bridge went down under the tread of infantry in France who had not broken step, and 300 were drowned. An experiment is often referred to of a tumbler or a small glass vessel being broken by the frequent repetition of some particular note by the human voice. It is said, and may be true, that certain German tavern-keepers increase their custom by the occasional performance of this feat. In the Talmud there is a curious question raised as to what would be the damages if a domestic vessel were broken by a noise made by an animal, such as a barking dog. Prof. Lovering here exhibited two pieces of clock-work, each giving a button a circular velocity of rotation. These are to turn a cord much as a skipping-rope is turned. The rotation twists an ordinary cord—or untwists it, as the case may be—and to avoid this twisting a tape is substituted, and a twisting or rotating machine is placed at each end. The chief difficulty now remaining is to have the machines twist in unison, which is difficult, as the two pieces of clock-work vary from each other, but on the whole the experiment is usually satisfactory. The tape was stretched across the stage, and the machines to rotate it were placed at each end. If the string is too slack for one segment of vibration, it subsides into parts, each having a vibration similar to the other. The tighter the string is drawn, the fewer the segments of harmonic vibration. The string started with five waves or segments of vibration. Drawn tighter, these were reduced to four, three, and finally two segments, the nodal point in each instance between the waves remaining perfectly unmoved. With a shorter string the first harmonic note was reached, and ultimately the fundamental note or a single vibration was exhibited. Very high harmonies were shown by means of a very flexible string with a high velocity dividing the revolving tape into very numerous equal segments of vibration, or, as the professor preferred to call them, harmonics.

Petroleum in Santo Domingo.—In a note to the *Mechanics' Magazine*, Mr. William M. Gabb describes a petroleum-spring situated three miles north of the town of Azua, in Santo Domingo. It is near a stream, the name of which signifies "stinking water." The spring makes its appearance as a stagnant, torpid pool, exuding slowly through a heavy gravel-deposit. A very small area in the vicinity is covered with deposits of pitch, and, for half a mile down the dry bed of a rain-water stream, the gravel and sand are more or less cemented by an impure pitch, sometimes plastic, oftener hardened to asphaltum. The water is colored a dirty brown by the presence of the oil. Jets of gas bubble up at different points near the spring. The gas is not inflammable, and has more of a fetid than kerosene odor. In appearance and mode of occurrence the spring strikingly resembles those of Trinidad and California. It is the only spot on the island where bituminous products are found.

Photographing the Eye and Ear.—Dr. Vogel writes to the *Philadelphia Photographer* as follows: "That the interior of the human eye has been photographed is well known. The experiment is a somewhat cruel one for a living subject; still there are victims who stand it. I know, for instance, a very handsome young lady, whose brother is a physician, who patiently takes extract of belladonna until the pupil has become sufficiently enlarged; the interior of the eye is then illuminated with magnesium-light, and photographed. In a similar manner has the ear been photographed, that is to say, the tympanum only. A tube is inserted, in which is a mirror inclined at a certain angle. The mirror throws light into the interior of the ear. The mirror is also provided with a central hole through which the illuminated tympanum can be inspected. A system of lenses projects an image on the sensitive plate, and the picture is made in the ordinary manner."

Chemical Influence of Light.—In a recent lecture on the chemical action of light, Prof. Roscoe gives some interesting facts concerning the chemical effects of sunlight at different times of the day, and in different atmospheres. The number of chemically-active rays vary throughout the day. Their maximum is always highest at noon. The curve of the heating rays reaches its highest point after noon, but this is not the case with the chemically-active rays. The chemical intensity appears to depend solely on the height of the sun in the heavens, and at the same distance from noon; on either side it appears to be equal. The chemical power of sunlight also varies with the place. Prof. Roscoe gives the results of measurements at Kew, Lisbon, and Para. At Kew the intensity was 94.5, at Lisbon 110, and at Para 313. An opalescent atmosphere appears to cause the absorption of a large number of the chemically-active rays. Hence the important advantage, in point of vegetation, which those countries have where the atmosphere is clear.

The Leaf a Vicarious Organ.—Some interesting experiments have lately been conducted by M. Calliet, to determine the precise action of plant-leaves in the absorption of water in the liquid form. They have led him to the conclusion that leaves do not absorb water while the roots are supplied. But when the ground is too dry for the roots to obtain it, if water be put in contact with the leaves, they will absorb it for the nourishment of the plant. The experimenter thus educes the fact that the action of the leaf is a vicarious and not a natural function.

Carbolic Acid from Plants.—M. Broughton, government chemist, attached to the cinchona-plantations of Ootacamund, in India, has obtained carbolic acid from the *Andromeda Leschmantii*, a plant which grows there abundantly. The product is less deliquescent than that obtained from coal-tar, and, owing to the expense attending its preparation, is not likely to compete with the article at present in the market.

NOTES.

A committee of astute reformers in England, charged with the duty of devising some means for repressing drunkenness and reforming drunkards, recommend that drunkenness, and even the first offence, be severely punished. For the first conviction, a month in jail; for the third, a year's imprisonment in a reformatory. Whether public or private, attended with a breach of the peace or not, the drunkenness is to be made a crime, and dealt with accordingly; not so much for the protection of society, but avowedly as a reformatory measure. If a man degrades himself by getting drunk, degrade him still more by sending him to jail; destroy his remaining self-respect, to the end that his respect for himself may be increased!

Donne and others have shown that water without air will acquire a temperature far above 212° without boiling, and that it is then liable to burst into steam with explosive violence. It is thought that many disastrous steam-boiler explosions have arisen from this cause; and a firm in Nottingham, England, have adopted a process which is said to entirely remove the difficulty. They inject heated air at a temperature of 650° Fahr., near the bottom of the water-space, into the boilers, waste-heat being utilized for the purpose. The incrustation of the boilers is thus prevented, the water is constantly aërated, and an economy of 15 per cent. secured; which in England alone, if the process were generally applied, would result in an annual saving of 16,500,000 tons of coal.

The Royal Astronomical Society are urging the English Government to erect an astronomical observatory in the highlands of India. A station in the region named, besides being of great service to science as affording an opportunity for observations within the tropics, would be of immediate utility, in observing the transit of Venus, as it is said that the egress of the planet could be better watched in these highlands than in any other part of the British dominions.

An inquiry into the foundering of the Peruvian steamer Calderon, in the bay of Biscay, has disclosed the fact that the leak resulted from corrosion caused by mercury spilled from the gauge-cocks into the bilge, where, by lodging under the boilers, and becoming oxidized with strong hot brine from the boiler-leaks, it was converted into oxychloride of mercury. In the recent investigation into the loss of the Megara, it was stated in evidence that the washing about of a copper nail, in the bilge of the iron steamer Grappler, destroyed one of her plates, and caused a dangerous leak. Both metals, when exposed to the action of salt-water, become converted into oxychlorides, which corrode iron rapidly when in contact with it.

If iron is withheld from animals, they sooner or later show signs of disease, which in man is attended with a peculiar greenish pallor of countenance, great weakness, and general disturbance of the functions. It has been observed that plants grown in a soil without iron are affected in a similar way—that is, they are less thrifty, lose color, and give other indications of disorder. It is therefore inferred that iron is quite as essential to the growth of plants as to the growth of animals.

An important discovery, which it is expected will ultimately reduce the cost of steam-power 60 per cent., has recently been made and put into practical operation in Boston. The discovery consists of a process by which the great amount of heat that now escapes into the air in the waste or exhaust steam from engines, is utilized by conducting it through the tubes of a boiler filled with bisulphide of carbon—a fluid which boils at 110° Fahr., and at the temperature of exhaust-steam gives a pressure of sixty-five pounds to the inch in the boiler. The vapor formed in this boiler is used to drive an engine, instead of steam, and after being used is condensed by cooling, pumped into the boiler again, and used continuously without loss. A number of carefully-made experiments are said to prove beyond question that, by means of this process, the same fuel now required to produce 100 horse-power, with the best engines in use, will produce 250 horse-power, showing a gain of 150 per cent. in the amount of power obtained by the consumption of coal. This is a very important discovery, and, if further experiments shall bear out the claim which is now made for it, will be of immense advantage to the entire manufacturing interests of the country. —*American Manufacturer.*

The coloring-matter of the blood-corpuscles is known as *hæmatosin*, and the red color of this substance is generally attributed to the presence of iron. This, however, appears to be a mistake, since Malder and Van Gondoever have been able to abstract the iron entirely, and yet the hæmatosin was as red as ever.

M. Gaudain states that a mixture of equal parts of cryolite and chloride of barium forms a flux superior to borax for soldering iron, or brazing copper, brass, or bronze. Cryolite is a mineral that occurs in great abundance in Greenland. It is a double fluoride of sodium and aluminium, and has been largely employed in the production of the metal aluminium.

At the recent scientific meeting in Dubuque, Miss Swain read a paper entitled "Why we differ, or the Law of Variety." In regard to the sexes, she took the ground of Luke Owen Pike, that differences are due to the different proportions of the same qualities, men and women differing not in elemental composition, but in excess or defect of common properties. She is said to be the first lady who has ever addressed this Association, but she is certainly not the first who has contributed to its proceedings. Mrs. Elisha Foote prepared a paper, the result of her experimental investigations on heat, which was read at the meeting in Albany in 1856.

It is stated by Jean that our ordinary soaps are so adulterated, under pretence of cheapness, that little of soap remains but the name. The chief adulterant is resin, which combines with the potash or soda in place of the 50 or 60 per cent. of fatty acid that should be present. These alkaline resinates impart to the soap the power of lathering copiously, and they even saponify in water containing gypsum. These good properties are, however, counterbalanced by serious disadvantages. If resinous soaps are used in fulling cloth, they produce blemishes. They also impart to worsted stuffs a peculiar greasy lustre, and wool scoured with these takes the mordants and dyes unequally.

Woodman reported at Dubuque on ancient mounds. He says that these and other old earthworks are far more abundant than is generally supposed. The city of Dubuque, he states, is full of them, although they have been extensively obliterated without being recognized. They are almost invariably fifteen paces apart from centre to centre, the smaller ones being from two to two and a half feet high, and about twenty feet in diameter, and are arranged in straight or slightly-curved lines. Some mounds contain skeletons, and were probably designed for tombs, while other and larger mounds are supposed to have been residences of the ancient inhabitants of the continent.

Dr. G. W. Hough has introduced a printing-chronograph into the Dudley Observatory, which has been in operation a year and a half. Observations have been made in that time on 10,000 stars, and the number of records taken and printed amount to 150,000. The chronograph is an instrument for noting precisely the astromical time at which the observation of a heavenly body is made. The first chronograph was a Morse register. Dr. Hough has improved upon this, and says that he can do twice as much work as formerly in the laboratory, by the use of the invention.

A paper from Prof. E. W. Hilgard, State Geologist of Mississippi, was contributed on "Soil Analyses and their Utility." Prof. Mapes a few years ago made a great deal of noise about soil analysis, and was accused of "running it into the ground." Prof. Johnson, of Yale, showed that there was a good deal of humbug about so-called soil-analyses, and pointed out the exaggerated value that is commonly attributed to them. But Prof. Hilgard has such faith in them that he proposes to vary the usual routine in State geological surveys by introducing them, and he thus returns to the policy of Emmons in conducting the New York State Geological Survey.

A new process, which has received the name of Helio-Autographic Printing, has recently been brought out in Paris. It is said to enable the artist to make his own designs and drawings, to print from them on photographic paper, and reproduce the same upon lithographic stone, so as to obtain impressions of his own work in the minutest detail, without the aid of the engraver, or lithographic draughtsman.

According to Schmidt, an excellent remedy against caterpillars consists in a dilute solution (1 part in 500) of sulphide of potassium, the infested tree being sprinkled with this substance by means of a small hand-syringe. This method has been used on a large scale in France, and, it is said, without any injury to vegetation.

According to the *Medical Times and Gazette*, the cholera is gradually making its way westward, having but recently entered Prussia. The disease is of a mild type, however, and spreads slowly. In Berlin it first appeared in one of the most fashionable streets in the city, three cases occurring nearly at the same time, in one and the same house.

Prof. Peirce exhibited at the Dubuque meeting some interesting astronomical photographs and engravings prepared by Prof. Winlock, of Harvard College. It appears, by these charts, that Jupiter changes his color even on successive nights. The representations of sun-spots were said to be very instructive, showing their connection with the solar protuberances; the drawings of the latter indicate an unmistakable atmosphere at an altitude of 100,000 miles.

A red color has sometimes been observed in white lead, and has been formerly attributed to the presence of silver. German investigations have recently shown that this is incorrect, and that the red tinge is due to defects in manufacture.

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