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## THE RELATIONS OF WOMEN TO CRIME.

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I.

THE first traditional crime, the fratricide of Abel, was a natural outgrowth from the conditions of society, which, compared to the present relations of civilized men, existed germ-like around him. These conditions alone gave motive and direction to the deed. To all the after-centuries of human crime this primal offense has existed as a type. Both in cause and effect it is reduced to its simplest proportions. The criminal represents the retrograde tendency of society; the savagism which exists in every community. Order and progress are preserved by an irrepressible conflict waged on the border-land, as it were, of civilization. Many of these crimes grow out of the artificial wants of society. Others are but relative and belong to particular conditions, or orders of men, and at other times and places are without meaning and void of offense. Thus society is ever eager for the warfare, and, at the time it creates the crime, prepares the weapons for its punishment.

The propensity to crime is a fixed element in human nature. Quetelet, whom I have frequently referred to in the course of these papers, has with singular sagacity and perseverance reduced the social relations of man nearly to an exact science. The dark and tortuous by-ways in life, which so many seem perforce to follow, arrange themselves with the regularity of geometrical lines under the clear illumination of his analysis. Yet these are surface-lines only. There are profound depths of human misery and crime, over which a veil seems drawn by a merciful hand, and in which we have but a suspicion of the force of law. But, in these depths, in which the terminal fibres of human relations find soil and sustenance, can be found the origin of the ordinances under which these surface-lines are grouped. If this be so, it follows that crime must be studied as a natural phenomenon rather than as an accident. Those efforts which society has made to stamp out and confine this tendency to evil must, to an equal extent, spring from higher law; just as a breakwater is reared to protect an exposed harbor from the encroachments of storm and wave.

We have of late years come to look upon criminals as a special class of the community. We have come to complacently call them the "criminal class," just as we do the mercantile class or any other reputable order of men. This is so far true as to be capable of proof more by the exceptions than the rule. We have come to look upon crime as we do the typhus fever or the cholera, as prevailing mainly amid dirt and ignorance. I believe this to be true only so far as ignorance permits those good qualities in men to be undeveloped which require culture for their development; and the existence of such qualities has not as yet been demonstrated. It must be understood that while the word "ignorance" does not express a positive quantity, it yet expresses a positive quality which is true of the mass of people. This word with perfect fairness may be applied to the vast numbers which swell the aggregate of a census-table, without any qualification. I believe it can be shown that it is simply from excess in numbers that the ignorant classes furnish the recruits to the ranks of crime, and not from any tendency to crime dependent upon the negative quality of ignorance. A careful analysis of facts in this field induces Mr. Buckle to say that "the existence of crime, according to a fixed and uniform scheme, is a fact more clearly attested than any other in the moral history of man."[1] Another high authority may be quoted in evidence to prove that this scheme is exempt from those laws which govern intellectual development: "It is one of the plainest facts that neither the individuals nor the ages that have been most distinguished for intellectual achievements have been most distinguished for moral excellence, and that a high intellectual and material civilization has often coexisted with much depravity."[2]

All this seems to show us that there is a rhythm in human actions that forms a minor chord in the forever unwritten music which those who love Nature know as existing profoundly in all her works.

Since we are dealing with an element in human character which preserves a fixed value, it is evident that we may study the relation of any class in any community to these constantly-recurring phenomena, provided we can isolate this class from all others. In the study before us, this has already been done by the division of mankind into the sexes. I need draw no other line. Women stand out so clearly as a class, and, in relation to any series of acts which preserve a more or less constant periodicity, are so sharply defined from man, that they are easily contrasted with him in relation to any condition common to both.

[1] "History of Civilization in England," vol. i., pp. 22, 23.

[2] "History of European Morals from Augustus to Charlemagne," vol. i., p. 157.

I have already called attention to the fact that intellectual development obeys other laws than those which relate to crime. This requires to be brought out more clearly in relation to women. In this age women are receiving more chivalric attention, more material respect, than in any other known to history. In this century they are accorded the full right, and are given the aid of some of the best intellects among the other sex, to adjust those wrongs under which they have labored for ages. They are identified with every scheme of love and purity which demands good motives and a sympathy that never slumbers. It is for this reason, then, that, when we associate women with the idea of crime, it is difficult to believe that they are not influenced by other laws than those which affect men. There is nothing in a brawny hand and coarse muscle which tends to evil. The hand which executes may be white and begemmed. The mind which plans may be cultivated and refined.

In the study before us, we shall be obliged to resort to other facts than those simply contained in tabulated statements of crime. Statistics has done much in social study, and in this instance it has pointed out the existence of law in human action in the aggregate; but it has gone no deeper. We can establish by its means a probable difference in the degree to which the sexes are affected by crime; we can so group these numerical statements that they will be a mutual check upon each other, but if we are to learn any thing of the under stratum of human life, of its curves and faults, of which we see only here and there an upheaval upon the surface of society, we must study sexual and general character, we must observe the mutual relation and dependence of the sexes and classes upon each other, and give due credit to the cerebral and physical differences which go to make up the sum of sex—all of which are beyond the province of figures to express. In the course of these papers, therefore, I shall resort to statistics only to the extent I have mentioned. The popular character which I have endeavored to give them also forbids the resort to statistical detail, except to the extent which is inseparable from the nature of the study.

As in hygiene so in crime, there is not one law for woman and another for man. The emotions which impel to crime are few, and to the operation of which the sexes are both exposed. But, it does not follow that these causes react in the production of crime to an equal degree. The propensity to crime, as defined by its actual commission, is four times as great in men as in women.[1] Here at the outset we are confronted by a remarkable contrast. But, allowed to stand as here stated, it involves a vital error. A propensity to crime is its existence latent in the possibilities of the individual. Justin McCarthy, in one of his novels, in describing a character defines her virtue as purely anatomical while mentally most unchaste. Here the

[1] Quetelet, "A Treatise on Man," p. 70.

propensity was one thing and its physical expression another. It therefore follows that if we are to reach the degree of woman's propensity to crime it must be by other means than a simple expression of the difference in the actual perpetration of total crime. The propensity can be approximately measured by the degree of the offense. Quality and degree are in law the measures of the punishment inflicted on the offender. This is called justice, and it is indeed tempered with mercy when we compare it with the operations of law less than a century ago, when it dealt with crime simply as a quality without reference to degree. In its treatment of criminals, society took its first scientific stand-point when it measured the propensity to evil by the degree of evil actually committed. It seems safe to assume that in a certain limited range, as the degree of crime defines its penalty, so also it expresses the extent of the propensity. Another fact may be approximately established from the same data. The causes of crime, those deeply-hidden undercurrents existing in society, the ebb and flow of which seem to register themselves in undeviating curves of human conduct, must vary in intensity to the degree of crime which is their natural outgrowth. Thus, a man who commits a criminal act with the full knowledge that his life is jeopardized thereby must surely be exposed to an influence far greater than one who, under all circumstances, would shrink from the greater crime through a sense of punishment, but would not hesitate to commit a lesser offense. If this is not so, then society has been acting upon a false theory in its repression of crime by the fear of punishment. But I believe legislation for this purpose has been based upon a correct knowledge of human nature, and that the average man with criminal tendencies is, to a certain degree, deterred from criminal conduct by a fear of punishment. There is strong confirmation of this in the condition of society existing in the border States and mining regions, in which there is a low estimate of the value of human life, not from the fact that life is individually less precious there than elsewhere, but that the tendency to this form of crime exists in greater force as a natural outcome of the conditions under which human life is there grouped. I believe it is just, therefore, to partly form an estimate of the tendency to crime by the method I have adopted, aided by a simple comparison of the prevalence of crime in general in the sexes.

The apparent great excess in the prevalence of crime among men forms one of the most interesting facts of sex in crime. At the outset we ought to reach, if possible, the cause. In this connection all ideas of the innate morality of women over men must be abandoned. Modern literature is full of a false and even morbid idea upon this subject. M. Michelet has written a romance called "Woman,"[1] and it is a fair sample of what may be termed the sentimental estimate of the sex. But the frail creature portrayed in the florid sentences of Michelet

[1] "Woman," from the French of M. Michelet, by J. W. Palmer. New York, 1874.

is not the woman of France. One glance at the tables of Quetelet proves this.

We must take a practical view of woman's character. She must be regarded as one in whom the passions burn with as intense heat as in the other sex. The limits of her morality are the same as man's. She attains purity in the same manner; and she meets sexual disaster through the same means. Her worldly view is bounded by the same horizon. She upholds for herself the same standard of success or failure. Temptations run in the same channel and are resisted by the same psychical traits. The forces of heredity play the some *rôle* in her mental and bodily life. Beyond these, she belongs to a different mental type from man, the effects of which in our present knowledge, and in the relations we are now studying the sex, reach limits impossible to fix. I can see no other way of viewing the sex, and reaching any thing like approximate truth in her relations to crime.

In crimes against persons in which personal strength forms an element, there is a physical factor for the difference. The ratio of strength between the sexes is as sixteen to twenty-six, and this is found to correspond to the difference in which women and men participate in crimes against persons and property.[1] Such a coincidence as this, constantly recurring, renders, in this broad classification of crimes in general, such an explanation probable. But, in a closer analysis of crime in particular, this physical basis loses its value as a probable cause. While we must allow that sexual difference in strength finds a reflex result in consciousness, and thus places a limit to the acts of either sex, yet in crimes against persons we find the sexes approaching to and receding from a common ratio. It is this fact which leads me to the conclusion that all argument regarding the innate excess of moral qualities in the female sex over the male, is based upon a fallacy. It is strongly confirmatory of this, that a simple numerical comparison of the prevalence of crime in the sexes leads to error, unless we credit women with the fewer temptations, the less opportunity, and those forms of sexual cerebration which find their expression in a want of belligerence which characterize women. Thus it would be obviously wrong to assert that, because twelve women to one hundred men are convicted of assassination, women represent more than eight times the morality of men in relation to this one offense. This crime is just the one to call into play all those conditions which constitute the moral atmosphere and conditions of sex. Woman's want of opportunity, the nature of her occupations, and the absence of the same degree of temptation, must all be taken into consideration in forming an opinion of the moral equivalent of women in connection with the crime. If it were possible to give to each one of these modifying conditions a numerical expression, this moral equivalent could be given a mathematical value. But this is impossible, and each possesses in itself

[1] Quetelet, *loc. cit.*, p. 91.

an imaginary yet appreciable value. Again, let us group all those crimes against persons which involve the taking of human life, and observe the extent to which the sexes are engaged. For all crimes against persons, Quetelet places the ratio at sixteen to one hundred; but in the class of crimes I have selected, involving infanticide, poisoning, parricide, assassination, and murder, we find this ratio nearly doubled, being thirty to one hundred. It is evident that woman's tendency to crime must be measured by some other standard than innate morality. If we apply to these figures the theory that the degree of crime is in a measure the test of propensity, we obtain some startling results. Take the felonies named above in the aggregate, and while the marked difference of sex in the commission of total crime is evident, we see that in the perpetration of these grave offenses she exceeds her ratio of crimes against property. I think this shows the probability that those emotions or passions which serve as the incentives to crime, approach in intensity the same mental conditions in the other sex. When we consider the strong emotional nature of women, and that many of these emotions are of an organic or sexual origin, and their social relations, and the habit of dependence, which they have inherited, upon these relations, we must admit that the moral elements of crime are so strengthened as to modify materially their deficiencies of strength and want of opportunity.

Many of woman's social relations are well calculated to clear and make easy the way to crime. It is another confirmation of the fact that society prepares the crime, and the criminal executes it. Compensation is found for her in the fact that society also places obstacles in her way by removing many temptations and opportunities for offense. But, in those crimes which are the natural outgrowth of her sexual and social relations, we find woman standing upon man's own level as a criminal. Thus, in infanticide and in poisoning, both of which, from the degree of offense involved, show a strong action of the exciting cause, all sexual difference in numbers disappears, and it is evident that the tendencies to those two crimes are equivalent in the sexes.

As the preceding shadows forth the interesting fact that woman, as a criminal, is under forces of both restraint and non-restraint other than sexual differences of mind or body, compared to man, it will be necessary to refer briefly to the nature and extent of these modifying circumstances, in order to appreciate the true bearings of the question. These conditions spring mainly from her social relations. This leaves us another important class of modifying conditions which may be traced to sexual relations. Two classes can therefore be made: (*A*) social conditions, and (*B*) sexual conditions, modifying woman's relation to crime.

The first (*A*) which exist sufficiently near to the subject to call for analysis are: (1) occupation, (2) opportunity, and (3) marriage;

and each of which must have a marked influence on sporadic cases of crime, and especially upon the creation of the criminal habit. But, much as these modifying circumstances have to do with the question before us, yet returns involving these particulars are so imperfect that we are able to get but a hint of the extent to which each acts.

(1.) Occupation, as it places woman above temptation to the minor degrees of crime, or as it brings her more closely in contact with constantly-recurring temptations, becomes an important factor. It is evident that these conditions must exist in the lives of both sexes, and have their influence on the frequency of crime and the nature of the offense. Thus in an official return[1] quoted by Quetelet, in which the offenders are classified by occupation, the accused of the eighth class who all exercised liberal professions, or enjoyed a fortune, are those who have committed the greatest number of crimes against persons; while eighty-seven hundredths of the accused of the ninth class, composed of people without character, as beggars and prostitutes, have attacked scarcely any thing but property. When the accused are divided into two classes, one of the liberal professions, and the other composed of journeymen, laborers, and servants, this difference is rendered still more conspicuous.[2] This is sufficient to render the broad inference probable that want or necessity induces but the minor degrees of crime against property, while the more serious phases of crime belong to the opposite conditions of society, or have their mainspring in other motives. In the *Compte Général de l'Administration de la Justice*, the occupation of the accused is given by sex, and under the article *Domestiques* we find one hundred and forty-nine men and one hundred and seventy-five women employed as personal servants, nearly all of whom were accused of the minor degrees of crimes against property. These proportions for this occupation hold about the same relations from year to year. As persons so engaged are maintained generally by their employers, want could not have existed as a motive for these offenses. Cupidity, or the desire to appear well, with the facility of its gratification, afforded by occupation, is the probable motive, and, making allowance for the slight excess of women so employed, exists in almost equal intensity in both sexes.

From what we know of the inadequate pay attending many of the employments in which women are engaged, it is safe to say that irresistible temptation is often the result. In the larger cities there are thousands of women, reaching from youth to advanced life, who are but just able to provide themselves with the necessities of life by labor extending over more than half of the hours in the day. Many of these have others dependent upon them, which must add very much to the tendency to the minor forms of crime. But the tendency to crime arising from inadequate pay is twofold. It may not be sufficient to meet necessary bodily wants, or barely sufficient, or, as is too gen-

[1] "Rapport au Roi," 1829. [2] *Loc. cit.*, p. 85.

erally the case, it is insufficient to supply those matters of personal adornment and comforts of surrounding, small as many of them are, which are so necessary to contentment. This tendency to adornment either in person or surroundings must be looked at seriously as a sexual mental trait in women. They need but to reach the rudimentary stage of education to have developed in them æsthetic tendencies, and which in many seem to exist innately. This feeling is also closely allied to that personal pride which is such a safeguard against the encroachments of vice. This pride of person is to many a struggling woman what a moral atmosphere is to others. To the one it is an instinct which keeps her from the degradation, and that conduct which leads to it; to the other it is the moral force which surrounds her and lifts her above the opportunities for evil. Viewed in this light, personal pride, as expressed in the adornment of person and home, may replace the purely moral sense to a certain extent. But pushed beyond the point at which it contributes to correct conduct, and allowed to exist solely as a sexual trait, it may become a strong incentive to crime. There is no reason to doubt but it is mainly the cause which makes crimes against property so nearly equal in the sexes among French domestics just alluded to. A mere desire for luxury would not be liable to develop in one never at any time of life exposed to its enervating influence, as the mass of working-women spring from parents who are also toilers, so that we may safely conclude that want, or a personal pride to appear better than others in the same station, is the most active cause of crime among underpaid women who have inherited no criminal taint.

The massing of large numbers of women at manufacturing centres is a circumstance from which spring many conditions which render the minor degrees of crime easy of commission. It is a singular fact that a great preponderance of numbers in one sex over the other, unrestrained by ties of family, and without the natural dependence of the different occupations and stations of life upon each other, almost invariably defines a locality in which the various forms of crime exist to excess. This has long been remarked of places in which the number of men greatly exceeds the number of women, but little attention has been called to the same condition as resulting from the preponderance in numbers of the other sex. Any one who has inquired into the causes of the social evil must have been struck by the numbers who admitted they had taken the first steps of their career in the populous manufacturing towns where an excessive number of their own sex was employed. There is this marked difference: an excess in the number of men leads to an increase of crimes against persons, while an excess of women increases crimes against property, in both cases relatively as to sex. I see no way, in our present knowledge of the subject, of explaining this, other than that a healthy tone of society demands an even balance of the different occupations and stations, and the presence of those ties of kinship which act so powerfully as restraints. Aside from these conditions I know of no facts which show that an even proportion in numbers of the sexes has a mutually conservative effect upon morals.

Generally, those in whom there is no inherited criminal taint, or no development of the criminal habit, would not seek nor create an opportunity for offense. But this can hold true only as to crimes against property, for in the other class of offenses, revenge, jealousy, avarice, and other emotions, may act suddenly as the exciting cause.

It is evident that woman's opportunities for crime are restricted by her relations to society, except, as we have already seen, certain facilities are afforded by her occupation. The moral influence of woman upon society is powerful; but it is negative rather than positive. Woman wields a sort of moral inhibitory power. Except as she may directly incite the other sex to crime, relationship to woman restrains and tones down the more salient points of the male character. Her lessened opportunity for crime results naturally from her sexual relations. Opportunity springs from the free mingling of large numbers in the heat and action of life. It is the antagonism between interests and objects, the friction, as it were, between the rapidly-moving actors, which brings out the intensity of emotion which results in the open or secret warfare of society. The vast majority of women are, to a certain extent, removed by the restraints not by any means artificial, but those which naturally result from their sexual relations, from the opportunity for crime. But I would limit even those restraints to crimes against property, rather than against persons. Although the ratio is sixteen and thirty-two to one hundred for each of these classes respectively, yet I believe it can be shown that the diminished ratio for crimes against persons depends upon other and more specific causes than her sexual attitude to society. Domesticity in this relation shows its potency as a conservator of morals; but, standing alone and unaided by mutual dependence and interest, its power is limited to placing each subject beyond the more closely-besetting opportunities to which men are exposed. It is but necessary to call attention to the fact that it is from among female domestics and operatives that the ranks of prostitution are recruited, in order to show that domesticity, which is the condition of seven-eighths of the female population, must be accompanied by other relations in order to act as a more or less complete restraint to crime. I use the word here in its broadest possible sense, as defining the position of the majority of the sex. Great as the influence of the domestic relation is, it is limited by the fact that it is not permanent. It is constantly exposed to those accidents to which all human relations are liable. The passions and discordant interests find in this relation a field for their utmost activity. The sexual relation, which is founded in the passions common to us all, finds in them the elements of its strength and permanency, as well as its weakness. It is created and made lasting as life, or as brief as a summer's day, by one and the same organic emotion. Otherwise marriage, which we may assume as the type of domesticity, would not seem of itself to exist as a factor in crime. As we study marriage in relation to crime in another part of this paper, we shall perceive some very singular facts in which its bearings upon society are not so healthy as might be expected. It cannot be charged, however, to marriage, which is the most perfect of all human relations, but to its underlying weakness, the changing sexual conditions upon which it is based. It is safe in a broad grouping of crime to say that the emotions and passions define offenses against persons, while those against property are characterized by processes of mental calculation and deliberation. The last needs opportunity and temptation; the first exists everywhere. The domestic relation affords a refuge to the one, and contains within itself the element of the other. For these reasons I believe that the restraint afforded by domesticity must be mainly limited to crime against property.

In connection with this division of our subject we are brought face to face with the fact that women are as capable of crime as men. "It is not the degree of crime which keeps a woman back," says Quetelet . . . . "Since parricides and wounding of parents are more numerous than assassinations, which again are more frequent than murder, and wounds and blows generally, it is not simply weakness, for then the ratio for parricide and wounding of parents should be the same as for murder and wounding of strangers."[1]

With opportunities equal to man's, with the way to crime made easy, instead of being hedged in by the limits of her occupations, woman may equal him in the tendency to crime. Infanticide, in view of the strength of woman's maternal emotions, of the acuteness of her sympathies, and the general attributes of her character, stands alone as a crime in its relations to the sex. Considering the violence done to emotions which are a part of her organic psychical life, it has no equivalent in degree in the range of crime. If we apply to it the theory that the degree of offense, to a certain extent, affords a measure of the tendency to crime in the individual, this crime would reveal in women such a tendency greatly in excess of the other sex. But we must bear in mind that this crime, more than any other, which tends to make woman appear unduly prominent as a criminal, is a natural outgrowth of social surroundings. It is a marked instance of the fact that society contains within itself, even in its normal conditions, the moral agencies that create crime. Society has raised for itself a gauge of conduct, by which the alternative may be presented to any woman, of either crime or disgrace. At the same time society has so organized itself that the chief aim

[1] *Loc. cit.*, p. 91.

of every woman has been to establish a permanent relation to some man based upon involuntary sexual emotions. So long has this been in existence, so much power has it acquired by the increment of the forces of heredity, that it has become an organic law of society. This is a factor which enters into every woman's existence; by it her sexual life is made to exceed in intensity the intellectual. Ceaseless indwelling upon what every woman is taught to regard as both a necessity and an honor has tended to give undue force to every thing that relates both mentally and physically to her sexual existence. This is the manner in which society has made the way easy for woman's sexual error. Reflecting upon this, I confess to admiration for a sex which in the face of these difficulties has ever maintained such a well-deserved reputation for purity, and shown us that mankind turns instinctively to good rather than evil. Punishment is part of the crime, with society. To women for a sexual offense it measures out a punishment relentless and life-long. They are banished and hang on the outermost skirts of the inexorable law-giver as "Scarlet-Letter" ones, for whom, in all their lives, there is no further hope.

Prepared in this fashion for infanticide, can it be wondered at that the ratio for this crime is 1,320 women to 100 men?[1] It is clearly an alternative of either social banishment and a total defeat of her selected destiny, or an attempt to conceal her error by crime. With an obliteration of one set of moral feelings there must be necessarily a weakening of the general moral character. She is therefore prepared to violate all the emotions and consciousness which have their origin in the very condition, through the undue development of which she met disaster. Infanticide appears to the woman's consciousness less formidable and repellent than her certain punishment by society. Her training has prepared her to place this lessened value upon the crime. Quetelet gives prominence to shame as an impelling motive to the crime. I can give it no such value. That sense of shame or modesty which exists as a phase of sexual cerebration in every mentally healthy woman, and that induces her to guard so jealously the casket after the jewel has been stolen or rather bestowed, is the part of her mental life to which the most violence has been done by her social error. What the French philosopher ought to refer to, is not the sexual quality of shame, but a sense of degradation which is common in an equal degree to both sexes. It is the sense that the good opinion of those we know, and whose esteem we value, has been forfeited. When we connect this sense of forfeiture with the fact that the interests in life which women are educated to hold most sacred, await but detection to be lost forever, I think we have found sufficient reason why this crime, which so antagonizes all womanly qualities, should exist to such a degree as to alter nearly one-half the ratio of the sexes in relation to crimes which involve human life. In ana

[1] Quetelet, *loc. cit.*

lyzing the circumstances which bear upon infanticide, we are studying the darkest page of woman's criminal history. It proves that under a sufficient motive, and with every opportunity which her peculiar relation to that offense gives, she demonstrates her capacity to equal man in both the degree and number of her criminal acts. It is, however, an offense so characteristically entwined with her sexual life, and with her relations to society, that we must have a due regard for circumstances in contrasting it with any crime or series of crime in men. As already perceived, I am disposed in this inquiry to assign it but one value: her disposition to entertain the criminal idea, and under favorable opportunity to give that idea expression. In other respects the crime stands alone, and can be used only in contrasting woman against woman. There are certain abnormal states of sexual cerebration connected with this offense which will more readily present themselves when we study the crime against society—the social evil.

In considering the effect of married or celibate life upon women in relation to crime, we are beset by many difficulties in regard to data. The officials upon whom devolve the duty of collecting criminal statistics, have yet to learn that they deprive their labor of much of its scientific usefulness by their errors of omission. The information has but little value that so many male or female criminals are married or unmarried. A proper study of the subject requires that this information be given in its relation to crime as it affects persons or property, the age at which the criminal career began in the two classes respectively, and crime among the widowed or divorced. Nearly all these facts are wanting. We can, however, collect sufficient data to enable us to shadow forth the probable truth in regard to this important matter. We may safely term marriage the unit of force in our present civilization. I have briefly called attention to its innate strength and weakness, which are inseparable from human mutability. It is easy to perceive the manner in which marriage may act as a conservator of morals, and its operation as a promoter of crime is equally evident; but the extent of its operation in either direction is difficult if not impossible to measure. In the examination of the returns of crime for the years 1867, 1871, and 1873, in New York City,[1] and which show great uniformity in the social condition of the sexes, we are met with the strange fact that the percentages of the married of both sexes correspond, being thirty-nine per centum; while for males the percentage of the unmarried is fifty-five, and for females in the same social condition it is forty-two. Regarding marriage as a conservator of morals in its affirmative rather than its negative relation, this statement places man on a level with woman; but observing further that the excess of male criminals is furnished from the unmarried,

[1] Table "B," 23d and 27th, and Table "A," 29th, "Annual Reports of the Prison Association, State of New York."

and that the single and married female criminals exist in nearly equal proportions, we can reach but one conclusion, that marriage exists as a restraining influence against crime more strongly among men than women. I think this result is opposed to the preconceived opinion of the majority, of the effect of marriage upon women. Marriage for women has ever been regarded as a preliminary condition to reform. This is the result of the sentimentalism which has entered into the solution of many social problems. Marriage is not unmixed good. Lecky says of it, that "beautiful affections which had before been latent are evoked in some particular forms of union, while other forms of union are particularly fitted to deaden the affections, and pervert the character."[1] Woman's keenly emotional nature is well disposed to be exalted or depraved by marriage. It seems hardly possible to reach the true causes of the nearly negative results of marriage upon the morality of women by a study of the character of this sex alone. In women, rather than men, are mirrored the lights and shadows of society. Mentally she is the plastic material which takes its form from the protean phases of life around her. She is spiritually the resultant of her moral atmosphere. I believe these influences are more potent in forming her character than man's, from the nature of her dependent circumstances. With man's opportunity for objective life, he can remove himself, partly at least, from the moral surroundings; and by identifying himself both bodily and mentally with labor, which has for its object, usually, something to be attained in the future, he has loop-holes to escape from impressions received from others, which with a more subjective life would result in introspection, by which the mind is familiarized with the criminal idea.

From the same source we may gain additional facts as to the negative effect of marriage upon the morality of women. In the tables referred to, involving in the aggregate an excess of males over females of about two to one, we find the number of widowed females over males in the same social state to be nearly double. It is impossible to state specifically the nature of the crimes involved in this excess; but it probably represents, in a great measure, offenses against property. The social condition of widowhood in the average woman is not conducive of morality; and yet we have already shown that actual marriage is attended with nearly negative results. From this we may gain an idea of the extent to which women are the victims of circumstances at the beginning of their criminal career. The figures we have been analyzing represent crime in a great city. Under this condition, the excess in the number of widows represents probably cases of complete destitution. The fact that this excess of widows had no means of coping with this difficulty, except by a resort to crime against property, renders the conclusion safe that not only marriage had not developed in them a condition favorable to morality, but had actually

[1] *Loc. cit.*, vol. ii., p. 369.

so lowered the moral tone as to render them unfit, as a class, to contend with the difficulties of life, and exhibit the same degree of morality as the unmarried woman. Much of this result must depend upon the unavoidable social position of the married woman—one not at all calculated to test either her morality or self-reliance. The duties of maternity and domesticity inseparable from her position, do not fortify her against evil in her changed relation to society. On the contrary, with the burden of children upon her, in the time of need, she looks upon crime less as a positive than as a comparative evil. With the true woman, there is no chance for hesitation in the choice between crime in its minor forms and her maternal feelings. But the marriage relation has other influences in forming woman's character as a criminal. The intimacy of the wife with a bad husband, who, if not a criminal, at least may be capable of infusing lax moral notions in the wife, would, if she were left a widow, surely bear fruit. We need a more intimate knowledge of many facts in order to fully understand this question of widowhood in its relation to crime. It is doubtful if returns of crime from less densely populated places than New York City would furnish results at all parallel to those in relation to widows. The most plausible explanation I can give is, that these figures represent cases of absolute destitution.

There are many other relations that marriage bears to woman's career as a criminal, but which are beyond the scope of a magazine-article. All that relates to infanticide, and the prevalence of the crime of the period, among the single and married, ought, I believe, in writings of a popular character, to be omitted, except possibly the grave words of warning. Upon this subject I have written all that I thought prudent several years ago, and to which I refer the reader.[1] The well-known lines of Pope upon the effect of familiarity with vice, are certainly very true to-day. It is by a too familiar view of even the shadow of crime, that in certain minds the criminal idea may be developed. We need but abolish the mental barriers to crime to step from the criminal idea to the criminal act.

Instinctive recoil from the criminal idea without any mental reservation is the characteristic of moral health. It is upon the morally healthy minds that unfavorable social conditions may have most deplorable effect. One in whom the tendency to crime exists as a latent mental quality, requires no social conditions for its development. Whatever his or her occupation or social condition may be, this latent quality is liable to assume active existence, and shape the destiny of the individual. There is one quality that the criminal exhibits which defines him as a class, and is the only trait by the existence of which he becomes the member of a class. This is the liability, after the first outbreak, to commit repeated offenses. I find no term which expresses

[1] "The Detection of Criminal Abortion, and a Study of Fœticidal Drugs." James Campbell, Boston, 1872.

this so well as that of the criminal habit. Mentally and physically we are the victims of custom. Existence, like running streams, has a tendency to find for itself fixed channels. Life as it expands seems to seek points of least resistance for its outlets, and in following which it encounters less friction to retard its flow. In relation to crime, this exists as strongly as the opium or alcohol habit. The habit may find its factor in perverted moral feeling, whether hereditary or acquired, but its physical expression becomes the rule of life. Take such an instance as that of Ruloff, to whom Nature had given the crude material of a magnificent mind. In spite of the terrible potency of his criminal ideas, a longing for a nobler and higher life existed within him in sufficient force to give direction to considerable self-culture. He stole, and would kill without remorse any one who stood between him and his object, simply to gain money to enable him to follow his studies. His life took the direction of the least resistance. That which existed in the normal man as a sense of right or wrong, and offered itself as an obstacle to wrong-doing, had no place in this man's mental life. The outgoings of his life in the direction of least resistance, simply and naturally led him to crime. Cerebral and bodily activities, among the good and bad alike, follow the channels in which they encounter the least friction, either objectively or subjectively. It is thus we have the parson and the thief. By inherited traits, early training, occupation or social condition, weak points may be created in the barriers which surround the activities of life, and when maturity is reached the individual's existence is defined by ineffaceable lines. At this stage of life, efforts, made either from within or without, to give a new direction to these channels, come too late. Habit has been established which confirms the direction life has taken. These two forces united seem irresistible. I was, several years ago, brought in contact with an instance which proves this. Lena S—— was of German descent, and about fifty years old. She was of more than average intelligence, and of spare, nervous temperament. Lena was an instance of sporadic crime, in the sense that she did not belong to a criminal family. She followed the specialty of shoplifting, one that requires great coolness and cunning. Caught in the act and arrested, her history was brought out. She was married, and her husband was serving out a term of imprisonment, but with whom she had not lived for many years. She wandered from city to city, following her business; she had been repeatedly arrested, and more than once punished, and every time her whereabouts was brought to the knowledge of her family by her arrest, attempts were made to reclaim her, but in vain. Sentenced to several years of imprisonment, she quickly began to droop. She passed sleepless nights, with quick, irritable pulse, and loss of appetite. She constantly brooded, and laid more than one plot to escape, one of which was nearly successful. Out of about a year and a half of confinement, not more than a month of light labor was exacted of her. Her health became so broken that, at the earnest solicitation of her relatives, the prison authorities took the case up, and secured her a pardon on condition that she left the State, and her relatives provided for her. But the transition from prison-life to the comforts of a home, and a life of ease, offered no attractions to the unfortunate woman. I believe she remained under the care of her relative—a devoted sister—but a few months, when she resumed, out of choice, her old mode of life, and is now serving out another sentence.

This case shows how irresistibly the deliberate acts of life flow in the channel which habit and mental traits mark out for them. The barriers which society, and fear of punishment, and love, place in the way of a career like this of Lena S——, are swept away, as it were, before a flood. This is the destiny of the fatalist, and the force of habit, an expression of the theory of least resistance, and the effects of heredity of the sociologist. Let us analyze the last case further, to illustrate the theory of least resistance, as modified by occupation and social condition. It presents a seeming contradiction. She moved on in her career of crime late in life, with her moral atmosphere charged with resistance to her progress. Contrasted with this was her criminal pupilage in early life. Her husband united pauperism and crime, and if originally her moral perceptions were clear—which I doubt—she thus found the best school to obscure these, and familiarize her with the criminal idea. With these faculties blunted and weakened, which serve to hedge in the impulses to evil, she proceeded to supply her wants by the method most familiar and easy. The thief looks upon the property of others in a peculiar way, and one that constitutes the essence of the crime. He believes in a sort of ownership which is mutual, and depends upon possession. This belief may become a fixed habit of mind. Originally it may have been easier to steal than to work, later it may become more impossible to work than to steal. Then came attempts at reform, made by others, with the life of ease and comfort, but the criminal grew wretched and drooped. There was but one life before her which met the demands of her nature—that was to wander from place to place and steal. This woman answered in no sense to the legal definition of the insane; she was not irresponsible for her acts, she knew their nature and the punishment which followed detection; but she simply did that which the most of us desire to do, follow the easier and pleasanter life. It has become the fashion of late to speak of criminals of this class as insane, but this theory cannot explain their irreclaimable condition. The real state, as it appears to me, is, that thoughts and acts move in the direction of least resistance. What began in this way, may be confirmed by habit, so that life may wear for itself channels from which it is impossible that its current may be driven.

# HYDROIDS.

BY MRS. S. B. HERRICK.

SOME of the most exquisite forms of organic Nature are to be found in that shadowy border-land which unites rather than divides the animal and vegetable worlds. It is hard to believe, even when looking with careful scrutiny at certain forms of animal life, at

FIG. 1.—PLUMULARIA FALCATA. (Natural Size.)

the corals, for instance, the sponges, and the hydroids, that an existence which so closely resembles vegetation should be essentially animal. Each of these families of the great invertebrate kingdom has been bandied back and forth from the botanist to the zoölogist, and each has finally found its place in the animal world.

No purely empirical knowledge is sufficient to determine, among the lower forms of life, to which kingdom they should be referred. It is only by studying facts in their relations, by patiently observing the life-history, and by ascertaining the modes of nutrition and reproduction of each form, that its true place in the organic world has been determined.

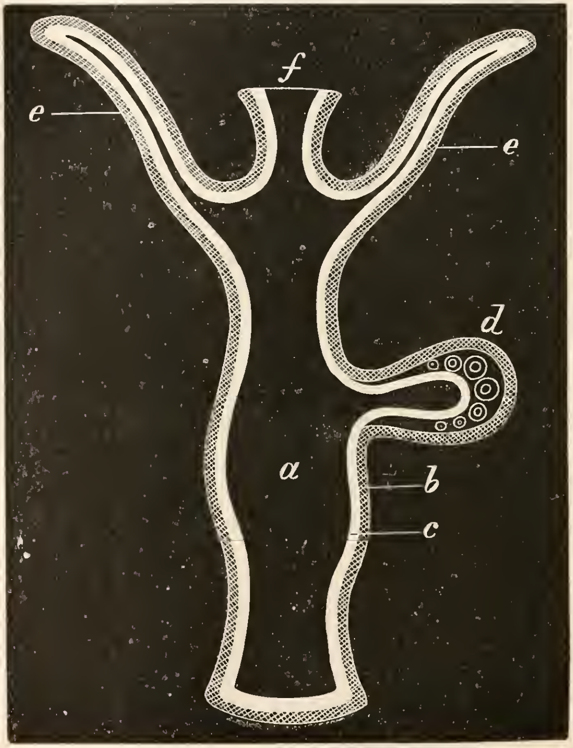


FIG. 2.—DIAGRAM OF A SECTION OF HYDROID.

It was, for many years, thought that, beyond the depth of 300 fathoms, organic life ceased to exist in the ocean. Forbes reached this zero of life in the Ægean Sea, and the fact ascertained for the Mediterranean was inferred for all other seas. The transmutation of inorganic into organic matter is only performed by vegetables, and then only under the controlling power of light. The distinction made by naturalists between the lowest forms of animal and vegetable life lies just here: vegetables convert the inorganic elements of earth, air, and water, into organized matter; animals rearrange this organized matter into animal tissue. It is well known, as no light penetrates the profounder oceanic depths, that no vegetation can exist there; an absence of animal life was therefore inferred. Certain exceptions to this definition of vegetable life, as being exhaustive, are found in the *Fungi*, which germinate and grow in darkness, and it is believed are nourished in great measure by organic matter, as well as in the curious carnivorous plants, which have of late attracted so much attention. This, however, does not invalidate the truth that all nutriment, in order to be fit for the maintenance of animal life, must pass, at least once, through the transmutation effected only by vegetation.

The non-existence of life below 300 fathoms, in all the oceans of our globe, was strongly supported by Forbes's investigations in the Mediterranean. The abyssal depths of the sea were thus determined by logic to be the universal empire over which reigned darkness, des-

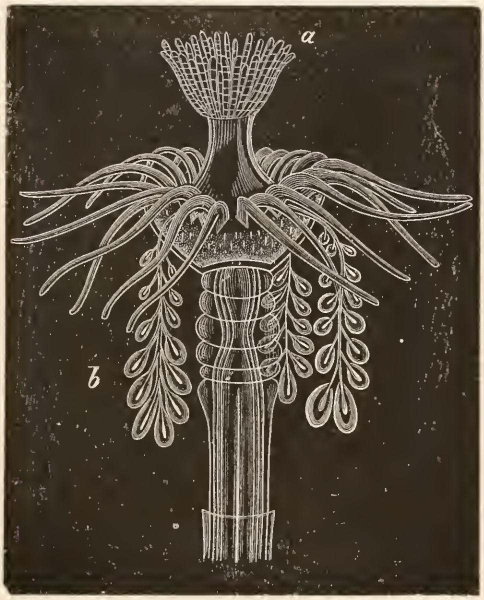


FIG. 3.—NUTRITIVE BUD OF TUBULARIA INDIVISA. (From Male Colony.)

olation, and death. No investigations were made as to the facts of the case. Logic and a hasty generalization from inadequate knowledge were made, once again in the history of science, to do duty for the more laborious method of patient observation. Commerce at last gave the impulse to deep-sea exploration, which had before been lacking. The commercial world demanded a more speedy mode of communication from continent to continent, and the response came in the form of the submarine telegraph. Thousands of soundings were made to determine the best position in the ocean's bed for its successful laying, and thousands, again, to secure the broken end after the first failure. These soundings and grapplings brought from the sea-depths unmistakable proof that life in many varied and exquisite forms existed there, far away from light and vegetation, under an enormous pressure of superincumbent waters; and logic retired discomfited.

The fact that the Ægean Sea is empty of life in its greatest depths is due to local causes. The humblest life, in the farthest recesses of the ocean's bed, is, in some of its essential features, but a sluggish copy of the higher types on land. Food and air are alike necessary

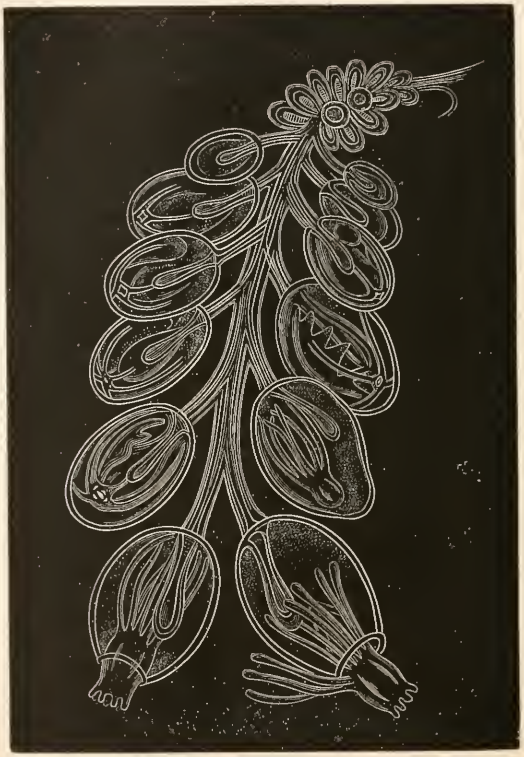

FIG. 4.—GENERATIVE BUDS OF TUBULARIA INDIVISA. (From Female Colony.)

to both. The circulation of currents throughout the open seas bears nutriment and oxygen to the lowly forms of animal life which lie far below the level penetrated by light, or capable of supporting vegetation. In the Mediterranean such currents are obstructed by the high rocky wall which runs under the straits of Gibraltar, from Spain to Africa. The lowest point in this wall is 10,000 feet above some portions of the bed of the Mediterranean. The currents in this sea are therefore superficial, as well as the life sustained by them.

Chemical analysis proves that the water of the open seas contains both organic matter in solution and oxygen; and that this same water, after having passed through the bodies of these lower forms of animal life, is deprived of both its organic elements and its oxygen. The theoretic difficulty which had determined the problem of life in the depths of the sea was thus removed; for, given this lowest form of animal existence, the higher are always possible.

The same awful cycle of life, death, decomposition, and life again, which is again and again repeated among the higher organisms, is found working itself out as inexorably in the oceanic depths. The elements which are appropriated from the mighty reservoir of the ocean for the maintenance of the life, are restored to it again by the death, of each organic being.

The bed of the ocean, from the tiny lakelets left by the retiring tide to the greatest depths ever reached by trawl and dredge, is found to be teeming with exquisite forms of life. Delicate plant-like forms are found clinging to rocks and shells, or spreading themselves over the broad fronds of the algæ. Every peculiarity of vegetation is mimicked; graceful stems rising from tangled roots send out branches which bear raceme-like clusters of buds, and delicate bells whose beauty no words can describe.

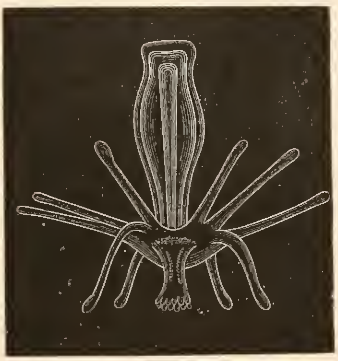

FIG. 5.—ROVING MEDUSA OF TUBULARIA INDIVISA. (Magnified.)

A hundred and fifty years ago nothing was known of these beautiful hydroids. The first investigation deserving the name was made by Abraham Trembley. This man was born in Geneva in the year 1700. While residing at the Hague, as tutor to the sons of Count de Bentinck, he made a series of remarkable observations upon the fresh-water hydra. The results of his observations were published first by Réaumur in 1742, and two years later by himself. In 1727 Peysonnel had paved the way for Trembley by proving the animality of the corals. Jussieu visited the coasts of Normandy to investigate the coral question, after Peysonnel's publication of his views, and there conclusively demonstrated the animality of *Tubularia indivisa*, one of the loveliest of the hydroid family. The hydroids are among the coral-makers. The vast beds of millepores found about the Pacific islands and the West Indies are the work of an animal allied to *coryne*, one of the Tubularians. The chitinous investment of the Sertularians also forms membranous coral of considerable size and great beauty. It was some time, however, after the discoveries of Peysonnel, Jussieu, and Trembley, before the great authorities of the day, Réaumur and Linnæus, gave in their adhesion to the animal theory, and stamped it as correct. Since that day some of the world's greatest naturalists have made the study of the *Hydroidæ* their life-work, and have not felt it an unworthy occupation to be the annalists of this humble family.

The nomenclature of the hydroids is still so unsettled that we will avoid as much as possible the use of scientific terms in describing the different portions of the colonies and their respective functions, for it is here that naturalists differ, not in the names of the varieties.

The hydroids measure from a few lines in height to several feet. Dana mentions an East Indian species which grows to the height of three feet; while Semper describes a gigantic *Plumularian*, which forms submarine forests extending over great areas of sea-bottom, and growing as high as six feet. The stems, he says, sometimes measure an inch in diameter at the base. *Tubularia indivisa* grows to the height of about ten inches.

The *Hydroidæ* are divided into four families: *Tubularinæ* (Figs. 3, 4, 5, 6), *Campanularinæ* (Fig. 10), *Sertularinæ* (Figs. 1, 7, 8, 9), and *Hydrinæ* (Fig. 12).

Every hydroid, however greatly the species may differ in external form, has a certain structural plan to which it adheres in all its modifications. The general type (Fig. 2.) may be simply described as an animal sac whose walls are composed of an inner and outer membrane. The outer wall corresponds to the skin, the inner to the lining of the stomach, in higher organisms. The simple elongated sac is not only the simplest form of hydroid, but is generally the earliest phase in the development of the more complicated forms.

The sac (Fig. 2) sends off branching processes, *e e*, and cœcal protuberances, *d*, throughout the extent of which the inner and outer membrane is continuous. Sometimes large numbers of these stems proceed from a basal net-work, the connection between every part of the animal colony being kept open through this basal reticulation, and the continuity of the two membranes being maintained intact. The basal portion, with the stems, branches, and the flower-and-fruit-like clusters, of this curious organism form the *hydrasoma*, as it is called by both Huxley and Allman.

The simple, sac-like form of the hydroid is the lowest term in a series which consists of an almost infinite number of terms. We find in this family the same orderly sequence which marks organic Nature everywhere. While the ideal type is adhered to, and a morphological unity may be proved, yet there is an orderly and beautiful gradation, in which each form becomes more complicated than the form which precedes it.

The clusters of buds (Fig. 4), and closed or open flowers (Fig. 3), are really individual zoöids, bound into an organic unity by a basal reticulation. With a single exception, every hydroid, at some period of its existence, lives this social life, being united with a number of other individuals into a plant-like group, and is really only one of an assemblage of zoöids possessing a common circulatory and nutritive system, the individuals of which are in organic union with each other.

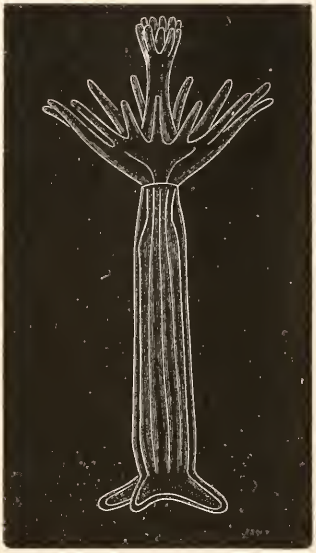

FIG. 6.—MEDUSA OF TUBULARIA INDIVISA. (After it has permanently fixed itself.)

The zoöids springing from one common base are of two kinds, and perform for the community two special offices. The grape-like clusters contain the generative elements, both ova and spermatozoa, while the flowers provide for the nutrition of the whole colony. These zoöids, which each investigator names according to his peculiar theory of scientific nomenclature, we will call nutritive and generative buds; the nutritive buds being destined for the preservation of the colony, the generative for the perpetuation of the species. The attached extremity of the animal in the fixed, or its equivalent in the free, species is called the proximal end, and the opposite extremity, which bears the two forms of buds, the distal end of the hydroid. The terms upper and lower cannot be used, because some varieties grow erect, while others grow in an inverted position.

The nutritive buds consist of an open digestive sac (Fig. 2);

around the mouth is a series or several series of tubular offsets, ranged radially about the stem. The shape of these blossom-like zoöids varies in the different species. In some varieties they are unprotected, while in others the tentacles may be withdrawn into a horny, cup-shaped sheath. The number of tentacles varies with the different species. The plates of *Tubularia indivisa* and *Hydra vulgaris* show the tentacles expanded. The other plates give, in the magnified portions, only the chitinous sheath, into which the polyp has withdrawn itself.

In the Plumularians, a branch of the Sertularian group, curious little cups of the horny sheath are developed. Unlike the cups which contain the living flower, these extensions are filled with the sarcode, or soft, gelatinous flesh of the animal. This sarcode, or protoplasmic flesh, acts like the flesh of the rhizopods and amœbæ; long filamentary processes are extended, just as the rhizopods improvise legs or arms when they need them, till sometimes the horny sheath is invested in this living gossamer. The function of these cups is not known. Allman considers them as special zoöids, whose morphological differentiation from the other zoöids is carried to an extreme. Hincks believes them to be a lower form of life, in organic union with the higher zoöids of the hydroid colony.

The horny sheath, which is described by earlier writers as an excretion, is by Allman considered to be rather the result of metamorphosis of tissue. In many varieties the stem and branches of the creature are slender, horny, and pipe-shaped, and the chitinous sheath is jointed at regular intervals, the joint being a mere break in the continuity of the chitine, not a movable hinge; while the living pulp within forms a continuous body, and is invested by its sheath as the pith of a plant is invested by its stalk.

The generative buds are cæcal offshoots from the body, the reproductive elements always developing between the inner and outer membrane (*see* Fig. 2, *d*). They sometimes, after development, free themselves from the parent stem, and lead a roving life as medusæ. In some cases the nutritive bud has its alimentary function suppressed, and, though not itself sexual, it is henceforth destined to produce sexual buds, either directly or through the medium of a non-sexual bud.

There is, it may almost be said, no differentiation of organs among the hydroids. In the adult form they possess no organs of sense, and have no circulatory, respiratory, nor nervous systems. All the functions of life are performed without the intervention of special organs. Voluntary motion takes place without muscles, sensibility is present without nerves, respiration is performed without lungs, and digestion goes on without a true stomach. The sea-water which flows within and about the creature bears to it the oxygen necessary to the maintenance of vital combustion, as well as the small living creatures and comminuted organic matter which form its food. Like the seaanemones, the hydroids reject such portions of their food as they do not assimilate through the mouth. In the fresh-water hydra an orifice has been observed at the lower extremity of the stomach. This, however, does not correspond to the alimentary canal of higher organisms; it is the analogue, in the simple hydra, of the ramifying cavity which permits a free circulation throughout the compound group.

A circulation has been observed in the varieties which possess a horny sheath, which is, however, very different in some respects from the circulation of the blood in higher organisms. The somatic fluid, as it is called, is loaded with granules which, upon microscopic examination, prove to be composed of disintegrated elements of food, of solid colored matter secreted by the walls of the somatic cavity, of cells detached from the living tissue of the animal, and of particles of effete matter. The fluid seems to be more nearly akin to chyme, or chyle, than it is to blood. There is perpetual motion in the somatic fluid; the flow will sometimes be steady for a while, and then a sudden reversal will take place in the direction of the current, before it has reached an extremity. The gastric cavity is traversed by the stream, as well as all portions of the hydrasoma. In some species the cause of the flow has revealed itself under the microscope. The cavities through which the current moves are seen to be clothed with cilia—tiny lashes whose rhythmic motion forever propels the fluid; this ciliary action is no doubt greatly aided by the contractility of the walls. In many species the cilia, if there be any, are too minute for detection; but it is a fair provisional inference that where

FIG. 7.—SERTULARINA CUPRESSINA. (Natural Size.)

the somatic flow is observed the like cause may account for the like effect.

The exquisite colors of the hydroids, which rival the tints of our loveliest flowers, are due to the colored granules secreted by the animal and discharged into the somatic fluid. A charm is added to these flowers of the sea by the flashing opalescent gleams of color which shine out from their crystalline walls. Even the exquisite representations of Allman, in his monograph on "The Tubularian Hydroids," fail to give an idea of the beauty of form and color to be found in the real object. The *Hydra viridis* is so called from its brilliant green color. This green is said by Allman to be of the nature of chlorophyll, and to possess the power, like the chlorophyll of plants, of decomposing carbonic acid, assimilating the carbon, and yielding up the oxygen. If this be true (and there is no reason to doubt it, Allman being one of the highest authorities), it only furnishes, in this form of animal life, one more curious resemblance to vegetation, and denies one more tradition of its animality.

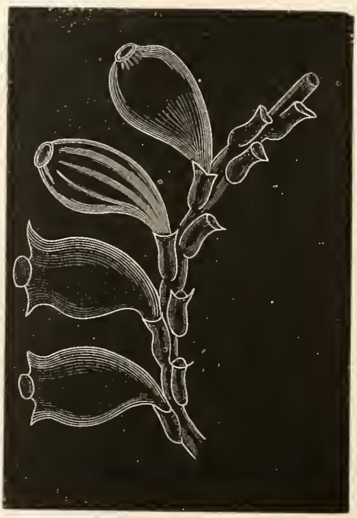

FIG. 8.—SERTULARINA CUPRESSINA. (Magnified.)

The most singular facts in connection with hydroid life lie in the variety of its modes of reproduction. It would almost seem as though every form of reproduction known in Nature had been mutely prophesied in the primeval world when the fossil hydroid and trilobite lived side by side in the Silurian seas.

They are generated, like plants, by buds and by artificial sections; like plants, they are able, from a small fragment, to produce the whole organism. They, however, go farther than most plants in this power of reproducing lost parts; for a small fragment taken from any portion will suffice for the production of a new individual; a single tentacle will produce a flower and stem, and finally a whole colony. A transverse section of the stem will produce a flower at the distal end, and a continuation of the stem, with the process by which it attaches itself, at the proximal end of the section. Just so far it shows orientation—that the stem has a distal and proximal end. There is no sign of bilaterality in most species, and in others the indication is so slight that it is hardly worthy of the name. This development of the flower always at the distal, and of the stem always at the proximal, extremity of the section, shows conclusively that the stem grows both ways, and that in every segment there exists a neutral plane midway between both ends.

Besides these plant-like modes of reproduction, hydroids are generated, like the actiniæ, by spontaneous fission, a development of one individual into two or more by a natural vertical cleavage.

They multiply by ova, by ovules, by independent ciliated embryos, like the lower invertebrates, the reptiles, and birds. Some varieties possess a sort of marsupial pouch, in which the undeveloped young

FIG. 9.—PLUMULARIA FALCATA. (Magnified.)

are retained till they attain maturity; and, like the mammals, in some cases, the individual quits the parent after attaining perfect development. Added to all these modes of reproduction, in which the analogy must not be pressed too closely to those of higher organisms, they possess two very curious modes of their own; one given by Allman in his monograph, the other by Carpenter in the latest edition of "The Microscope, and its Revelations." The *Tubularian* and *Campanularian hydroids*, Allman tells us, develop upon their stems bell-shaped medusæ (Figs. 4, 5, 11), which free themselves and swim the adjacent waters. All free-swimming medusæ have not yet been traced to hydroid stems; but, as all which have been carefully studied through their life-history are found to originate there, it is supposed to be true of the others.

The most remarkable fact in regard to these medusæ is, that the immature form shows a higher type, a greater differentiation of organs, than the parent hydroid. The medusa possesses, in common with the parent, a digestive cavity and cnidæ; and, in addition to these, an organ at the base of each tentacle, which, if it does not unite within itself the senses of sight and hearing, at least is akin to those organs in the lower invertebrates. They certainly possess distinct bundles of muscles and nerve-ganglia, which are not found in the parent form. When the roving medusa has sown its wild-oats, and comes to settle down into a respectable family hydroid, it loses all these advantages belonging to its wandering life, and becomes in its later form identical with the parent; it returns to the privileges and traditions of its fathers.

Fig. 10.—Campanularia dumosa. (Natural Size, and magnified.)

The huge *Rhizostoma*, and the beautiful *Chrysaora*, common to the English coast, Carpenter tells us, are oceanic medusæ developed from a small hydroid stem. The embryo emerges in the form of a ciliated ovule, resembling some of the infusoria. One end contracts, forms a foot and attaches itself, the other sends out four tubular offshoots, as tentacles, and "the central cells melt down to form the cavity of the stomach." This hydra-like form multiplies in the ordinary way by budding, for an indefinite length of time. After a while, however, a change takes place, the stem shows constrictions, beginning near the distal end, till the whole stem looks like a *rouleau* of coins; the constrictions deepen, making the stem look like a pile of saucer-shaped bodies; the disks become serrated, and finally the tentacles which belonged to the original medusæ disappear, and new tentacles are formed upon the uppermost disk of the pile. Soon this disk begins to show a sort of convulsive struggle which results in its freeing itself, and swimming away as a medusa; each disk develops in the same way, and in turn separates itself from the parent stem. The original zoöid often returns to its hydra-life and reproduces itself by budding in the old fashion, and finally becomes "the progenitor of a new colony, every member of which may in its turn bud off a pile of medusa-disks."

The bodies thus detached have all the characteristics of the fully-developed medusæ. Each consists of an umbrella-shaped disk divided along its margin into lobes, generally eight in number, and of a stomach terminating in a prosbosciform mouth. As the creature grows, the spaces between the marginal lobes fill up; from its border long tentacles are developed, and a fringe of tendril-like filaments sprout forth from the margin. The young medusa eats voraciously, and grows proportionately large; the *Chrysaora*, which we have been describing, attaining a diameter of fifteen inches, and the *Rhizostoma* sometimes reaching to three feet. These medusæ are familiarly known as *sea-nettles*. When they have reached full development the generative organs appear in four chambers arranged round the stomach, and are contained in curious fluted membranous ribbons which hold the sperm-cells in the male, and ova in the female. The fertilized embryos repeat the same wonderful cycle just described, developing into a hydroid from which medusa-disks are budded off.

The relation which late investigations have established between the stationary hydroids, and the medusæ, forms one of the most interesting cases, yet known, of the curious phenomenon called alternate generation. In the majority of cases we find a non-sexual, plant-like form interposed between the ovum and the directly or indirectly sexual form of medusa, though this is not always the case, as direct development has been observed from ovum to medusa.

The nearest approach, in the adult form, to special organs are the digestive cavity, and the cnidæ. The stomach, however, possesses no true parietal walls, and in one form—the fresh-water hydra—the stomach will do duty for the skin, and the skin for the stomach, if necessary; they seem to be able to live very comfortably, and digest their food without difficulty when turned wrong-side outward.

The cnidæ are barbed filaments inclosed in tiny sacs, which they can shoot out at will, for their own protection, or for the capture of their prey, as the case may be. In the hydra the sac is ejected, and a central dart is projected into the body attacked. There must be a minute poison-sac in communication with the darts, as it is found that any soft-bodied victim, released from the clasp of the tentacles, is invariably dead, no matter how short the time of its imprisonment may have been. The effects of the cnidæ in the medusæ are very well known, and have gained for them their popular name of sea-nettles. Many an unlucky swimmer has found himself wrapped in the long thread-like filaments of these transparent, floating bells, and been almost maddened as he found himself inextricably inclosed in what seemed an invisible sheet of living fire. A tentacle of the hydroid, when carefully pressed between two glass slides, or in a compressorium, may be seen, under the microscope, to dart out thousands of these little barbed arrows.

FIG. 11.—MEDUSA OF COROMORPHA NUTANS. (Magnified.)

Chronologically, the *Hydræ* (Fig. 12) come first in the group *Hydroidæ*, for they were first carefully studied and truly classified by Trembley. His observations, though made in the earlier half of the eighteenth century, were so accurate, and his delineations so correct, that he is still quoted in the latest works as authority. The hydra is found generally in fresh water, though some few species have been discovered, in this country, in that which is somewhat brackish. It loves still or slowly-running water, and attaches itself generally to the under-side of the leaves or to the stalks of aquatic plants. Its body is extremely contractile, and consists, like the oceanic hydroids,


FIG. 12.—HYDRA VULGARIS. (Natural Size.)

in its earliest stage of development, of a simple elongated sac, with an opening which answers the purpose of a mouth. Around the mouth are a series of hollow filaments which it can entirely withdraw, and it then looks like a minute tubercle. The tentacles are roughened by the clusters of thread-cells, or cnidæ, already described. The threads have been observed in some instances to be, when extended, as much as eight inches long, and are shot out, it is thought, by the propulsive power of a liquid injected into the central cavity. It grows erect, horizontal, or inverted, as the case may be, and lives only upon animal food. The little creatures are extremely voracious and not over-nice. Trembley observed two hydras attack, at the same time, the opposite extremities of a worm. Each having swallowed its respective half of the worm, he watched to see the result. The worm would not yield to the force of circumstances; and break, and the problem looked a difficult one of solution. The larger hydra, however, proved itself superior to circumstances, it quietly swallowed worm, antagonist, and all; and, after having sucked out the worm, disgorged his dinnerless foe!

Trembley tried the experiment, already alluded to, of turning one inside out, and fastening it in that position. The domestic economy did not appear to be at all disturbed; the little creature eating with as much relish, and digesting with as much ease, to all appearance, as in its normal position. He inserted one hydra within the cavity of another, and fastened them with a bristle which was run through both. Returning after a short absence he found them strung, side by side, upon the bristle. He repeated the experiment and watched the manœuvres of the two. The hydra inside managed to work its way through the small aperture made in the side of its neighbor by the bristle, and soon occupied the position he had before observed, side by side with its companion on the bristle. He then turned one of them inside out, inserted it in that position, and fastened them securely together. Soon the pair, finding that there was no help for it, philosophically yielded, and united their fortunes; the inner one of the couple providing nourishment for them both. They seemed to live quite comfortably, on these very close terms of intimacy, for some time.

Hydras generate in summer by buds, which grow to maturity and are then sloughed off. These young buds often produce others before they separate from the parent stem, and they others again; so that there are sometimes twenty generations produced in a month's time. In autumn oviform gemmules are extruded, lie quiescent till spring, and are then developed. Any number of artificial sections may be made, and from each a perfect animal will be developed. Wherever a wound or cut has been made, buds sprout more quickly than from the sound tissue, and the hydras generated by artificial sections are more prolific than those generated in the ordinary way. The sprouting, as may be seen in the plate (Fig. 12), takes place from any portion of the body. The leaves, flowers, and stems, of this specimen of *Hydra vulgaris*, together form the hydrasoma. This specimen was selected more to illustrate the plant-like character of the organism than for its intrinsic beauty.

The geographical distribution of the *Hydroidæ* has not yet been determined; but, like other low forms of life, we find them spreading over vast areas of space, and extending back through uncounted ages of time. We have already spoken of their distribution in depth. A well-defined specimen was taken up in the deepest cast recorded by Wyville Thomson, in his "Depths of the Sea"—that made in the Bay of Biscay, and to a depth of nearly three miles. But, though their existence is proved at these enormous depths, they love best the rock-bound pools left by the retiring tide and the shallow water which fringes our islands and continents; and there they probably attain their greatest beauty and most perfect development.

Their distribution in time reaches back to the earliest dawnings of life upon our globe. The *Graptolites* of the Lower and Upper Silurian, the *Hydroid Medusæ* of the Jurassic, the *Hydractinea* of the Cretaceous, Miocene, and Pliocene, the *Serturella* of the Pleistocene, and the numberless forms of the present day, are the representatives of this family in geologic and historic time.

Like other humble forms of life, it shows a marvelous persistency. It has lived, almost unchanged, while great dynasties of higher organisms have one after the other risen, developed, and perished, or left only a few meagre representatives among the fauna of the present day. The fragility of their chitinous envelope and the perishable nature of their protoplasmic flesh would, of course, render it impossible that any full record of their existence should ever be found in the rocks of the primeval would, but the fragments which have, here and there, left their impress on the various geologic strata, show them to have been the contemporaries of the oldest forms of life which inhabited the Silurian seas, and to have quietly existed in the depths of those ancient waters over which the great fish and saurian dynasties lorded it through so many centuries.

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## ORIGIN AND DEVELOPMENT OF ENGINEERING.[1]

BY SIR JOHN HAWKSHAW, F. R. S.

TO those on whom the British Association confers the honor of presiding over its meetings the choice of a subject presents some difficulty. The presidents of sections give accounts of what is new in their departments; and essays on science in general, though desirable in the earlier years of the Association, would be less appropriate to-day. Past presidents have discoursed on many subjects, on the mind and on things beyond the reach of mind, and I have arrived at the conclusion that humbler themes will not be out of place on this occasion. I propose to say something of a profession to which my life has been devoted—a theme which cannot stand as high in your estimation as in my own, but which I have chosen because I ought to understand it better than any other. I propose to say something on its origin, its work, and kindred topics.

[1] *Times's* summary of Inaugural Address at the Bristol Meeting of the British Association.

Rapid as has been the growth of the art of the engineer during the last century, we must, if we would trace its origin, seek among the earliest evidences of civilization. When settled communities were few and isolated, opportunities for the interchange of knowledge were scanty or wanting. The slowly accumulated results of the experience of a community were lost on its downfall. Inventions were lost and found again. The art of casting bronze over iron was known to the Assyrians, though it has only lately been introduced into modern metallurgy; and patents were granted in 1609 for processes connected with the manufacture of glass, which had been practised centuries before. An inventor in the reign of Tiberius devised a method of producing flexible glass, but the manufactory of the artist was totally destroyed in order to prevent the manufacture of copper, silver, and gold, from becoming depreciated.

In the long discussion which was held as to the practicability of making the Suez Canal, an early objection was brought against it that there was a difference of thirty-two and one-half feet between the level of the Red Sea and that of the Mediterranean. Laplace declared that such could not be the case, for the mean level of the sea was the same on all parts of the globe. Centuries before the time of Laplace the same objection had been raised against a project for joining the waters of these two seas. According to the old Greek and Roman historians, it was a fear of flooding Egypt with the waters of the Red Sea that made Darius, and in later times again Ptolemy, hesitate to open the canal between Suez and the Nile. Yet this canal was made and was in use some centuries before the time of Darius. Strabo tells us that the same objection, that the adjoining seas were of different levels, was made by his engineers to Demetrius, who wished to cut a canal through the Isthmus of Corinth some two thousand years ago. But Strabo dismisses at once this idea of a difference of level, agreeing with Archimedes that the force of gravity spreads the sea equally over the earth.

When knowledge in its higher branches was confined to a few, those who possessed it were called upon to perform various services for the communities to which they belonged; and we find mathematicians, and astronomers, painters, sculptors, and priests, called upon to perform the duties which now pertain to the profession of the architect and the engineer. As soon as civilization had advanced so far as to admit of the accumulation of wealth and power, then kings and rulers sought to add to their glory while living by the erection of magnificent dwelling-places, and to provide for their aggrandizement after death by the construction of costly tombs and temples.

The earliest buildings of stone to which we can assign a date, with any approach to accuracy, are the pyramids of Ghizeh. The genius for dealing with large masses in building did not pass away with the pyramid-builders in Egypt, but their descendants continued to gain in mechanical knowledge. The Romans, though they did not commonly use such large stones in their own constructions, carried off the largest obelisks from Egypt and erected them at Rome, where more are now to be found than remain in Egypt.

It has sometimes been questioned whether the Egyptians had a knowledge of steel. It seems unreasonable to deny them this knowledge. Iron was known at the earliest times of which we have any record. It is often mentioned in the Bible, and in Homer; it is shown in the early paintings on the walls of the tombs at Thebes; it has been found in quantity in the ruined palaces of Assyria; and in the inscriptions of that country fetters are spoken of as having been made of iron, which is also so mentioned in connection with other metals as to lead to the supposition that it was regarded as a base and common metal. The quality of iron which is now made by the native races of Africa and India is that which is known as wrought-iron. Dr. Percy says the extraction of good malleable iron, directly from the ore, "requires a degree of skill very far inferior to that which is implied in the manufacture of bronze." The supply of iron in India as early as the fourth and fifth centuries seems to have been unlimited. In the temples of Orissa iron was used in large masses as beams or girders in roof-work in the thirteenth century, and India well repaid any advantage which she may have derived from the early civilized communities of the West if she were the first to supply them with iron and steel. If we look still farther to the East, China had probably knowledge of the use of metals as soon as India, and, moreover, had a boundless store of iron and coal. A great future is undoubtedly in store for that country; but can the race who now dwell there develop its resources, or must they await the aid of an Aryan race? The art of extracting metals from the ore was practised at a very early date in this country. The Romans worked iron extensively in the Weald of Kent, as we assume from the large heaps of slag containing Roman coins which still remain there. Coal, which was used for ordinary purposes in England as early as the ninth century, does not appear to have been largely used for iron-smelting until the eighteenth century, though a patent was granted for smelting iron with coal in the year 1611. The use of charcoal for that purpose was not given up until the beginning of this century, since which period an enormous increase in the mining and metallurgical industries has taken place; the quantity of coal raised in the United Kingdom in 1873 having amounted to 127,000,000 tons, and the quantity of pig-iron to upward of 6,500,000 tons.

The early building energy of the world was chiefly spent on the erection of tombs, temples, and palaces. While in Egypt, as we have seen, the art of building in stone had 5,000 years ago reached the greatest perfection, so in Mesopotamia the art of building with brick, the only available material in that country, was in an equally advanced state some ten centuries later. The practice of building great pyramidal temples seems to have passed eastward to India and Burmah, where it appears in buildings of a later date, in Buddhist topes and pagodas; marvels of skill in masonry, and far surpassing the old brick mounds of Chaldea in richness of design and in workmanship. Egypt was probably far better irrigated in the days of the Pharaohs than it is now; and Lake Mœris, of which the remains have been explored by M. Linant, was a reservoir made by one of the Pharaohs, and supplied by the flood-waters of the Nile. It was 150 square miles in extent, and was retained by a bank or dam 60 yards wide and 10 high, which can be traced for a distance of 13 miles. This reservoir was capable of irrigating 1,200 square miles of country. No work of this class has been undertaken on so vast a scale since, even in these days of great works. The springs of knowledge which had flowed so long in Babylonia and Assyria were dried up at an early period; but Egypt remained the fountain-head whence knowledge flowed to Greece and Rome. The early constructive works of Greece, till about the seventh century B. C., form a strong contrast to those of its more prosperous days. Commonly called Pelasgian, they are more remarkable as engineering works than admirable as those which followed them were for architectural beauty. Walls of huge unshapely stones — admirably fitted together, however — tunnels, and bridges characterize this period. In Greece, during the few and glorious centuries which followed, the one aim in all construction was to please the eye, to gratify the sense of beauty; and in no age was that aim more thoroughly and satisfactorily attained.

In these days, when sanitary questions attract each year more attention, we may call to mind that twenty-three centuries ago the city of Agrigentum possessed a system of sewers, which on account of their large size was thought worthy of mention by Diodorus. This is not, however, the first record of towns being drained. The well-known Cloaca Maxima, which formed part of the drainage system of Rome, was built some two centuries earlier, and great vaulted drains passed beneath the palace-mounds of unburnt brick at Nimroud and Babylon, and possibly we owe the preservation of many of the interesting remains found in the brick-mounds of Chaldea to the very elaborate system of pipe drainage discovered in them and described by Loftus. While Pelasgian art was being superseded in Greece, the city of Rome was founded, in the eighth century before our era; and Etruscan art in Italy, like the Pelasgian art in Greece, was slowly merged in that of an Aryan race.

It would be impossible for me to do justice to even a small part of the engineering works which remain to this day as monuments of the skill, the energy, and ability, of the great Roman people. War, with all its attendant evils, has often indirectly benefited mankind. In the sieges which took place during the wars of Greece and Rome, the inventive power of man was taxed to the utmost to provide machines for attack and defense. The ablest mathematicians and philosophers were pressed into the service, and helped to turn the scale in favor of their employers. The world has to regret the loss of more than one who, like Archimedes, fell slain by the soldiery while applying the best scientific knowledge of the day to devising means of defense during the siege. The necessity for roads and bridges for military purposes has led to their being made where the stimulus from other causes was wanting; and means of communication and the interchange of commodities, so essential to the prosperity of any community, have thus been provided. Such was the case under the Roman Empire. So, too, in later times, the ambition of Napoleon covered France and the countries subject to her with an admirable system of military roads. So, again, in this country, it was the rebellion of 1745, and the want felt of roads for military purposes, which first led to the construction of a system of roads in it unequaled since the time of the Roman occupation. And lastly, in India, in Germany, and in Russia, more than one example could be pointed out where industry will be benefited by railways which have originated in military precautions rather than in commercial requirements.

But to return to Rome. Roads followed the tracks of her legions into the most distant provinces of the empire. Three hundred and seventy-two great roads are enumerated, together more than 48,000 miles in length, according to the itinerary of Antoninus. The water-supply of Rome during the first century of our era would suffice for a population of 7,000,000, supplied at the rate at which the present population of London is supplied. This water was conveyed to Rome by nine aqueducts; and in later years the supply was increased by the construction of five more aqueducts. Three of the old aqueducts have sufficed to supply the wants of the city in modern times. These aqueducts of Rome are to be numbered among her grandest engineering works. Time will not admit of my saying any thing about her harbor works and bridges, her basilicas and baths, and numerous other works in Europe, in Asia, and in Africa.

In the fourth and succeeding centuries the barbarian hordes of Western Asia, people who felt no want of roads and bridges, swept over Europe to plunder and destroy. With the seventh century began the rise of the Mohammedan power, and a partial return to conditions apparently more favorable to the progress of industrial art, when wide-spread lands were again united under the sway of powerful rulers. Still, few useful works remain to mark the supremacy of the Mohammedan power at all comparable to those of the age which preceded its rise.

A great building-age began in Europe in the tenth century, and lasted through the thirteenth. While the building of cathedrals progressed on all sides in Europe, works of a utilitarian character, which concern the engineer, did not receive such encouragement, excepting perhaps in Italy. In India, under the Moguls, irrigation works, for which they had a natural aptitude, were carried on during these centuries with vigor, and more than one emperor is noted for the numerous great works of this nature which he carried out.

It is frequently easier to lead water where it is wanted than to check its irruption into places where its presence is an evil, often a disaster. For centuries the existence of a large part of Holland has been dependent on the skill of man. How soon he began in that country to contest with the sea the possession of the land we do not know, but early in the twelfth century dikes were constructed to keep back the ocean. To the practical knowledge acquired by the Dutch, whose method of carrying out hydraulic works is original and of native growth, much of the knowledge of the present day in embanking, and draining, and canal-making, is due. While the Dutch were acquiring practical knowledge in dealing with water, and we in Britain, among others, were benefiting by their experience, the disastrous results which ensued from the inundations caused by the Italian rivers of the Alps gave a new importance to the science of hydraulics. Some of the greatest philosophers of the seventeenth century—among them Torricelli, a pupil of Galileo—were called upon to advise and to superintend engineering works; nor did they confine themselves to the construction of preventive works, but thoroughly investigated the condition pertaining to fluids at rest or in motion, and gave to the world a valuable series of works on hydraulics and hydraulic engineering, which form the basis of our knowledge of these subjects at the present day.

The impulse given to road-making in the early part of the last century soon extended to canals, and means for facilitating locomotion and transport generally. Tramways were used in connection with mines at least as early as the middle of the seventeenth century, but the rails were, in those days, of wood. The first iron rails are said to have been laid in this country as early as 1738, after which time their use was gradually extended, until it became general in mining districts. By the beginning of this century the great ports of England were connected by a system of canals; and new harbor-works became necessary, and were provided to accommodate the increase of commerce and trade, which improved means of internal transport had rendered possible. But it was not until the steam-engine, improved and almost created by the illustrious Watt, became such a potent instrument, that engineering works to the extent they have since been carried out became possible or necessary. But, while Watt had gained a world-wide, well-earned fame, the names of those men who have provided the machines to utilize the energies of the steam-engine are too often forgotten. Of their inventions the majority of mankind know little. They worked silently at home, in the mill, or in the factory, observed by few. Indeed, in most cases these silent workers had no wish to expose their work to public gaze. How long in the silent night the inventors of these machines sat and pondered ; how often they had to cast aside some long-sought mechanical movement and seek another and better arrangement of parts, none but themselves could ever know. They were unseen workers, who succeeded by rare genius, long patience, and indomitable perseverance.

More ingenuity and creative mechanical genius is perhaps displayed in machines used for the manufacture of textile fabrics than by those used in any other industry. It was not until late in historical times that the manufacture of such fabrics became established on a large scale in Europe. Linen was worn by the old Egyptians, and some of their linen mummy-cloths surpass in fineness any linen fabrics made in later days. The Babylonians wore linen also and wool, and obtained a wide-spread fame for skill in workmanship and beauty in design. In this country wool long formed the staple for clothing. Silk was the first rival, but its costliness placed it beyond the reach of the many. To introduce a new material or improved machine into this or other countries a century or more ago was no light undertaking. Inventors and would-be benefactors alike ran the risk of loss of life. Loud was the outcry made in the early part of the eighteenth century against the introduction of Indian cottons and Dutch calicoes. Until 1738, in which year the improvements in spinning-machinery were begun, each thread of worsted or cotton-wool had been spun between the fingers, in this and all other countries. Wyatt, in 1738, invented spinning by rollers instead of fingers, and his invention was further improved by Arkwright. In 1770 Hargreaves invented the spinning-jenny, and Crompton the mule in 1775, a machine which combined the advantages of the frames of both Hargreaves and Arkwright. In less than a century after the first invention by Wyatt, double mules were working in Manchester with over 2,000 spindles. Improvements in machines for weaving were begun at an earlier date. In 1579 a ribbon-loom is said to have been invented at Dantzic, by which from four to six pieces could be woven at one time, but the machine was destroyed and the inventor lost his life. In 1800 Jacquard's most ingenious invention was brought into use, which, by a simple mechanical operation, determines the movements of the threads which form the pattern in weaving. But the greatest improvement in the art of weaving was wrought by Cartwright's discovery of the power-loom, which led eventually to the substitution of steam for manual labor, and enabled a boy with a steam-loom to do fifteen times the work of a man with a hand-loom. For complex ingenuity few machines will compare with those used in the manufacture of lace and bobbin net. Hammond, in 1768, attempted to adapt the stocking-frame to this manufacture, which had hitherto been conducted by hand. It remained for John Heathcoat to complete the adaptation in 1809, and to revolutionize this branch of industry, reducing the cost of its produce to one-fortieth of what the cost had been before Heathcoat's improvements were effected. Time would fail me if I were to attempt to enumerate one tithe of these rare combinations of mechanical skill; and, indeed, no one will ever appreciate the labor and supreme mental effort required for their construction who has not himself seen them and their wondrous achievements.

Steamboats, the electric telegraph, and railways, are more within the cognizance of the world at large, and the progress that has been made in them in little more than one generation is better known and appreciated. It is not more than forty years since one of our scientific men, and an able one too, declared at a meeting of this Association that no steamboat would ever cross the Atlantic; founding his statement on the impracticability, in his view, of a steamboat carrying sufficient coal, profitably, I presume, for the voyage. Like most important inventions, that of the steamboat was a long time in assuming a form capable of being profitably utilized, and, even when it had assumed such a form, the objections of commercial and scientific men had still to be overcome. The increase in the number of steamboats since the time when the Sirius first crossed the Atlantic has been very great. Whereas in 1814 the United Kingdom only possessed two steam-vessels, of together 456 tons burden, in 1872 there were on the register of the United Kingdom 3,662 steam-vessels, of which the registered tonnage amounted to over a million and a half of tons, or to nearly half the whole steam tonnage of the world, which did not at that time greatly exceed three million tons. As the number of steamboats has largely increased, so also gradually had their size increased until it culminated in the hands of Brunel in the Great Eastern. A triumph of engineering skill in ship-building, the Great Eastern has not been commercially so successful. In this, as in many other engineering problems, the question is not how large a thing can be made, but how large, having regard to other circumstances, it is proper at the time to make it.

A distinguished member of this Association, Mr. Froude, has now for some years devoted himself to investigations carried on with a view to ascertain the form of vessel which will offer the least resistance to the water through which it must pass. So many of us in these days are called upon to make journeys by sea as well as by land that we can well appreciate the value of Mr. Froude's labors, so far as they tend to curtail the time which we must spend on our ocean-journeys; and we should all feel grateful to him if from another branch of his investigations, which relates to the rolling of ships, it would result that the movement in passenger-vessels could be reduced.

There is no more remarkable instance of the rapid utilization of what was at first regarded as a mere scientific idea than the adoption and extension of the electric telegraph. Those who read Odier's letter written in 1773, in which he made known his idea of a telegraph which would enable the inhabitants of Europe to converse with the Great Mogul little thought that in less than a century a conversation between persons at points so far distant would be possible. Still less did those, who saw in the following year messages sent from one room to another by Lesage in the presence of Frederick of Prussia, realize that they had before them the germ of one of the most extraordinary inventions among the many that will render this century famous. I should weary you were I to follow the slow steps by which the electric telegraph of to-day was brought to its present state of efficiency; but yet within how short a period of time has all the wonderful progress been achieved! How incredulous the world a few years ago would have been if then told of the marvels which in so short a space of time were to be accomplished by its agency! It is not long ago—1823—that Mr. (now Sir Francis) Ronald, one of the early pioneers in this field of science, published a description of an electric telegraph. He communicated his views to Lord Melville, and that nobleman was obliging enough to reply that the subject should be inquired into; but before the nature of Sir Francis Ronald's suggestions could be known, except to a few, that gentleman received a reply from Mr. Barrow that "telegraphs of any kind were then wholly unnecessary, and that no other than the one then in use would be adopted;" the one then in use being the old semaphore, which, crowning the tops of hills between London and Portsmouth, seemed perfection to the Admiralty of that day. The telegraphic system of the world comprises almost a complete girdle round the earth; and it is probable that the missing link will be supplied by a cable between San Francisco, in California, and Yokohama, in Japan. How resolute and courageous those who engaged in submarine telegraphy have been will appear from the fact that, though we have now 50,000 miles of cable in use, to get at this result nearly 70,000 miles were constructed and laid.

Of railways the progress has been enormous; but I do not know that in a scientific point of view a railway is so marvelous in its character as the electric telegraph. The results, however, of the construction and use of railways are more extensive and wide spread, and their utility and convenience brought home to a larger portion of mankind. The British Association is peripatetic, and without railways its meetings, if held at all, would, I fear, be greatly reduced in numbers. Moreover, you have all an interest in them; you all demand to be carried safely, and you insist on being carried fast. I shall not enter on a history of the struggles which preceded the opening of the first railway. They were brought to a successful issue by the determination of a few able and far-seeing men. The names of Thomas Gray and Joseph Sandars, of William James and Edward Pease, should always be remembered in connection with the early history of railways, for it was they who first made the nation familiar with the idea. There is no fear that the name of Stephenson will be forgotten, whose practical genius made the realization of the idea possible. Railways add enormously to the national wealth. More than twenty-five years ago it was proved, to the satisfaction of a committee of the House of Commons, that the Lancashire & Yorkshire Railway effected a saving to the public using the railway of more than the whole amount of the dividend which was received by the proprietors. These calculations were based solely on the amount of traffic carried by the railway and on the difference between the railway rate of charge and the charges by the modes of conveyance anterior to railways. No credit whatever was taken for the saving of time, though in England preëminently time is money. Considering that railway charges on many items have been considerably reduced since that day, it may be safely assumed that the railways in the British Islands now produce, or rather save to the nation, a much larger sum annually than the gross amount of all the dividends payable to the proprietors, without at all taking into account the benefit arising from the saving in time. The benefits under that head defy calculation, and cannot with any accuracy be put into money; but it would not be at all over-estimating this question to say that in time and money the nation gains at least what is equivalent to ten per cent. on all the capital expended on railways. It follows that, whenever a railway can be made at a cost to yield the ordinary interest of money, it is in the national interest that it should be made. Further, that, though its cost might be such as to leave a smaller dividend than that to its proprietors, the loss of wealth to so small a section of the community will be more than supplemented by the national gain, and therefore there may be cases where a government may wisely contribute in some form to undertakings which, without such aid, would fail to obtain the necessary support. And so some countries—Russia, for instance—to which improved means of transport are of vital importance, have wisely, in my opinion, caused lines to be made which, having regard to their own expenditure and receipts, would be unprofitable works, but in a national point of view are or speedily will be highly advantageous.

A question more important probably in the eyes of many—safety of railway-traveling—may not be inappropriate. At all events, it is well that the elements on which it depends should be clearly understood. It will be thought that longer experience in the management of railways should go to insure greater safety, but there are other elements of the question which go to counteract this in some degree. The safety of railway-traveling depends on the perfection of the machine in all its parts, including the whole railway, with its movable plant, in that term; it depends also on the nature and quantity of traffic; and, lastly, on human care and attention. With regard to what is human, it may be said that so many of these accidents as arise from the fallibility of men will never be eliminated until the race be improved. The liability to accident will also increase with the speed, and might be reduced by slackening that speed. It increases with the extent and variety of the traffic on the same line. The public, I fear, will rather run the risk than consent to be carried at a slower rate. The increase in extent and variety of traffic is not likely to receive any diminution; on the contrary, it is certain to augment. I should be sorry to say that human care may not do something, and I am not among those who object to appeals through the press and otherwise to railway companies, though sometimes perhaps they may appear in an unreasonable form. I see no harm in men being urged in every way to do their utmost in a matter so vital to many. It is practicable, by certain corrections of the official returns, to make some sort of comparison between the accidents in the earlier days of our own railways and the accidents occurring at a later date. I have endeavored to make these corrections, and I believe the results arrived at may be taken as fairly accurate. From the figures it appears that the passenger mileage has doubled between 1861 and 1873; and at the rate of increase between 1870 and 1873 it would become double what it was in 1873 in twelve years from that time—namely, in 1885. The number of passengers has doubled between 1864 and 1873, and at the rate of increase between 1870 and 1873 it would become double what it was in 1873 in eleven and a half years, or in 1885. Supposing no improvement had been effected in the working of railway-traffic, the increase of accidents should have borne some proportion to the passenger mileage, multiplied by the proportion between the train mileage and the length of line open, as the number of trains passing over the same line of rails would tend to multiply accidents in an increasing proportion, especially where the trains run at different speeds. The number of accidents varies considerably from year to year, but, taking two averages of ten years each, it appears that the proportion of deaths of passengers from causes beyond their control to passenger miles traveled in the ten years ending December 31, 1873, was only two-thirds of the same proportion in the ten years ending December 31, 1861. The limit of improvements will probably be reached before long, and the increase of accidents will depend on the increase of traffic, together with the increased frequency of trains. Up to the present time the improvements appear to have kept pace with the increase of traffic and of speed, as the slight increase in the proportion of railway accidents to passenger miles is probably chiefly due to a larger number of trifling bruises being reported now than formerly. I believe it was a former president of the Board of Trade who said to an alarmed deputation, who waited upon him on the subject of railway traveling, that he thought he was safer in a railway-carriage than anywhere else. If he gave any such opinion, he was not far wrong, as is sufficiently evident when it can be said that there is only one passenger injured in every four million miles traveled, or that, on an average, a person may travel 100,000 miles each year for forty years, and the chances be slightly in his favor of his not receiving the slightest injury.

A pressing subject of the present time is the economy of fuel. Members of the British Association have not neglected this momentous question. Many cases of waste arise from the existence of old and obsolete machines, of bad forms of furnaces, of wasteful grates, existing in most dwelling-houses; and these are not to be remedied at once, for not every one can afford, however desirable it might be, to cast away the old and adopt the new. In looking uneasily to the future supply and cost of fuel, it is, however, something to know what may be done even with the application of our present knowledge; and, could we apply it universally to-day, all that is necessary for trade and comfort could probably be as well provided for by one-half the present consumption of fuel; and it behooves those who are beginning to build new mills, new furnaces, new steamboats, or new houses, to act as though the price of coal which obtained two years ago had been the normal and not the abnormal price.

There was in early years a battle of the gauges, and there is now a contest about guns; but your time will not permit me to say much on their manufacture. Here, again, the progress made in a few years has been enormous, and in contributing to it, two men—Sir William Armstrong and Sir Joseph Whitworth, both civil engineers—in this country, at all events, deservedly stand foremost. Docks and harbors I have no time to mention, for it is time this long and, I fear, tedious address should close.

"Whence and whither" is the aphorism which leads us away from present and plainer objects to those which are more distant and obscure; whether we look backward or forward our vision is speedily arrested by an impenetrable veil. On the subject I have chosen you will probably think I have traveled backward far enough. I have dealt to some extent with the present. The retrospect, however, may be useful to show what great works were done in former ages. Some things have been better done than in those earlier times, but not all. In what we choose to call the ideal we do not surpass the ancients. Poets and painters and sculptors were as great in former times as now; so, probably, were the mathematicians. In what depends on the accumulation of experience we ought to excel our forerunners. Engineering depends largely on experience; nevertheless, in future times whenever difficulties shall arise, or works have to be accomplished for which there is no precedent, he who has to perform the duty may step forth from any of the walks of life, as engineers have not unfrequently hitherto done. The marvelous progress of the last two generations should make every one cautious of predicting the future. Of engineering works it may be said that their practicability or impracticability is often determined by other elements than the inherent difficulty in the works themselves. Greater works than any yet achieved remain to be accomplished—not, perhaps, yet awhile. Society may not yet require them; the world could not at present afford to pay for them. The progress of engineering works, if we consider it, and the expenditure upon them, has already in our time been prodigious. One hundred and sixty thousand miles of railway alone, put into figures at £20,000 a mile, amounts to £3,200,000,000 sterling; add 400,000 miles of telegraph at £100 a mile, and £100,000,000 more for sea-canals, docks, harbors, water and sanitary works constructed in the same period, and we get the enormous sum of £3,340,000,000 sterling expended in one generation and a half on what may undoubtedly be called useful works. The wealth of nations may be impaired by expenditure on luxuries and war; it cannot be diminished by expenditure on works like these.

As to the future, we know we cannot create a force; we can, and no doubt shall, greatly improve the application of those with which we are acquainted. What we called inventions can do no more than this, yet how much every day is being done by new machines and instruments! The telescope extended our vision to distant worlds. The spectroscope has far outstripped that instrument, by extending our powers of analysis to regions as remote. Postal deliveries were and are great and able organizations, but what are they to the telegraph? Need we try to extend our vision into futurity farther? Our present knowledge, compared with what is unknown even in physics, is infinitesimal. We may never discover a new force—yet, who can tell?

# INSECTIVOROUS PLANTS.

By E. R. LELAND.

MOST amateur botanists have in the course of their walks come upon the peculiar leaves of the common sundew (*Drosera rotundifolia*), with the clear drops which the leaves bear glistening in the morning sun, and, on referring to their manuals, have noted the relationship which it bears to Venus's fly-trap (*Dionæa muscipula*), whose famous irritability is always a matter for mention.

In collecting the showy side-saddle-flower (*Sarracenia purpurea*), they have, of course, observed that its curious, trumpet-shaped leaves are usually half-filled with water and drowned insects.

In fishing from the stagnant pools, the inconspicuous, yellow blossoms, and rootless capillary leaves of the bladderwort (*Utricularia vulgaris*), they have doubtless noticed how they swarmed with insects and small crustaceans; and have accepted, with that unhesitating faith which our whole system of education begets and fosters, the statement that the little bladders are filled with air, and that their function is to float the plant at the time of flowering.

Possibly they may have noticed that the sticky leaves of the butterwort (*Pinguicula vulgaris*) are sometimes strongly incurved.

If, observing these matters, they have given them but a passing thought; have failed to see the relation, or apprehend the motives of the phenomena; and are surprised some day by learning that they point to one of the most wonderful discoveries of modern biology—they need reproach themselves with no exceptional heedlessness or obtuseness, for they have the illustrious company of most of the famous botanists from Linnæus down to those of the present generation.

Some attention has recently been called to the carnivorous habits of what Dr. Hooker calls "our brother-organisms—plants," by the appearance in different scientific periodicals of some brief note, or paper, by occasional observers; and more generally by Prof. Gray's papers which appeared in the *Nation*, April, 1874, pp. 216, 232, in which he announced some of the facts that had been communicated by Mr. Darwin and others. Some of these statements must, it should be said, be modified in the light of later observations.

It has turned out, as so often it does, that some of the more obvious observations and conclusions were made and drawn long ago, and recorded only to be overlooked and forgotten. The subject has a history running back a century or more. It is of more than common interest, and has been well told by Dr. Joseph Hooker, in his address to the department of Zoölogy and Botany, British Association, Belfast, August, 1874. Much condensed, it is as follows:

*Dionæa.*—About 1768, Ellis, a well-known English naturalist, sent to Linnæus a drawing of a plant, to which he gave the poetical name of *Dionæa*. "The plant," wrote Ellis, "shows that Nature may have some views toward its nourishment in forming the upper joint of its leaf like a machine to catch food; upon the middle of this lies the bait for the unhappy insect that becomes its prey. Many minute red glands that cover its surface tempt the animal to taste them; and, the instant these tender parts are irritated by its feet, the two lobes rise up, grasp it fast, lock the rows of spines together, and squeeze it to death. And further, lest the strong efforts for life in the creature, just taken, should serve to disengage it, three small spines are fixed near the middle of each lobe, among the glands, that effectually put an end to its struggles. Nor do the lobes ever open again while the dead animal continues there. It is nevertheless certain that the plant cannot distinguish an animal from a vegetable or mineral substance; for, if we introduce a straw or pin between the lobes, it will grasp it fully as fast as if it were an insect."

This account, substantially correct, but erroneous in some particulars, led Linnæus to declare that, though he had seen and examined no small number of plants, he had never met with so wonderful a phenomenon. He was, however, too sagacious to accept Ellis's account of the *coup-de-grâce* which the insects received from the three stiff hairs in the centre of each lobe of the leaf. He was also unable to bring himself to believe that Nature intended the plant "to receive some nourishment from the animals it seizes," and he accordingly declared that, as soon as the insects ceased to struggle, the leaf opened and let them go. He only saw in these wonderful actions an extreme case of sensitiveness in the leaves; and he consequently regarded the capture of the disturbing insects as merely accidental, and of no importance to the plant.

Linnæus's authority caused his statements to be faithfully copied from book to book.

Sixty years after Linnæus wrote, an able botanist, the Rev. Dr. M. A. Curtis (who died in 1872), lived at Wilmington, North Carolina, the headquarters of this very local plant. In 1834 he published an account of it in the *Boston Journal of Natural History*, which is a model of accurate scientific observation. He said: "Each half of the leaf is a little concave on the inner side, where there are placed three delicate, hair-like organs, in such order that an insect can hardly traverse it without interfering with one of them, when the two sides suddenly collapse, and inclose the prey, with a force surpassing an insect's efforts to escape. The fringes of hairs on the opposite sides of a leaf interlace like the fingers of two hands clasped together. The sensitiveness resides only in these hair-like processes on the inside, as the leaf may be touched or pressed in another part without sensible effects. The little prisoner is not crushed and suddenly destroyed, for I have often liberated captive flies and spiders which sped away as fast as fear or joy could carry them. At other times, I have found them enveloped in a fluid of mucilaginous consistence which seems to act as a solvent, the insects being more or less consumed in it. This circumstance has suggested the possibility of their being made subservient to the nourishment of the plant through an apparatus of absorbent vessels in the leaves."

To Ellis belongs the credit of divining the purpose of the capture of insects by the *Dionæa*. But Curtis made out the details of mechanism by ascertaining the seat of the sensitiveness of the leaves; and he also pointed out that the secretion was not a lure exuded before the capture, but a true digestive fluid poured out like our own gastric juice after the ingestion of food. (Prof. Gray quotes Dr. Curtis's observations on the *Dionæa* in his "Genera of the Plants of the United States," vol. i., p. 196, 1849, without comment; and his plate of the plant does not show any of the important sensitive spines.)

The investigation of this curious question again rested until 1868, when it was taken up by Mr. Canby, who was then staying in the *Dionæa* district. He found that the leaf had the power of dissolving animal matter, and that small pieces of beef that were fed to it were completely dissolved and absorbed; the leaf opening again with a dry surface and ready for another meal, though with an appetite somewhat jaded. It not only could be surfeited, but it suffered from indigestion; and a meal of cheese disagreed with the leaves so seriously as finally to kill them.

Finally, Dr. Burdon-Sanderson has made an important contribution to this investigation, by demonstrating the correspondence between the electrical phenomena which accompany muscular action and those which are associated with the closing of the Dionæa-leaf. He has shown that, not alone in the electrical but in structural changes which ensue, the resemblance is complete between the contraction of muscle and that of the leaf; and, the further the inquiry is pursued, the more striking does the resemblance appear.

*Drosera.*—Unlike the preceding genus, which is confined to a single district, the sundews are widely distributed. The fact that they are closely related to the *Dionæa* was little known when the curious habits, which are now attracting so much attention, were first discovered.

Mr. Gardom, a Derbyshire botanist, gives an account of what his friend Mr. Whateley, an eminent London surgeon, made out in 1780: "On inspecting some of the contracted leaves we observed a small insect very closely imprisoned therein, which occasioned some astonishment as to how it happened to get into so confined a situation. Afterward, on Mr. Whateley's centrically pressing with a pin other leaves yet in their natural and unexpanded form, we observed a remarkably sudden and elastic spring of the leaves, so as to become inverted upward, and, as it were, encircling the pin, which evidently showed the method by which the fly came into its embarrassing situation."

This account, which is erroneous in representing the movement of the hairs as much more rapid than it really is, must have been written from memory.

In July of the preceding year (though the account was not published till two years afterward), Roth, in Germany, had remarked, in *Drosera rotundifolia* and *longifolia*, that "many leaves were folded together from the point toward the base, and that all the hairs were bent like a bow." Upon opening these leaves, he says: "I found in each a dead insect; hence I imagined that this plant, which has some resemblance to the *Dionæa muscipula*, might also have a similar moving power. . . . With a pair of pliers I placed an ant upon the middle of the leaf of *D. rotundifolia.* The ant endeavored to escape, but was held fast by the clammy juice at the points of the hairs, which was drawn out by its feet into fine threads. In some minutes, the short hairs on the disk of the leaf began to bend, and in some hours the end of the leaf was so bent inward as to touch the base. The ant died in fifteen minutes, which was before all the hairs had bent themselves."

These facts, established nearly a century ago, by the testimony of independent observers, have up to the present time been almost ignored.

More recently, however, they have been repeatedly verified: in Germany, by Nitschke, in 1860; in this country by L. A. Millington, a correspondent of the *American Naturalist*, April, 1868; by Mrs. Treat, of New Jersey, *American Journal of Science*, November, 1871, and *American Naturalist*, December, 1873; by Mr. A. W. Bennett, at the meeting of the British Association for the Advancement of Science, 1873.

It is noticeable that all of these observers unite in reporting one erroneous conclusion, namely, that the movements do not result when inorganic substances are placed upon the leaves. Darwin's experiments show that although the effect is not so great and the substances are not so long detained, yet such bodies as bits of cinder do possess the power of irritation.

Mrs. Treat also reported that, when a living fly was pinned at a distance of half an inch from the leaves of the *D. filiformis*, the leaves bent toward it and reached it in an hour and twenty minutes. Mr. Darwin was not only unable to obtain any similar results, but, to admit that this motion was any thing other than an accident, would compel him to adopt some other theory than the one he now holds to account for the transmission of the impulse to motion.

Reference may here be made to a remarkable statement in a note of M. Ziegler to the Paris Academy of Sciences, in 1872. He says: "In studying these remarkable plants, I noticed that all the albuminoid animal substances, if held for a moment between the fingers, acquired the property of making the hairs of the *Drosera* contract. I also observed that such substances, when they had not been in contact with a living animal, had no visible action on the hairs. This shows that the simple contact of the fingers communicates to inert animal substances a property which they did not possess before." Repeated experiments, in which every precaution was taken by Mr. Darwin, seem effectually to negative this extraordinary belief of M. Ziegler.

This, then, is a brief review of the subject up to the recent publication of Mr. Darwin's book upon it. It has for some time been known, to all who have followed the question, that he was engaged in researches that would one day be published, and they have been waiting for them with eager interest. With characteristic patience and caution, it is only after fifteen years of careful investigation that he puts forth the results of the long series of observations. As one reads the book, the most vivid impression made is by the wonderful amount of painstaking labor that the record of the experiments shows. Like the artist of Kouroo, he seems to have said to himself: "Time is an ingredient that enters into no perfect work; and my work shall be perfect in all respects, though I should do nothing else in my life." And, lo!

while the task which he set to himself was to answer the question, "Why the *Drosera* caught such numbers of insects," the result has been the most valuable contribution to botanical literature which this age has seen. Competent critics pronounce it more important than his works on the "Fertilization of Orchids," and the "Movements and Habits of Climbing Plants;" and in scientific research there is, for Mr. Darwin, no higher standard of comparison than to compare him with himself.

The greater part of the book is given to the record of observations on the phenomena shown by *Drosera rotundifolia*. This well-known plant bears from two or three to five or six leaves, generally extended more or less horizontally, but sometimes extending vertically upward. The shape and general appearance are shown, as seen from above, in Fig. 1:

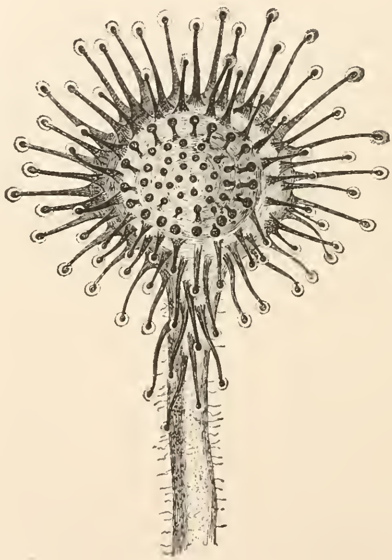

FIG. 1.—DROSERA ROTUNDIFOLIA.—Leaf viewed from above; enlarged four times.

The leaves are commonly a little broader than long; the whole upper surface being covered with gland-bearing filaments, or tentacles, as Mr. Darwin calls them, from their manner of acting.

A tentacle consists of a thin, straight, hair-like pedicel, carrying a gland on the summit. Each gland is surrounded by a large drop of extremely viscid secretion; they average about two hundred on each leaf, and as they glitter in the morning sun have given to the plant its poetical name. The tentacles on the central part of the leaf are short and stand upright, and their pedicels are green. Toward the margin they become longer and longer and more inclined outward, with their pedicels of a purple color. Those on the extreme margin project in the same plane with the leaf, or more commonly (*see* Fig. 2) are considerably reflexed.

If a small object be placed on the glands in the centre of the leaf, a motor impulse is transmitted to the marginal tentacles. The nearer ones are first affected, and then those farther off, until at last all are slowly but unerringly inflected, and close over the object. This takes place in from one to five or more hours; the difference in time de-

FIG. 2.—DROSERA ROTUNDIFOLIA.—Old leaf viewed laterally; enlarged about five times.

pending on several circumstances, as the size of the object and its nature; on the vigor and age of the leaf; whether it has lately been in action; and the temperature.

The tentacles in the centre do not become inflected when directly excited, though they are capable of inflection if excited by a motor impulse from other glands; but through and from them the motor impulse spreads gradually on all sides. Such is not the case with the marginal tentacles. If a bit of meat be placed on one of these it quickly transmits an impulse to its own bending portion, but never to those adjoining (*see* Fig. 5), for these are never affected until the meat has been carried to the central glands, which then radiate their conjoined impulse on all sides.

The sensitiveness of the leaves is located in the glands together with the immediately underlying cells of the tentacles. Though it is necessary that the glands should be touched, it is wonderful how slight a pressure will suffice. A bit of human hair $\frac{1}{50}$ of an inch in length and weighing only $\frac{1}{78740}$ of a grain will induce motion, transmit a motor impulse through the whole length of a marginal tentacle, and cause it to sweep through an angle of 180° or more. This minute morsel, it must be borne in mind, rests upon and is supported by the dense, viscid fluid which surrounds the gland, and the pressure is thus rendered inconceivably slight. Mr. Darwin conjectures that it may be less than the millionth of a grain. While the pressure may be extremely slight, it needs must be steady. A sharp, sudden brush of the tentacles does not induce inflection, nor do drops of water falling upon the glands from any height. This specialized nature of the sensitiveness may readily be seen to be of great use to the plant, effecting an economy of time and energy, for the process of inflection is slow and that of reëxpansion still slower, often occupying many hours, and even days. It should be mentioned that, when excited by soluble matter of the proper kind, not only the tentacles, but the disks, are inflected and close in about the object. There is thus formed out of the leaf a stomach; a comparison that Mr. Darwin has proved to be no fanciful one. Space will not permit giving even examples of his exhaustive experiments; to the book itself must be referred those who may doubt their thoroughness, or question the conclusions drawn from them.

Fig. 3.—Drosera rotundifolia.—Leaf (enlarged) with all the tentacles closely inflected.

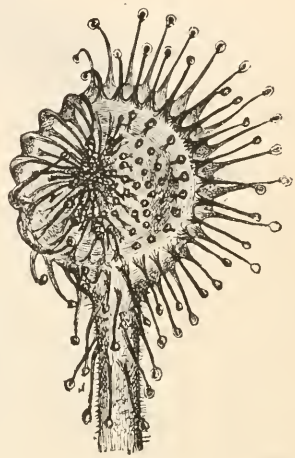

Fig. 4.—Drosera rotundifolia.—Leaf (enlarged) with the tentacles on one side inflected over a bit of meat.

It is proved that the leaves are capable of true digestion, and that the glands absorb the digested matter. The correspondence between the secretion of the *Drosera* and the gastric juice of animals is shown in that which it fails to digest as well as that which it succeeds in digesting. As is well known, the gastric juice contains an acid and a ferment, both of which are requisite for digestion; so it is with the secretion of *Drosera*. When the stomach of an animal is mechanically irritated, it secretes an acid; when bits of glass are put on the glands of *Drosera*, the secretion and that of the surrounding glands are increased in quantity and become acid. The stomach of an animal, however, does not secrete its proper ferment, pepsin, until certain substances called peptogenes are absorbed; matter must be absorbed by the glands of *Drosera* before they secrete their proper ferment. Like gastric juice, the secretion of *Drosera* has antiseptic properties. Meat is dissolved by each in the same manner and by the same stages. It promptly dissolves cartilage, a substance so little affected by water. It dissolves bone, and even the enamel of teeth. In short, there is no doubt that the ferment in both cases is closely similar if not identically the same, a fact in physiology which may well be called wonderful!

When it is considered where the plant grows—generally on extremely poor, peaty soil—it is evident that the supply of nitrogen would be quite deficient unless the plant had the power of obtaining this important element from captured insects, and we can thus understand how its roots are so poorly developed. These usually consist of only two or three slightly divided branches from half to one inch in length, furnished with absorbent hairs: it appears that they serve only to imbibe water, though, of course, they will absorb nitrogenous matter when supplied.

Confirmation of these statements is furnished by some experiments, concluded since the publication of Mr. Darwin's book, by Mr. Lawson Tait, an account of which he sends to *Nature*, July 29, 1875, p. 251. Only the results can be stated, and those briefly: "It is certain that the sundew not only absorbs nutriment by its leaves, but that it can actually live and thrive by their aid alone (that is, without the aid of roots); that nitrogenous matter is more readily absorbed by the leaves than by the roots, for over-feeding kills the plant sooner by the leaves alone than by the roots alone."

Mr. Tait also announces that from the secretion of *Drosera dichiotoma* he has been able to separate a substance closely resembling pepsin.

If a tentacle receives an impulse from its own glands the movement is always toward the centre of the leaf (Fig. 5).

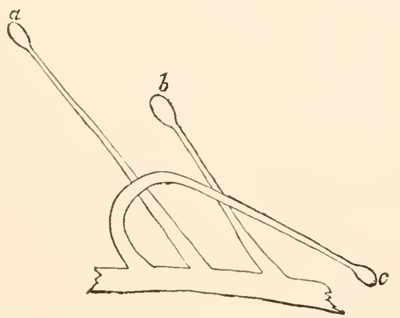


FIG. 5.—DROSERA ROTUNDIFOLIA.—Diagram showing one of the exterior tentacles closely inflected; the two adjoining ones in their ordinary position.

On the other hand, when the motor impulse comes from one side of the disk, the surrounding tentacles, including the short central ones, all bend with precision toward the point of excitement, wherever this may be seated. This is in every way a remarkable phenomenon; for the leaf falsely appears as if endowed with the senses of an animal (*see* Fig. 4).

In every case the impulse from a gland has to travel for at least a short distance to the basal part of the tentacle, the gland being carried solely by the inflection of the lower part. When the central glands are stimulated, and the extreme marginal tentacles become inflected, the motor impulse is transmitted across half the diameter of the disk. It passes not along the vascular system, but through the cellular tissue, traveling more rapidly and easily in a longitudinal than in a transverse line, probably for the reason that the cells are elongated longitudinally, and some obstruction is encountered at each cell-wall through which the motor impulse must pass.

A molecular change of the protoplasm within the cells, to which Mr. Darwin has given the name of aggregation, precedes and accompanies all motion. When a leaf which has not been excited or inflected is examined, the cells forming the pedicels are seen to be filled with an homogeneous purple fluid. If the tentacle be examined some hours after having been excited, the purple matter is found to be aggregated into masses of various shapes suspended in a colorless fluid. The change begins within the glands and travels downward, being arrested for a short time at each cell-wall; the aggregated masses perpetually changing form, separating and uniting. After the cause of the excitement has been removed, and the tentacles have reëxpanded, the colored masses of protoplasm are redissolved, and the purple fluid again becomes homogeneous and transparent. This process of aggregation is not dependent upon the inflection of the tentacles or increased secretion of the glands—a most remarkable feature of the phenomenon being that in the tentacles which are inflected by an indirect irritation, conveyed by motor impulse from other glands, some influence is sent up to the glands, as their secretion is increased and becomes acid; then the glands thus excited send back some other action, causing the protoplasm to aggregate in cell beneath cell. There can actually be seen a molecular change proceeding, which may be somewhat similar to the molecular change which is supposed to be sent from one end of a nerve to another when sensation is felt. We have here a reflex action, and the only known case thereof in the vegetable kingdom. The rate at which the motor impulse is transmitted is much slower than in animals. This fact, as well as that of the motor impulse not being specially directed to certain points, are both, no doubt, due to the absence of nerves. Nevertheless, we perhaps see the prefigurement of the formation of nerves in animals in the transmission of the motor impulse being much more rapid down the confined space within the tentacles than elsewhere, and somewhat more rapid in a longitudinal than in a transverse direction across the disk.

Of course, there is not in this, or in the reflex action, any thing comparable with the nervous systems of animals, and, as Mr. Darwin says, "the greatest inferiority of all is the absence of a central organ, able to receive impressions from all points, to transmit their effects in any definite direction, to store them up and reproduce them." That is to say, *Drosera* seems to be without even the prefigurement of a brain, and we can almost fancy that we detect a trace of disappointment or regret in this admission.

A wide range of experiment shows that probably all the species of *Drosera* are adapted for catching and digesting insects by nearly the same means, though not with equal development or completeness.

*Dionæa muscipula.*—The form of the bilobed leaf which is the most wonderful feature of this wonderful plant, already described, may be seen from the accompanying sketch.

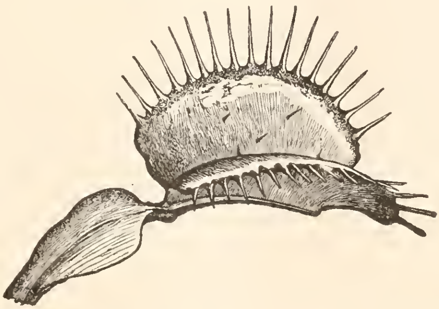

FIG. 6.—DIONÆA MUSCIPULA.—Leaf viewed laterally in its expanded state.

In the *Dionæa* the locality of sensitiveness is the three filaments which appear on each half of the upper surface of the leaf. It is unlike *Drosera* in that the filaments are sensitive to sudden impact, the transmission of the impulse is more rapid and the consequent movement instantaneous. Another point of unlikeness consists in the power of secretion of the glands, those of *Dionæa* being only excited by the absorption of nitrogenous matter. When any substance comes in contact with the filaments, the lobes of the disk close instantly upon it, confining it in a concave chamber; if the imprisoned matter be nitrogenous the lobes are gradually pressed closer together, the glands secrete freely and reëxpansion takes place only after from nine to twenty-four days, when nearly all trace of the substance will have disappeared, and sensitiveness is lost, only to reappear after some time has elapsed, if at all. If, however, the closing is the result of sudden impact or of the contact of a non-nitrogenous substance, the leaf shortly opens again and is at once sensitive, the glands showing no signs of secretion. The constitution and action of the secretion are identical with those of *Drosera*, as is probably the manner of transmission of the motor impulse. But want of space again excludes many interesting details.

*Aldrovanda*, *Drosophyllum*, *Roridula*, and *Byblis*, four other genera of the same order, all are provided with secreting glands and seem to have similar powers, though in a lesser degree.

Mr. Darwin was also led to investigate the habits of *Pinguicula* *vulgaris*, the result being to establish beyond question the predatory practices of the bladderwort, a plant which had hitherto enjoyed a good name.

It is not provided with any irritable filaments, the sensitiveness residing in the surface of the leaf, which is set with two kinds of glandular hairs secreting an extremely viscid fluid which seems to be the only agent for entrapping the insects. When once caught they are detained by the slowly-inflecting leaf. Here, too, contact with nitrogenous bodies changes the nature of the secretion, so that it becomes

FIG. 7.—PINGUICULA VULGARIS.—Outline of leaf with left margin inflected over a row of small flies.

FIG. 8.—PINGUICULA VULGARIS.—Outline of leaf, with right margin inflected against two square bits of meat.

capable of dissolving and digesting insects and other nutritious substances, when the secretion and the digested matter are reabsorbed by the glands. When the objects are too large to be inclosed by the inflected leaf, they are by its incurving pushed along over the surface, constantly coming in contact with fresh and hungry glands, subserving the needs of the plants as well as by the other method (*see* Fig. 8).

*Utricularia neglecta and U. vulgaris* (*common Bladderwort*).—It will be a new revelation to most readers to be told that the bladders of this plant are not, as the manuals have always stated, filled with air and intended to float the plant, but that their real use is to capture small aquatic animals, which they do on a large scale.

The general appearance of a bladder is shown in the figure (10) given below. The lower side is straight, the other surface convex and terminating in two long prolongations bearing six or seven long pointed bristles. The prolongations are called antennæ, for, as Mr. Darwin says, "the whole bladder curiously resembles the entomostracean crustacea" upon which they prey so freely.

Under these antennæ, where the bladder is slightly truncated, is situated the most curious and important part of the whole structure, namely, the entrance and valve.

The valve is attached on all sides to the bladder, excepting by its posterior margin, which is very thin, and rests on a collar or rim, which dips deeply into the bladder. The valve can only open in-

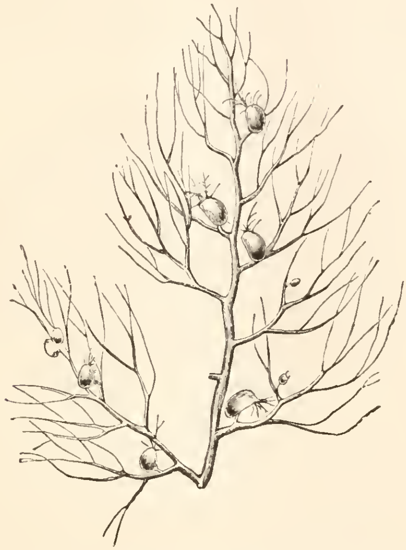

FIG. 9.—UTRICULARIA NEGLECTA.—Branch with the divided leaves bearing bladders; about twice enlarged.

ward; there are on its surface numerous glands, which have the power of absorption, but are not known to secrete.

The whole inner surface of the bladder is covered with a serried mass of processes, consisting each of four divergent arms, whence they

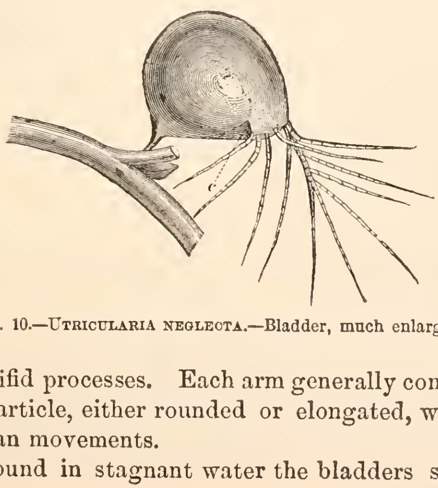

FIG. 10.—UTRICULARIA NEGLECTA.—Bladder, much enlarged.

are called quadrifid processes. Each arm generally contains a minute, faintly-brown particle, either rounded or elongated, which shows incessant Brownian movements.

Whenever found in stagnant water the bladders swarm with insects, crustaceans, larvæ, and fresh-water worms, in various stages of decay. The animals enter the bladder by bending in the free edge of the valve, which shuts again instantly. How it is that such weak and minute animals get into the bladders is not yet understood, but they do succeed in entering as do inanimate objects, if laid upon the valve. The locality of the irritability, if indeed there be any, is not determined.

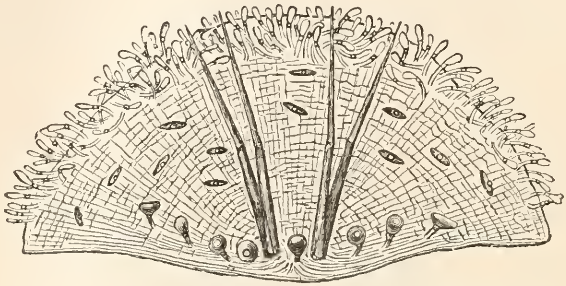

FIG. 11.—UTRICULARIA NEGLECTA.—Valve of bladder, greatly enlarged.

Notwithstanding the elaborate mechanism for the capture of animal food, there seems to be no power of digesting it, nor for hastening its decay; although, when decomposition sets in, its products are slowly absorbed by the quadrifid processes; at least, these processes from bladders containing decayed animals generally show masses of spontaneously-moving protoplasm which do not appear in those taken from clean bladders.

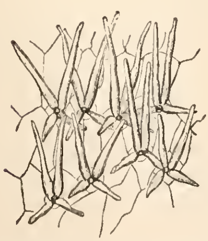

FIG. 12.—UTRICULARIA NEGLECTA.—Small portion of inside of bladder, much enlarged, showing quadrifid processes.

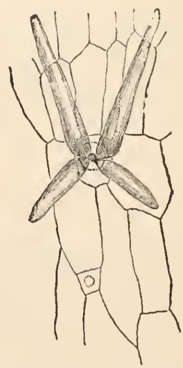

FIG. 13.—UTRICULARIA NEGLECTA.—One of the quadrifid processes greatly enlarged.

Investigations were extended to many other species of *Utricularia*, with results showing, in all cases, an adaptation for capturing small animals and power to absorb the products of their decay.

To be classed with this genus, as being insectivorous to a similar extent, are *Sarracenia* and *Darlingtonia*. Upon these Mr. Darwin records no observations.

*Sarracenia variolaris* has, however, had its powers carefully investigated by Dr. Mellichamp, of Bluffton, South Carolina. This species differs from the common Northern one (*S. purpurea*) chiefly in having a lid which closes over the mouth of the trumpet-shaped leaves, so that rain can not readily enter. The leaves are usually half-filled with a fluid which Dr. Mellichamp is satisfied is secreted at the bottom of the tubes. He describes it as mucilaginous, and leaving in the mouth a peculiar astringency. In it meat decomposes more rapidly than in water, and he concludes that as the leaves when stuffed with insects become most disgusting in odor, we have to do with an accelerated decomposition, though not with digestion. He attributes anæsthetic effects to the fluid. The lure which brings the insects to the mouth of the pitcher is a honey-baited pathway running from the ground along the broad wing of the pitcher to its mouth, up which the insects are lured to their fate. Nothing of this kind is observed in *S. purpurea*, and its exposed mouth is so placed that rain must fall into it. It is not probable, as Dr. Hooker says, that pitchers presenting such differences should act similarly, and he adds: "The fact that insects normally decompose in the fluid of all would suggest the probability that all feed on the products of decomposition; but as yet we are ignorant whether the glands within the pitchers are secretive or absorptive, or both; if secretive, whether they secrete water or a solvent; if absorptive, whether they absorb animal matter or the products of decomposition."

Prof. C. V. Riley (American Association for the Advancement of Science, 1874) is of opinion that the only benefit to the plant is from the liquid manure.

But this fascinating subject cannot be pursued further.

Sentimental flower-worshipers, fond of quoting the pretty metaphor of their buds and blossoms being "truly the language of angels," will doubtless be pained to learn that they are not all ethereal creatures subsisting on such lovely foods as dew and sunlight, but that they are at times given to dining off the more substantial fricassees which their alert tentacles know so well how to prepare. And although they may consign the sanguinary *Droseras* and *Dionæas* to the limbo of the unclean, and turn with renewed admiration to their own floral pets, still the matter does not end here. Mr. Darwin throws out some dark hints as to the private lives of the immaculate *Primula*, the brilliant *Pelargonium* and other greenhouse favorites, that must lead the thoughtful mind to conclude that that they will at least bear watching.

Seriously, these revelations afford abundant food for thought. There are three remarkable powers connected with the phenomenon: the movement of the leaves when excited; the secreting of a digestive fluid; the absorption of digested matter. The species possessing them all hold them in different degree; some possess two and others but one of them. What light can natural selection throw upon the steps by which these wonderful powers were gradually acquired? is one of the problems presented to the evolutionist.

Mr. Darwin submits his work wonderfully advanced when compared with the state in which he found it, but there remains much to be done.

# INDUCED DISEASE FROM THE INFLUENCE OF THE PASSIONS.[1]

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

MANY of the forms of disease previously detailed may be induced by other causes than worry or mental strain. They may be the effects of the unrestrained influence of certain of the passions. I say certain of the passions, because all do not seem to act with the same intensity. Some of them act with a sharpness of intensity that is peculiar, while others apparently excite no physical injury.

The passions which act most severely on the physical life are anger, fear, hatred, and grief. The other passions are comparatively innocuous. What is called the passion of love is not injurious until it lapses into grief and anxiety; on the contrary, it sustains the physical power. What is called ambition is of itself harmless; for ambition, when it exists purely, is a nobility lifting its owner entirely, from himself into the exalted service of mankind. It injures when it is debased by its meaner ally, pride; or when, stimulating a man to too strenuous efforts after some great object, it leads him to the performance of excessive mental or physical labor and to the consequences that follow such effort.

The passion called avarice, according to my experience, tends rather to the preservation of the body than to its deterioration. The avaricious man, who seems to the luxurious world to be debarring himself of all the pleasures of the world, and even to be exposing himself to the fangs of poverty, is generally placing himself in the precise conditions favorable to a long and healthy existence. By his economy, he is saving himself from all the worry incident to penury; by his caution he is screening himself from all the risks incident to speculation or the attempt to amass wealth by hazardous means; by his regularity of hours and perfect appropriation of the sunlight, in preference to artificial illumination, he rests and works in periods that precisely accord with the periodicity of Nature; by his abstemiousness in living he takes just enough to live, which is precisely the right thing to do according to the rigid natural law. Thus, in almost

[1] From advance sheets of a new work in press of D. Appleton & Co., entitled "The Diseases of Modern Life."

every particular, he goes on his way freer than other men from the external causes of all the induced diseases, and better protected than most men from the worst consequences of those diseases which spring from causes that are uncontrollable.

I do not hold up this picture as an encouragement to avarice, for an avaricious world would truly be a sad one. "But there is a soul of goodness in things evil, would men observingly distill it out," and, certainly, much goodness might be observed even in the perverted passion of avarice, if reckless and over-generous men would condescend to the distillation.

Some of the most extreme instances, at all events, nay, the most typical instances, of longevity with perfect physical health that I have met with, have been in those who are tinctured practically with the passion under consideration. It is true some have not been happy, and none eminently useful; but to the physiological mind they present a remarkable picture of the endurance of health and life under what are nearest to the natural conditions necessary for both. They suggest that if with this physical standard a higher and nobler mental development could be attained, with art and science and benevolent labors as the pleasures added to the life, the approach to perfection of existence would be closely realized, and the age, not of the man only but of the world of life to which he belongs, would be more thoughtfully conserved.

Of the passions I have enumerated as most detrimental to life, anger stands first. He is a man very rich indeed in physical power who can afford to be angry. The richest cannot afford it many times without insuring the penalty, a penalty that is always severe. What is still worse of this passion is, that the very disease it engenders feeds it, so that if the impulse go many times unchecked it becomes the master of the man.

The effects of passion are brought out entirely through disturbance in the organic nervous chain. We say a man was "red" with rage, or we say he was "white" with rage, by which terms, as by degrees of comparison, we express the extent of his fury. Physiologically we are then speaking of the nervous condition of the minute circulation of his blood: that "red" rage means partial paralysis of minute blood-vessels: that "white" rage means temporary suspension of the action of the prime mover of the circulation itself. But such disturbances cannot often be produced without the occurrence of permanent organic evils of the vital organs, especially of the heart and of the brain.

The effect of rage upon the heart is to induce a permanently perverted motion, and particularly that perverted motion called intermittency. One striking example, among others of this kind which I could name, was afforded me in the case of a member of my own profession. This gentleman told me that an original irritability of temper was permitted, by want of due control, to pass into a disposition of almost persistent or chronic anger, so that every trifle in his way was a cause of unwarrantable irritation. Sometimes his anger was so vehement that all about him were alarmed for him even more than for themselves, and when the attack was over there were hours of sorrow and regret, in private, which were as exhausting as the previous rage. In the midst of one of these outbreaks of short, severe madness, he suddenly felt, to use his own expression, as if his "heart were lost." He reeled under the impression, was nauseated and faint: then, recovering, he put his hand to his wrist, and discovered an intermittent action of his heart as the cause of his faintness. He never completely rallied from that shock, and to the day of his death, ten years later, he was never free from the intermittency. As a rule he was not conscious of the intermittency unless he took an observation on his own pulse, as though he were apart from himself: but occasionally after severe fatigue he would be subjectively conscious of it, and was much distressed and depressed. "I am broken-hearted," he would say, "physically broken-hearted." And so he was: but the knowledge of the broken heart tempered, marvelously, his passion, and saved him many years of a really useful life. He died ultimately from an acute febrile disorder.

The effect of anger upon the brain is to produce first a paralysis, and afterward, during reaction, a congestion of the vessels of that organ; for, if life continues, reactive congestion follows paralysis as certainly as day follows night. Thus, in men who give way to violent rage there comes on, during the acute period, what to them is merely a faintness, which, after a time of apparent recovery, is followed by a slight confusion, a giddiness, a weight in the head, a sense of oppression, and a return to equilibrium. They are happy who, continuing their course, suffer no more severely. Many die in one or other of the two stages I have named. They die in the moment of white rage, when the cerebral vessels and heart are paralyzed. Then we say they die of faintness, after excitement. Or, they die more slowly when the rage has passed and the congestion of reaction has led to engorgement of the vessels of the brain. Then the engorgement has caused stoppage of the circulation there; or a vessel has given way; or serous fluid has exuded, producing pressure, and we report that the death was from apoplexy, following upon some temporary excitement.

Hatred, when it is greatly intensified, acts much like anger in the effects it produces. The phenomena differ in that they are less suddenly developed and more closely concealed; they very rarely, in fact, come under the cognizance of the physician unmixed with other phenomena. They are made up of the symptoms of suppressed anger with morose determination, and they keep the sufferer from rest. He is led to neglect the necessities of his own existence; he is rendered feverish and feeble; and at last he either sinks into chronic despondency and irritability, or rushes hastily to the performance of some act which indicates disordered mind.

The effects of fear are all but indentical with those of rage, and like rage grow in force with repetition. The phenomena are so easily developed in the majority of persons, they may actually be acquired by imitation, and may be intensified and perhaps induced by listening to the mere narratives of events which act as causes of fear. I am daily more and more convinced that not half the evils resulting from what may be called the promptings of fear in the young and the feeble are duly appreciated, and that fear is the worst weapon of physical torture the thoughtless coward wields. The organs upon which fear exerts its injurious influence are, again, the organic nervous chain, the heart, and the brain.

Permanent intermittency of the heart is one of the leading phenomena incident to sudden and extreme terror. One example, sufficiently characteristic, will illustrate this fact:

A gentleman of middle age was returning home from a long voyage in the most perfect health and spirits, when the vessel in which he was sailing was struck from a collision, and, hopelessly injured, began to sink. With the sensation of the sinking of the ship and the obvious imminence of death—five minutes was the longest expected period of remaining life—this gentleman felt his heart, previously acting vehemently, stop in its beat. He remembered then a confused period of noise and cries and rush, and a return to comparative quiet, during which he discovered himself being conveyed, almost unconsciously, out of the sinking vessel on to the deck of another vessel that had rendered assistance. When he had gained sufficient calmness he found that periods of intermittent action of his heart could be counted. They occurred four and five times in the minute for several days, and interfered with his going to sleep for many nights. On reaching land the intermittency decreased, and when the patient came to me, soon afterward, there were not more than two intermittent strokes in the minute, all the intervening strokes being entirely natural and the action of the heart and the sounds of it being simply perfect. In this gentleman the intermittent pulse became a fixed condition, but so modified in character that it was endurable. At his last visit to me he was not conscious of the symptom except he took it objectively from himself, by feeling his own pulse or listening to his own heart.

The effect of fear on the brain may be to the extent of that which is produced by extremity of rage, so that even sudden death, from syncope, may ensue. I have known two such instances as these, but the more common effect is an intense irritability, followed by doubt, suspicion, and distrust, leading toward or to insanity. From a sudden terror deeply felt the young mind rarely recovers, never, I believe, if hereditary tendency to insanity be a part of its nature. A man, who is now the inmate of an asylum, owing to fixed delusions that all his best friends are conspiring to injure and kill him, explained to me, before his delusion was established, from what it started. When he was a boy he had a nervous dread of water, and his father, for that very reason, and with the best of intentions, determined that he should be taught to swim. He was taken by his tutor, in whom he had every confidence, to the side of a river, and when he was undressed he suddenly found himself cast by his instructor, without any warning, into the stream. No actual danger of drowning was implied, for the tutor himself was at once in the water to hold him up or to bring him to land; but the immediate effect, beginning with the faintness of fear, was followed by vomiting, by a long train of other nervous symptoms, by constant dread that some one was in some way about to repeat the infliction, by frequent dreaming of the event by night, by thinking upon it in the day. At last all the phenomena culminated in that breach between the instinctive and the reasoning powers which we, for want of a better term, call dangerous and insane delusion.

The effect of grief varies somewhat according to the suddenness or slowness with which it is expressed. Sudden grief tells chiefly upon the heart, leading to irregular action, and to various changes in the extreme parts of the circulation incidental to such irregularity. Under sudden impulse of grief I have known singular local manifestations of disease, as for instance the development of a *goître;* an hæmoptysis or loss of blood from the lungs; a local paralysis of the lip and tongue; a failure of sight.

When the grief is less sudden and more prolonged, want of power and intermittency of the circulation are again the most common phenomena. They are most easily developed in women, but I have seen them occur even in men of strong habit but sensitive feeling. Thus a gentleman whom I know well, and who suffers in the way I describe, tells me that he first became conscious of the intermittency in the action of his heart, upon the anxiety he felt from the loss of one of his brothers, to whom he was deeply attached and for whose superior talents he had, as indeed many others had, a profound admiration. The attacks at first were so severe that they created in his mind some alarm; but in course of time he became accustomed to them, and the sense of fear passed away. The intermittency in this instance alternated with periods in which there was very slight interruption of natural action. During the more natural periods there was, however, an occasional absence of stroke once in two or three hundred beats, but the fact was not evident to the subject himself. When the extreme attacks were present the intermittency of pulse occurred six or even seven times in the minute, and the fact, which was subjectively felt, was very painful. The stomach at the same time was uneasy, there were flatulency and a sensation of sinking and exhaustion. In the worst attacks there was also some difficulty in respiration, and a desire for more capacity for air, but unattended by spasm or acute pain. A severe attack was induced readily by any cause of disturbance, such as broken rest or mental excitement; on the other hand, rest and freedom from care seemed to him curative, for a time.

In this gentleman another symptom was presented for one or two years, which is somewhat novel, and exceedingly striking. The symptom was this: When the intermittent action of the heart was at its worst, there came on in the fingers of one or other hand a sensation of coldness and numbness, followed instantly by quick blanching of the skin, precisely the same appearance, in fact, as is produced when the surface of the body is frozen. The numbness and temporary death of the parts would often remain for a full hour, during which time the superficial sensibility was altogether lost. When recovery commenced in the fingers it was very rapid, and after recovery no bad results were ever noticeable. I have since seen one similar illustration in another individual, occurring under nearly similar circumstances.

From the irregularity of the circulation of the blood induced by prolonged grief, varied central phenomena in the nervous matter follow, and in persons who have passed middle life these phenomena are usually permanent if not progressive. They consist of organic feebleness extending to all the active organs of the body, and affecting specially the mental organism. A constant desire for rest, for avoidance of cares, for seclusion, mark this stage of disease, if so it may be called. It is not necessarily a stage leading to rapid failure of further physical or mental power, for the mind and body are subdued so equally that there is no galling irritability, no wearing depression from the influence of other passions. The worst that happens ultimately in those instances is the gradual but premature encroachment of dementia previous to death, if the life be prolonged to its natural term.

Under some circumstances the passions, excited in turn, injure by the combined influence of their action. In games of chance where money is at stake we see the play of the worst passions in all its mischievous intensity. Fear and anger, hate and grief, hope and exultation, stand forth, one after the other, keeping the trepitant heart in constant excitement and under tremulous strain, until at length its natural steadiness of motion is transformed into unnatural irregularity which, if it do not remain permanent, is called up by the slightest irritation. The act of playing at whist for high stakes is a frequent source of disease from this cause. I know that professed or habitual card-players declare that, however much may be played for, the losses and winnings of games are equalized by turn, and that after a year's play the player has, practically, neither won nor lost. I may accept that what is declared on this point is true; but the fact, if it be one, does not alter the physical evil that results, one iota. The man who, after being engaged in business all day, sits down regularly at night to play his rubbers on rubbers, to stake heavily on his games, to bet on his odd tricks, never, I believe, escapes the effects of organic nervous shock. Some of the worst forms of such shock I have seen have sprung from this cause.

Political excitements call forth readily the reel of the passions with dangerous energy. A few specially constructed men, who have no passions, pass through active political excitement and, maybe, take part in it without suffering injury; but the majority are injured. As they pour forth their eloquent or rude speeches, as they extol or condemn, as they cheer or hiss, as they threaten or cajole, they are taking out of themselves force they will never regain.

It has been observed since the time of Pinel, that when to political excitement there is added the excitement of war, especially of civil war, the effects on the physical life of the people is at once marked by the disturbance of nervous balance. This fact was forcibly illustrated during and after the last great civil war in America, and it formed the subject of several most able reports by the physicians of that country. One report, by Dr. Stokes, of the Mount Hope Institution of Baltimore, was, I remember, a masterly history which, when the time comes that war shall be no more, will be read with as much wonder as we now read of the witch or dancing mania of the middle ages. One victim of the war mania is cursed with fear until he fails to sleep; another believes all his estates are confiscated; a third imagines himself taking part in some bloody fray; a fourth, the subject of aural delusions, no sooner sleeps than he wakes up, roused by what he considers to be awful sounds afar off, but approaching nearer. These are the more visible evidences of the injuries of war beyond those inflicted on the fighting-men. They represent much, but they represent little if they be compared with the minor but still formidable physical injuries to the heart and brain which stop short of real insanity, but which reduce life, and which pass in line from the generation that receives them primarily to the generations that have to come.

The reel of the passions as a cause of diseases of modern life rests not with the excitements of gaming, of political strife, of war. It is stirred up by some fanatical manifestations for the regeneration of the world, which are well meant, but which, missing the mark, plant degeneration instead.

In a sentence, whenever, from undue excitement of any kind, the passions are permitted to overrule the reason, the result is disease: the heart empties itself into the brain; the brain is stricken, the heart is prostrate, and both are lost.

# THE PROPERTIES OF PROTOPLASM.[1]

By ERNST HAECKEL,

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THE term protoplasm, from Gr. πρῶτος, *first*, and πλάσμα, *form*, is applied to the supposed original substance from which all living beings are developed, and which is the universal concomitant of every phenomenon of life. All that is comprehended for brevity under the term life, whether the growth of plants, the flight of birds, or a train of human thought, is thus supposed to be caused by corporeal organs which either themselves consist of protoplasm, or have been developed out of it. Wherever nutrition and propagation, motion and sensation exist, there is as their material basis this substance designated in a general sense as protoplasm. The proof of it is held to be furnished by the protozoans called moners, the whole completely developed body of which consists solely of protoplasm. They are not only the simplest organisms with which we are acquainted, but also the simplest living beings we can conceive of as capable of existing; and though their entire body is but a single, formless, small lump of protoplasm, and (each molecule of it being like the other) without any combination of parts, yet they perform all the functions which in their entirety constitute in the most highly-organized animals and plants what is comprehended in the idea of life, namely, sensation and motion, nutrition and propagation. By examining these moners we shall gain a clear conception of the nature of protoplasm, and understand the important biological questions connected with the theory.

Some moners live in fresh water, and others in the sea. They are as a rule invisible to the naked eye, but some are as large as the head of a pin, and may be distinguished without the aid of a microscope. When completely at rest a moner commonly assumes the shape of a simple sphere. Either the surface of the body is quite smooth, or numerous exceedingly delicate threads radiate from it in all directions. These threads are not permanent and constant organs of the slime-like body, but perishable continuations of it, which alternately appear and disappear, and may vary every moment in number, size, and form. For this reason they are called false feet or pseudopodia. Nevertheless, by means of these pseudopodia the moners perform all the functions of the higher animals, moving them like real feet either to creep, climb, or swim. By means of these sticky threads they adhere to foreign bodies as with arms, and by shortening or elongating them they drag their own bodies after them. Each thread, like the whole body, is capable of being contracted, and every portion of it is as sensitive and excitable as the entire form. When any point on the

[1] From the forthcoming volume of Appletons' "American Cyclopædia."

surface of the body is touched with the point of a pin, or with another body producing a chemical alteration, as for example a small drop of acid, or when a current of electricity is passed through it, the threads are drawn in, and the entire body contracts into the form of a spherical lump. The same threads perform also the function of providing alimentation.

When a small infusorium or any other nutritive particle comes accidentally in contact with the extended pseudopodia, these run quickly over it like a fluid, wind around it with their numerous little branches, fuse into one, and press it into the interior of the body, where all the nutritive portions are rapidly absorbed and immediately assimilated, while all that is useless is quickly ejected.

The variations among the different moners, of which so far sixteen kinds have been described (Haeckel's "Monographie der Moneren)," consist partly in the various forms of the pseudopodia, but especially in the different kinds of propagation. Some of them merely divide into halves on reaching a certain size; others put forth little buds which gradually separate from them; and others experience a sudden division of the mass into numerous small spherical bodies, each of which instantly begins a separate existence and gradually reaches the size of the ancestral organism.

The chemical examination of the homogeneous protoplasmic body shows that it consists throughout of an albuminous or slime-like mass, hence of that azotic carbonate of the character of the highly-compounded connective group called proteine, albuminoids, or plasson bodies. Like other chemical compounds of this group, protoplasm exhibits several reactions which distinguish it from all others. It is easy to detect it under the microscope, on account of the facility with which it combines with certain coloring matters, as carmine and aniline; it is colored dark yellow or yellowish brown by iodine and nitric acid; and it is coagulated by alcohol and mineral acids, as well as by heat. The quantitative composition of protoplasm, though in some cases greatly varying, resembles as a whole that of other albuminoids, and hence consists of from fifty to fifty-five per cent. of carbon, probably six to eight of hydrogen, fifteen to seventeen of nitrogen, twenty to twenty-two of oxygen, and one to two of sulphur. Protoplasm possesses the quality of absorbing water in various quantities, which renders it sometimes extremely soft and nearly liquid, and sometimes hard and firm like leather; but it is usually of a medium degree of density. Its more prominent physical qualities are excitability and contractility, which Kühne and others have made a special subject of investigation.

On examining with the microscope the numerous substances constituting the various organs of the higher animals, it appears that they all consist of a large number of minute elements, known since Schleiden and Schwann (1838) by the name of cells; and in these cells protoplasm is the oldest, most primordial, and most important constituent. In every real cell there is, besides protoplasm, and while still alive and independent, a second important constituent, the cellular germ, so called (nucleus or cytoblast); but even this germ consists of an albuminous chemical compound which is closely related to protoplasm, and was orginally produced from it by an exceedingly slight chemical alteration. The germ is usually a smaller and firmer formation within the protoplasm of the cell.

Inasmuch as the idea of an organic cell, as now adopted by histologists, rests on the presence of two different essential parts in this elementary organism, the internal cell and the external protoplasm, we must distinguish also two different kinds of elementary organisms: germless cytods, as moners for example, and the real germ-inclosing cells, which originate from the former by secreting in the interior of the small mass of protoplasm a true germ or nucleus. Cells of the simplest kind consist only of protoplasm with a nucleus, while in general the cells of animal or vegetable bodies have also other constituents, particularly and frequently an inclosing skin or capsule (the cellular membrane), also crystals, grains of fat, pigments, and the like, within the protoplasm. But all of these parts came into being only secondarily through the chemical action of protoplasm; they are but the internal and external products of protoplasm. (Haeckel's "Generelle Morphologie," vol. i., p. 279). The single cell of the simplest kind is able to exist as an independent organism. Many of the lowest plants and animals, and also many neutral *protista* (which are neither animals nor plants), retain for life the character of a simple cell. Such unicellular organisms of the simplest kinds are the *amœbæ*, found in large numbers as well in fresh as in salt water. Amœbæ are simple naked cells of various and varying forms. The whole difference between them, especially *protamœbæ*, and certain moners, is that they have a germ. It is probable that this germ of the amœbæ (as may be supposed to be the case with many and perhaps all other cells) is only an organ of propagation, and hence of heredity; while all the other functions, alimentation, motion, and sensation, are performed by the protoplasm. This seems to indicate that at the reproduction of the cells, which is usually effected by segmentation, it is the germ which first divides in two, and that the protoplasm afterward gathers around each of the two sister germs till it also falls in two. It is impossible to distinguish from the common amœbæ the cellular ovules of many of the inferior animals, as for example the sponges, medusæ, and other plant-like animals. With these the eggs are simple naked cells, which, with the sponges especially, sometimes crawl about independently in the body of the animal, giving rise to the idea that they were a class of parasitic amœbæ. But with other animals also, and with most plants, the eggs of which generally obtain subsequently special and often very complicated encasements and other additions, every egg is originally a simple cell. The seminal elements of the male are also only simple cells, and the entire mysterious process of fructification is after all nothing but the fusion or concrescence of two different cells, the one a female egg-cell, and the other a male semen-cell. In consequence of this fusion the germs of the two combined cells dissolve, and therewith the young, newly-generated individual begins his existence as a simple cytod, or a small germless ball of protoplasm. But inside of this cytod soon arises a new germ, which turns it again into a cell, and this simple cell forms by oft-repeated segmentation an accumulation of cells. Out of this heap are produced by secretion certain germinal layers or "germ-leaves," and out of these proceed all the other organs of the complete being. Each of these organs again originally consists only of cells, and in all of these cells the essential constituent parts are only the germ and protoplasm: the germ as the elementary organ of propagation and heredity, protoplasm as the elementary organ of all the other functions, sensation, motion, alimentation, and adaptation. Cells and cytods, therefore, are true elementary organisms, independent minute forms of life, which either in the lowest existences continue to live independently, or in the higher organisms combine in numbers to form a community. Cells and cytods are the veritable "formers" of life, or plastids. The most ancient and primordial forms of plastids are cytods, the whole body of which consists of protoplasm, in which the germs are internally produced, and from which therefore the cells proceed.

As a matter of course, to the infinite varieties presented by the organic forms and vital phenomena in the vegetable and animal kingdom, corresponds an equally infinite variety of chemical composition in the protoplasm. The most minute homogeneous constituents of this "life-substance," the protoplasm molecules, or plastidules, as they are called by Elsberg, must in their chemical composition present an infinite number of extremely delicate gradations and variations. The atoms of carbon, hydrogen, nitrogen, oxygen, and sulphur, which compose each of the plastidules, must enter into an infinite number of diverse stratifications and combinations. The chemistry of to-day, with its imperfect methods of investigation, is totally powerless before these intricate organic compounds, and it is possible only to surmise, from the infinitely varied physiological qualities of the numberless kinds of plastids, the infinite variety of plastidules out of which they are composed.

According to the plastid theory recently advanced, the great variety of vital phenomena is the consequence of the infinitely delicate chemical difference in the composition of protoplasm, and it considers protoplasm to be the sole active life-substance. This theory puts force and matter in living organisms into the same causal connection which has long been accepted for force and matter in inorganic bodies. This conception has been rapidly matured, especially in the past twenty years, through the more exact information obtained in regard to the lowest kinds of organisms. Yet the idea had been grasped more than half a century ago; for the "primordial slime" which Lorenz Oken proclaimed in 1809 to be the original source of life, and the material basis of all living bodies, possessed in all essentials the same qualities and the same importance now ascribed to protoplasm; and the *sarcode* so called, which in 1835 was pointed out by the French zoölogist Félix Dujardin as the only living substance in the body of rhizopods and other inferior primitive animals, is identical with protoplasm. But when Schleiden and Schwann, in 1838, developed their cell theory, they were not acquainted with the fundamental significance of protoplasm. Even Hugo Mohl, who in 1846 was the first to apply the name protoplasm to the peculiar serous and mobile substance in the interior of vegetable cells, and who perceived its high importance, was very far from understanding its significance in relation to all organisms. Not until Ferdinand Cohn (1850), and more fully Franz Unger (1855), had established the identity of the animate and contractile protoplasm in vegetable cells and the sarcode of the lower animals, could Max Schultze in 1858–'61 elaborate this protoplasm theory of the sarcode, so as to proclaim protoplasm to be the most essential and important constituent of all organic cells, and to show that the bag or husk of the cell, the cellular membrane, and the intercellular substances, are but secondary parts of the cell, and are frequently wanting. In a similar manner Lionel Beale (1862) distinguished such primary forming and secondary formed substances in all organic tissues, and gave to protoplasm, including the cellular germ, the name of "germinal matter," and to all the other substances entering into the composition of tissues, being secondary and produced, the name of "formed matter."

The protoplasm theory received a wide and thorough illustration from the study of rhizopods which Ernst Haeckel published in 1862 in his "Monographie der Radiolarien," and its complete application in the "Generelle Morphologie der Organismen" by the same naturalist. Haeckel distinguishes in these works, for the first time, between germless protoplasm, consisting only of plastids called cytods by him, and the germ-containing real cells, the elementary organism of which consists already of two different essential parts, germ and protoplasm. He conceived the cytods and cells as two different gradations of plastids, of organic elementary individuals, or as "individuals of the first order," and adopted entirely, in regard to the individual independence of the plastids, the ideas which had been set forth by Rudolf Virchow and Ernst Brücke.

Virchow, whose "Cellular-Pathologie" contains the most complete application of the cell theory to pathology, called the cells and the "cell territories" belonging to them the individual hearth or source of life; Brücke designated them as "elementary organisms." The plastids or individuals of the first order, identical with them, were determined by Haeckel phylogenetically, to the effect that cytods and cells must be distinguished as two essentially different orders of formation; i. e., that cells were phylogenetically produced in a secondary manner from homogeneous cytods by means of the secretion of a germ by the protoplasm. This distinction is important for the reason that many of the lowest orders of organisms have no germ in the protoplasm; such is the case especially with the moners. These simplest of organisms were first discovered by Haeckel in 1864, and described by him in 1868 in his "Monographie der Moneren." Cienkowski and Huxley also made valuable investigations of various moners. The latter discovered in 1868 the famous bathybius, a very remarkable kind of moner, which at immense depths covers the bottom of the sea in immeasurable numbers, and which consists of formless and variable protoplasm tissues of different sizes.

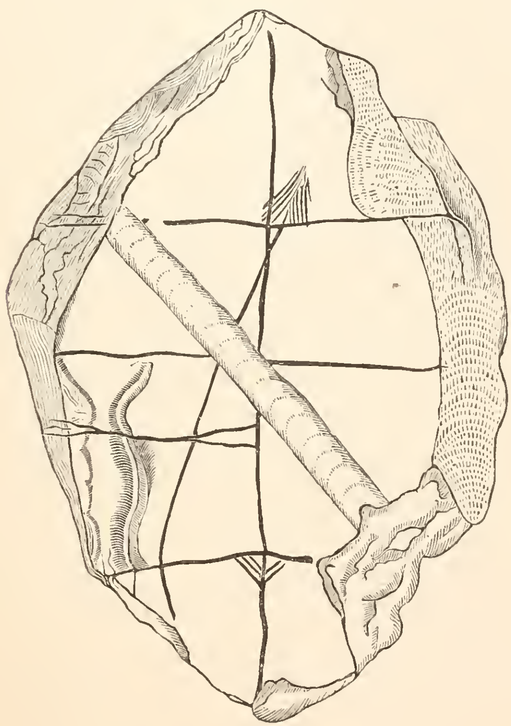
Among the moners investigated by Cienkowski, the most interesting are the vampire-cells, which are formless little bodies of protoplasm that bore into vegetable cells by means of their pointed pseudopodia, kill them, and absorb the protoplasm they find in them. On the basis of these discoveries Haeckel elaborated his plastid theory and carbon theory, which give the extremest philosophical consequences of the protoplasm theory.

In England the monistic philosophy of protoplasm has received the most weighty support from Huxley, whose "Protoplasm, or the Physical Basis of Life" (1868), put it in its true light, and called forth numerous writings for and against it. One of the most recent treatises in favor of it is that of James Ross "On Protoplasm" (1874). Probably the name of plasson will be given to the primordial, perfectly structureless, and homogeneous protoplasm of the moners and other cytods, in contradistinction to the protoplasm of germ-containing cells, which are produced only subsequently, by the differentiation of an internal nucleus and external protoplasm by the plasson bodies of moners. Édouard van Beneden especially calls for this distinction in his "Recherches sur l'évolution des grégarines;" and Haeckel has adduced new facts in favor of it in his "Monograpphie der Kalkschwämme." For the theory of "primordial generation," the spontaneous generation of the first vitality on earth, the distinction is of special importance, as the first organisms thus produced could have been only structureless specks of plasson, like the bathybius and other moners. The great theoretical difficulties formerly in the way of the theory of primordial or spontaneous generation have been removed by the discovery of the moners and the establishment of the plastid theory. As the protoplasm of the bathybius is not yet as much as individualized, while in the case of other moners there are individual lumps of constant sizes, it follows that the moners are to be regarded as the natural bodies which effect the transition from inorganic to organic Nature.

# A CURIOUS INDIAN RELIC.

By CHARLES C. ABBOTT, M. D.

AMONG the several thousands of Indian relics gathered by the writer, in the immediate vicinity of Trenton, New Jersey, there has occurred one wholly different from all the others, and which bears some resemblance to the well-known Indian bark-letters, as figured by Schoolcraft and Catlin; but this inscribed stone is far more primitive than these. The specimen (as shown in the following diagram) is a slab of impure mica or micaceous slate, about an inch in thickness, seven inches in length, and four and three-fourths inches in



greatest width. The edges have been rudely beveled, and the specimen chipped into its present shape previous to the inscribing of the peculiar markings which characterize the relic.

These consist of a series of well-defined lines, one extending the entire length of the specimen, and dividing it into two nearly equal parts or surfaces. There are also three well-defined lines crossing the central one at right angles, and a fourth short one, with "split" ends, on the left-hand side, below the centre of the slab.

The wide, shallow groove crossing obliquely from left to right is, I think, a subsequent marking, possibly from a ploughshare passing lightly over the stone. It has the appearance of having been done quite recently. Perhaps the most noticeable feature of the inscribed side of the stone is the well-defined arrow, extending obliquely across the specimen from right to left. This certainly helps one, at least, to imagine some plausible explanation of the meaning of the various markings.

The relic was found in a dense swamp, which until very lately has in no way been disturbed, otherwise than by cutting off the matured timber. Just where found it probably had been lying since the distant day when, for some purpose, it was placed in position by the aborigines.

That the specimen is really an Indian relic I am positive, having examined the spot where it was found; and from the fact that the lad that found it brought it to me with considerable doubt in his own mind as to its being really "Indian" work. In the immediate neighborhood were found quite a number of stone axes, spears, and arrow-points, all of them of the rudest workmanship.

As the specimen exhibits no attempt on the part of its primeval owner at ornamentation, not even polishing, it can scarcely be doubted that the markings upon it were placed there to express some fact to others who might find it; that it is a "bark-letter" written upon stone—a very primitive attempt at "picture-writing."

Admitting, then, that the specimen has been engraved, as we now find it, by an aborigine, I suggest the following as an explanation or interpretation of the various markings: The slab has been engraved and then placed in the trail which the Indian or party of them were following, with the long central line pointing due north or else in the direction of the trail. The crossing lines would indicate three days' journeys up to the time of "locating" the stone, or, more probably, that three streams of water had been crossed; and the direction of the arrow indicated the direction the party had taken from the point where the stone was placed, on leaving the trail they had been following.

That the specimen was intended to convey some such meaning, I have myself no doubt; but, looked at in any light, it is certainly a very remarkable form of "relic," and being (as yet) unique, in the enormous "find" from this neighborhood, I think goes to show it is really a "record" or "letter," as such "picture-writings" would naturally be made at rare intervals and under unusual circumstances.

The specimen is preserved in the Museum of the Peabody Academy of Science, at Salem, Massachusetts.

# METEOROLOGY OF THE SUN AND EARTH.[1]

By Prof. BALFOUR STEWART, F.R.S.

SINCE the last meeting of the British Association, Science has had to mourn the loss of one of its pioneers, in the death of the veteran astronomer, Schwabe, of Dessau, at a good old age, not before he had faithfully and honorably finished his work. In truth, this work was of such a nature that the worker could not be expected long to survive its completion.

It is now nearly fifty years since he first began to produce daily sketches of the spots that appeared upon the sun's surface. Every day on which the sun was visible (and such days are more frequent in Germany than in this country), with hardly any intermission for forty years, this laborious and venerable observer made his sketch of the solar disk. At length this unexampled perseverance met with its reward in the discovery of the periodicity of sun-spots, a phenomenon which very speedily attracted the attention of the scientific world.

It is not easy to overrate the importance of the step gained when a periodicity was found to rule these solar outbreaks. *A priori* we should not have expected such a phenomenon. If the old astronomers were perplexed by the discovery of sun-spots, their successors must have been equally perplexed when they ascertained their periodicity. For while all are ready to acknowledge periodicity as one of the natural conditions of terrestrial phenomena, yet every one is inclined to ask what there can be to cause it in the behavior of the sun himself. Manifestly it can only have two possible causes. It must either be the outcome of some strangely hidden periodical cause residing in the sun himself, or must be produced by external bodies, such as planets, acting somehow in their varied positions on the atmosphere of the sun. But whether the cause be an internal or external one, in either case we are completely ignorant of its nature.

We can easily enough imagine a cause operating from the sun himself and his relations with a surrounding medium to produce great disturbances on his surface, but we cannot easily imagine why disturbances so caused should have a periodicity. On the other hand we can easily enough attach periodicity to any effect caused by the planets, but we cannot well see why bodies comparatively so insignificant should contribute to such very violent outbreaks as we now know sun-spots to be.

If we look within we are at a loss to account for the periodicity of solar disturbances, and if we look without we are equally at a loss to account for their magnitude. But, since that within the sun is hidden

[1] Opening Address in Section A, at the Bristol Meeting of the British Association.

from our view, it cannot surely be considered blameworthy if astronomers have directed their attention to that without and have endeavored to connect the behavior of sun-spots with the positions of the various planets. Stimulated no doubt by the success which had attended the labors of Schwabe, an English astronomer was the next to enter the field of solar research.

The aim of Mr. Carrington was, however, rather to obtain very accurate records of the positions, the sizes, and the shapes of the various sun-spots than to make a very extensive and long-continued series of observations. He was aware that a series at once very accurate and very extended is beyond the power of a private individual, and can only be undertaken by an established institution. Nevertheless, each sun-spot that made its appearance during the seven years extending from the beginning of 1854 to the end of 1860 was sketched by Mr. Carrington with the greatest possible accuracy, and had also its heliographic position, that is to say its solar latitude and longitude, accurately determined.

One of the most prominent results of Mr. Carrington's labors was the discovery of the fact that sun-spots appear to have a proper motion of their own—those nearer the solar equator moving faster than those more remote. Another was the discovery of changes, apparently periodical, affecting the disposition of spots in solar latitude. It was already known that sun-spots confined themselves to the sun's equatorial regions, but Mr. Carrington showed that the region affected was liable to periodical elongations and contractions, although his observations were not sufficiently extended to determine the exact length of this period.

Before Mr. Carrington had completed his seven years' labors, celestial photography had been introduced by Mr. Warren De la Rue. Commencing with his private observatory, he next persuaded the Kew Committee of the British Association to allow the systematic photography of the sun to be carried on at their observatory under his superintendence, and in the year 1862 the first of a ten years' series of solar photographs was begun. Before this date, however, Mr. De la Rue had ascertained, by means of his photoheliograph, on the occasion of the total eclipse of 1860, that the red prominences surrounding the eclipsed sun belong, without doubt, to our luminary himself.

The Kew observations are not yet finally reduced, but already several important conclusions have been obtained from them by Mr. De la Rue and the other Kew observers. In the first place the Kew photographs confirm the theory of Wilson that sun-spots are phenomena, the dark portions of which exist at a level considerably beneath the general surface of the sun; in other words, they are hollows, or pits, the interior of which is of course filled up with the solar atmosphere. The Kew observers were likewise led to associate the low temperature of the bottom of sun-spots with the downward carriage of colder matter from the atmosphere of the sun, while the upward rush of heated matter was supposed to account for the faculæ or bright patches which almost invariably accompany spots. In the next place the Kew observers, making use not only of the Kew series but of those of Schwabe and Carrington, which were generously placed at their disposal, have discovered traces of the influence of the nearer planets upon the behavior of sun-spots. This influence appears to be of such a nature that spots attain their maximum size when carried by rotation into positions as far as possible remote from the influencing planet —that is to say, into positions where the body of the sun is between them and the planet. There is also evidence of an excess of solar action when two influential planets come near together. But, although considerable light has thus been thrown on the periodicity of sun-spots, it ought to be borne in mind that the cause of the remarkable period of eleven years and a quarter, originally discovered by Schwabe, has not yet been properly explained. The Kew observers have likewise discovered traces of a peculiar oscillation of spots between the two hemispheres of the sun, and finally their researches will place at the command of the observers the data for ascertaining whether centres of greater and lesser solar activity are connected with certain heliocentric positions.

While the sun's surface was thus being examined both telescopically and photographically, the spectroscope came to be employed as an instrument of research. It had already been surmised by Prof. Stokes, that the vapor of sodium at a comparatively low temperature forms one of the constituents of the solar atmosphere, inasmuch as the dark line D in the spectrum of the sun coincides in position with the bright line given out by incandescent sodium-vapor.

This method of research was greatly extended by Kirchhoff, who soon found that many of the dark lines in the solar spectrum were coincident with the bright lines of sundry incandescent metallic vapors, and a good beginning was thus made toward ascertaining the chemical constitution of the sun.

The new method soon brought forth further fruit when applied in the hands of Huggins, Miller, Secchi, and others, to the more distant heavenly bodies. It was speedily found that the fixed stars had constitutions very similar to that of the sun. But a peculiar and unexpected success was attained when some of the nebulæ were examined spectroscopically. To-day it seems (so rapidly has knowledge progressed) very much like recalling an old superstition to remind you that until the advent of the spectroscope the irresolvable nebulæ were considered to be gigantic and remote clusters of stars, the individual members of which were too distant to be separated from each other even with a telescope like that of Lord Rosse. But Mr. Huggins, by means of the spectroscope, soon found that this was not the case, and that most of the nebulæ which had defied the telescope gave indications of incandescent hydrogen gas. It was also found by this observer that the proper motions of some of the fixed stars in a direction to or from the earth might be detected by means of the displacement of their spectral lines, a method of research which was first enunciated by Fizeau. Hitherto, in such applications of the spectroscope, the body to be examined was viewed as a whole. It had not yet been attempted to localize the use of this instrument so as to examine particular districts of the sun, as for instance a sun-spot, or the red flames already proved by De la Rue to belong to our luminary. This application was first made by Mr. Lockyer, who in the year 1865 examined a sun-spot spectroscopically, and remarked the greater thickness of the lines in the spectrum of the darker portion of the spot.

Dr. Frankland had previously found that thick spectral lines correspond to great pressure, and hence the inference from the greater thickness of lines in the umbra of a spot is that this umbra or dark portion is subject to a greater pressure; that is to say, it exists below a greater depth of the solar atmosphere than the general surface of the sun. Thus the results derived from the Kew photoheliograph and those derived from the spectroscope were found to confirm each other. Mr. Lockyer next caused a powerful instrument to be constructed for the purpose of viewing spectroscopically the red flames round the sun's border, in the hope that if they consisted of ignited gas the spectroscope would disperse, and thus dilute and destroy the glare which prevents them from being seen on ordinary occasions.

Before this instrument was quite ready these flames had been analyzed spectroscopically by Captain Herschel, M. Janssen, and others, on the occasion of a total eclipse occurring in India, and they were found to consist of incandescent gas, most probably hydrogen. But the latter of these observers (M. Janssen) made the important observation that the bright lines in the spectrum of these flames remained visible even after the sun had reappeared, from which he argued that a solar eclipse is not necessary for the examination of this region.

Before information of the discovery made by Janssen had reached this country, the instrument of Mr. Lockyer had been completed, and he also found that by its means he was able to analyze at leisure the composition of the red flames without the necessity of a total eclipse. An atmosphere of incandescent hydrogen was found to surround our luminary, into which, during the greater solar storms, sundry metallic vapors were injected—sodium, magnesium, and iron, forming the three that most frequently made their appearance.

Here we come to an interesting chemical question.

It had been remarked by Maxwell and by Pierce as the result of the molecular theory of gases that the final distribution of any number of kinds of gas in a vertical direction under gravity is such that the density of each gas at a given height is the same as if all the other gases had been removed, leaving it alone. In our own atmosphere the continual disturbances prevent this arrangement from taking place, but in the sun's enormously extended atmosphere (if, indeed, our luminary be not nearly all gaseous) it appears to hold, inasmuch as the upper portion of this atmosphere, dealing with known elements, apparently consists entirely of hydrogen. Various other vapors are, however, as we have seen, injected from below the photosphere into the solar atmosphere on the occasion of great disturbances, and Mr. Lockyer has asked the question, whether we have not here a true indication of the relative densities of these various vapors derived from the relative heights to which they are injected on such occasions.

This question has been asked, but it has not yet received a definite solution, for chemists tell us that the vapor densities of some of the gases injected into the sun's atmosphere on the occasion of disturbances are, as far as they know from terrestrial observations, different from those which would be indicated by taking the relative heights attained in the atmosphere of the sun. Mr. Lockyer has attempted to bring this question a step nearer to its solution by showing that the vapors at the temperatures at which their vapor densities have been experimentally determined are not of similar molecular constitution, whereas in the sun we get an indication, from the fact that all the elements give us line spectra, that they are in similar molecular states.

Without, however, attempting to settle this question, I may remark that we have here an interesting example of how two branches of science—physics and chemistry—meet together in solar research.

It had already been observed by Kirchhoff that sometimes one or more of the spectral lines of an elementary vapor appeared to be reversed in the solar spectrum, while the other lines did not experience reversal. Mr. Lockyer succeeded in obtaining an explanation of this phenomenon. This explanation was found by means of the method of localization already mentioned.

Hitherto, when taking the spectrum of the electric spark between the two metallic poles of a coil, the arrangements were such as to give an average spectrum of the metal of these poles; but it was found that, when the method of localization was employed, different portions of the spark gave a different number of lines, the regions near the terminals being rich in lines, while the midway regions give comparatively few.

If we imagine that in the midway regions the metallic vapor given off by the spark is in a rarer state than that near the poles, we are thus led to regard the short lines which cling to the poles as those which require a greater density or nearness of the vapor-particles before they make their appearance; while, on the other hand, those which extend all the way between the two poles come to be regarded as those which will continue to make their appearance in vapor of great tenuity.

Now, it was remarked that these long lines were the very lines which were reversed in the atmosphere of the sun. Hence, when we observe a single coincidence between a dark solar line and the bright line of any metal, we are further led to inquire whether this bright line is one of the long lines which will continue to exist all the way between two terminals of that metal when the spark passes.

If this be the case, then we may argue with much probability that the metal in question really occurs in the solar atmosphere; but if, on the other hand, the coincidence is merely between a solar dark line and a short bright one, then we are led to imagine that it is not a true coincidence, but something which will probably disappear on further examination. This method has already afforded us a means of determining the relative amount of the various metallic vapors in the sun's atmosphere. Thus, in some instances all lines are reversed, whereas in others the reversal extends only to a few of the longer lines.

Several new metals have thus been added to the list of those previously detected in the solar atmosphere, and it is now certain that the vapors of hydrogen, potassium, sodium, rubidium, barium, strontium, calcium, magnesium, aluminium, iron, manganese, chromium, cobalt, nickel, titanium, lead, copper, cadmium, zinc, uranium, cerium, vanadium, and palladium, occur in our luminary.

I have spoken hitherto only of telescopic spectroscopy; but photography has been found capable of performing the same good service toward the compound instrument consisting of the telescope and its attached spectroscope, which it had previously been known to perform toward the telescope alone. It is of no less importance to secure a permanent record of spectral peculiarities than it is to secure a permanent record of telescopic appearances. This application of photography to spectrum observations was first commenced on a sufficient scale by Mr. Rutherford, of New York, and already promises to be one of the most valuable aids in solar inquiry.

In connection with the spectroscope I ought here to mention the names of Respighi and Secchi, who have done much in the examination of the solar surface from day to day. It is of great importance to the advancement of our knowledge, that two such competent observers are stationed in a country where the climate is so favorable to continued observation.

The examination of the sun's surface by the spectroscope suggests many interesting questions connected with other branches of science. One of these has already been alluded to. I may mention two others put by Mr. Lockyer, premising, however, that at present we are hardly in a position to reply to them. It has been asked whether the very high temperatures of the sun and of some of the stars may not be sufficient to produce the disassociation of those molecular structures which cannot be disassociated by any terrestrial means; in other words, the question has been raised, whether our so-called elements are really elementary bodies.

A third question is of geological interest. It has been asked whether a study of the solar atmosphere may not throw some light upon the peculiar constitution of the upper strata of the earth's surface, which are known to be of less density than the average interior of our planet.

If we have learned to be independent of total eclipses as far as the lower portions of the solar atmosphere are concerned, it must be confessed that as yet the upper portions—the outworks of the sun—can only be successfully approached on these rare and precious occasions. Thanks to the various government expeditions dispatched by Great Britain, by the United States, and by several Continental nations—thanks, also, to the exertions of Lord Lindsay and other astronomers—we are in the possession of definite information regarding the solar corona.

In the first place, we are now absolutely certain that a large part of this appendage unmistakably belongs to our luminary, and in the next place, we know that it consists, in part at least, of an ignited gas giving a peculiar spectrum, which we have not yet been able to identify with that of any known element. The temptation is great to associate this spectrum with the presence of something lighter than hydrogen, of the nature of which we are yet totally ignorant.

A peculiar physical structure of the corona has likewise been suspected. On the whole, we may say that this is the least known, while it is perhaps the most interesting, region of solar research; most assuredly it is well worthy of further investigation.

If we now turn our attention to matters nearer home, we find that there is a difficulty in grasping the facts of terrestrial meteorology no less formidable than that which assails us when we investigate solar outbreaks. The latter perplex us because the sun is so far away, and because also his conditions are so different from those with which we are here familiar; while, on the other hand, the former perplex us because we are so intimately mixed up with them in our daily lives and actions; because, in fact, the scale is so large and we are so near. The result has been that until quite recently our meteorological operations have been conducted by a band of isolated volunteers individually capable and skillful, but from their very isolation incapable of combining together with advantage to prosecute a scientific campaign. Of late, however, we have begun to perceive that, if we are to make any advance in this very interesting and practical subject, a different method must be pursued, and we have already reaped the first fruits of a more enlightened policy; already we have gained some knowledge of the constitution and habits of our atmosphere.

The researches of Wells and Tyndall have thrown much light on the cause of dew. Humboldt, Dové, Buys Ballot, Jelinek, Quetelet, Hansteen, Kupffer, Forbes, Welsh, Glaisher, and others, have done much to give us an accurate knowledge of the distribution of terrestrial temperature. Great attention has likewise been given to the rainfall of Great Britain and Ireland, chiefly through the exertions of one individual, Mr. G. J. Symons.

To Dové we are indebted for the law of rotation of the wind, to Redfield for the spiral theory of cyclones, to Francis Galton for the theory of anti-cyclones, to Buchan for an investigation into the disposition of atmospheric pressure which precedes peculiar types of weather, to Stevenson for the conception of barometric gradients, to Scott and Meldrum for an acquaintance with the disposition of winds which frequently precedes violent outbreaks; and, to come to the practical application of laws, we are much indebted to the late Admiral Fitzroy and the system which he greatly helped to establish for our telegraphic warnings of coming storms.

Again, the meteorology of the ocean has not been forgotten. The well-known name of Maury will occur to every one as that of a pioneer in this branch of inquiry. Fitzroy, Leverrier, Meldrum, Toynbee, and others, have likewise done much; and it is understood that the meteorological offices of this and other maritime countries are now busily engaged upon this important and practical subject. Finally, the movements of the ocean and the temperatures of the oceanic depths have recently been examined with very great success in vessels dispatched by her Majesty's government; and Dr. Carpenter has by this means been able to throw great light upon the convection-currents exhibited by that vast body of water which girdles our globe.

It would be out of place to enter here more minutely into this large subject, and already it may be asked what connection has all this with that part of the address that went before it.

There are, however, strong grounds for supposing that the meteorology of the sun and that of the earth are intimately connected together. Mr. Broun has shown the existence of a meteorological period connected apparently with the sun's rotation; five successive years' observations of the barometer at Singapore all giving the period 25.74 days. Mr. Baxendell, of Manchester, was, I believe, the first to show that the convection-currents of the earth appear to be connected somehow with the state of the sun's surface as regards spots; and still more recently, Mr. Meldrum, of the Mauritius Observatory, has shown by a laborious compilation of ships' logs, and by utilizing the meteorological records of the island, that the cyclones in the Indian Ocean are most frequent in years when there are most sun-spots. He likewise affords us grounds for supposing that the rainfall, at least in the tropics, is greatest in years of maximum solar disturbance.

M. Pocy has found a similar connection in the case of the West Indian hurricanes; and, finally, Piazzi Smyth, Stone, Köppen, and still more recently, Blanford, have been able to bring to light a cycle of terrestrial temperature having apparent reference to the condition of the sun.

Thus, we have strong matter-of-fact grounds for presuming a connection between the meteorology of our luminary and that of our planet, even although we are in complete ignorance as to the exact nature of this bond.

If we now turn to terrestrial magnetism, the same connection becomes apparent.

Sir Edward Sabine was the first to show that the disturbances of the magnetism of the earth are most violent during years of maximum sun-spots. Mr. Broun has shown that there is likewise a reference in magnetic phenomena to the period of the sun's rotation about his axis, an observation recently confirmed by Hornstein; and still more recently, Mr. Broun has shown that the moon has an action upon the earth's magnetism which is not altogether of a tidal nature, but depends, in part, at least, upon the relative position of the sun and moon.

I must trust to your forbearance if I now venture to bring forward considerations of a somewhat speculative nature.

We are all familiar with the generalization of Hadley, that is to say, we know there are under-currents sweeping along the surface of the earth from the poles to the equator, and upper-currents sweeping back from the equator to the poles. We are likewise aware that these currents are caused by the unequal temperature of the earth; they are in truth convection-currents, and their course is determined by the positions of the hottest and coldest parts of the earth's surface. We may expect them, therefore, to have a reference not so much to the geographical equator and poles as to the hottest and coldest regions. In fact, we know that the equatorial regions, into which the trade-winds rush and from which the anti-trades take their origin, have a certain annual oscillation depending upon the position of the sun, or, in other words, upon the season of the year. We may likewise imagine that the region into which the upper-currents pour themselves is not the geographical pole, but the pole of greatest cold.

In the next place we may imagine that these currents, as far as regards a particular place, have a daily oscillation. This has, I believe, been proved as regards the lower-currents or trade-winds, which are more powerful during the day than during the night, and we may therefore expect it to hold good with regard to the upper-currents or anti-trades; in fact, we cannot go wrong in supposing that they also, as regards any particular place, exhibit a daily variation in the intensity with which they blow.

Again, we are aware that the earth is a magnet. Let us not now concern ourselves about the origin of its magnetism, but rather let us take it as it is. We must next bear in mind that rarefied air is a good conductor of electricity; indeed, according to recent experiments, an extremely good conductor. The return-trades that pass above from the hotter equatorial regions to the poles of cold, consisting of moist rarefied air, are therefore to be regarded in the light of good conductors crossing lines of magnetic force; we may therefore expect them to be the vehicle of electric currents. Such electric currents will of course react on the magnetism of the earth. Now, since the velocity of these upper-currents has a daily variation, their influence, as exhibited at any place upon the magnetism of the earth, may be expected to have a daily variation also.

The question thus arises, Have we possibly here a cause which may account for the well-known daily magnetic variation? Are the peculiarities of this variation such as to correspond to those which might be expected to belong to such electric currents? I think it may be said that, as far as we can judge, there is a likeness of this kind between the peculiarities of these two things, but a more prolonged scrutiny will of course be essential before we can be absolutely certain that such currents are fitted to produce the daily variation of the earth's magnetism.

Besides the daily and yearly periodic changes in these upper convection-currents we should also expect occasional and abrupt changes forming the counterparts of those disturbances in the lower strata with which we are familiar. And these may be expected in like manner to produce non-periodic occasional disturbances of the magnetism of the earth. Now, it is well known that such disturbances do occur; and, further, that they are most frequent in those years when cyclones are most frequent; that is to say, in years of maximum sun-spots. In one word, it appears to be a tenable hypothesis to attribute at least the most prominent magnetic changes to atmospheric motions taking place in the upper regions of the atmosphere where each moving stratum of air becomes a conductor moving across lines of magnetic force; and it was Sir William Thomson, I believe, who first suggested that the motion of conductors across the lines of the earth's magnetic force must be taken into account in any attempted explanation of terrestrial magnetism.

It thus seems possible that the excessive magnetic disturbances which take place in years of maximum sun-spots may not be directly caused by any solar action, but may rather be due to the excessive meteorological disturbances which are likewise characteristic of such years. On the other hand, that magnetic and meteorological influence which Mr. Broun has found to be connected with the sun's rotation points to some unknown direct effect produced by our luminary, even if we imagine that the magnetic part of it is caused by the meteorological. Mr. Broun is of opinion that this effect of the sun does not depend upon the amount of spots on his surface.

In the next place, that influence of the sun, in virtue of which we have most cyclones and greater meteorological disturbance in the years of maximum spots, cannot, I think (as far as we know at present), be attributed to a change in the heating power of the sun. We have, no doubt, traces of a temperature effect which appears to depend upon the sun-period, but its amount is very small, whereas the variation in cyclonic disturbance is very great. We are thus tempted to associate this cyclone-producing influence of the sun with something different from his light and heat. As far, therefore, as we can judge, our luminary would appear to produce three distinct effects upon our globe. In the first place, a magnetic and meteorological effect, depending somehow upon his rotation; secondly, a cyclonic effect, depending somehow upon the disturbed state of his surface; and, lastly, the well-known light and heat effect with which we all are familiar.

If we now turn to the sun, we find that there are three distinct forms of motion which animate his surface-particles. In the first place, each particle is carried round by the rotation of our luminary. Secondly, each particle is influenced by the gigantic meteorological disturbances of the surface, in virtue of which it may acquire a velocity ranging as high as one hundred and thirty or one hundred and forty miles a second; and lastly, each particle, on account of its high temperature, is vibrating with extreme rapidity, and the energy of these vibrations communicated to us by means of the ethereal medium produces the well-known light and heat effect of the sun.

Now, is it philosophical to suppose that it is only the last of these three motions that influences our earth, while the other two produce absolutely no effect? On the contrary, we are, I think, compelled, by considerations connected with the theory of energy, to attribute an influence, whether great or small, to the first two as well as to the last.

We are thus led to suppose that the sun must influence the earth in three ways, one depending on his rotation, another on his meteorological disturbance, and a third by means of the vibrations of his surface-particles.

But we have already seen that, as a matter of fact, the sun does appear to influence the earth in three distinct ways—one magnetically and meteorologically, depending apparently on his period of rotation; a second cyclonically, depending apparently on the meteorological conditions of his surface; and a third, by means of his light and heat.

Is this merely a coincidence, or has it a meaning of its own? We cannot tell, but I may venture to think that, in the pursuit of this problem, we ought to be prepared at least to admit the possibility of a threefold influence of the sun.

Even from this very meagre sketch of one of the most interesting and important of physical problems, it cannot fail to appear that while a good deal has already been done, its progress in the future will very greatly depend on the completeness of the method and continuity of the observations by which it is pursued. We have here a field which is of importance not merely to one, or even to two, but almost to every conceivable branch of research.

Why should we not erect in it a sort of science-exchange, into which the physicist, the chemist, and the geologist, may each carry the fruits of his research, receiving back in return some suggestion, some principle, or some other scientific commodity that will aid him in his own field? But to establish such a mart must be a national undertaking, and already several nations have acknowledged their obligations in this respect.

Already the German Government have established a Sonnenwarte, the mere building and equipment of which is to cost a large sum. With an appreciation of what the spectroscope has done for this inquiry, the first directorship was offered to Kirchhoff, and, on his declining it, Herr Vogel has been placed in charge. In France, also, a physical observatory is to be erected at Fontenay, on an equal, if not greater scale, of which Janssen has already accepted the directorship; while in Italy there are at least three observatories exclusively devoted to this branch of research. Nor must we forget that in this country the new observatory at Oxford has been so arranged that it can be employed in such inquiries. But what has England as a nation done?

Some years since, at the Norwich meeting of this Association, a movement was set on foot by Colonel Strange, which resulted in the appointment of a royal commission on the advancement of science, with the Duke of Devonshire as chairman. This commission have quite recently reported on the steps that ought in their opinion to be taken for the advancement of scientific research.

One of their recommendations is expressed in the following words:

"Important classes of phenomena relating to physical meteorology and to terrestrial and astronomical physics require observations of such a character that they cannot be advantageously carried on otherwise than under the direction of Government. Institutions for the study of such phenomena should be maintained by the Government; and, in particular, an observatory should be founded specially devoted to astronomical physics."

If the men of science of this country who procured the appointment of this commission, and who subsequently gave evidence before it, will now come forward to support its recommendations, it can hardly be doubted that these will be speedily carried into effect.

But other things besides observations are necessary, if we are to pursue with advantage this great physical problem.

One of these is the removal of the intolerable burden that has hitherto been laid upon private meteorologists and magneticians. Expected to furnish their tale of bricks, they have been left to find their own straw. Nothing more wretched can be imagined than the position of an amateur—that is to say, a man who pursues science for the love of it, and is unconnected with any establishment—who has set himself to promote observational inquiries, whether in meteorology or magnetism.

He has first to obtain with great expenditure of time or money, or both, copies of the individual observations taken at some recognized institution. He has next to reduce these in the way that suits his inquiry; an operation again consuming time and demanding means. Let us suppose all this to be successfully accomplished, and a valuable result obtained. It is doubtless embodied in the transactions of some society, but it excites little enthusiasm, for it consists of something which cannot be repeated by every one for himself like a new and interesting experiment. Yet the position of such men has recently been improved. Several observatories and other institutions now publish their individual observations; this is done by our Meteorological Office, while Dr. Bergsma, Dr. Neumayer, and Mr. Broun, are recent examples of magneticians who have adopted this plan. The publication of the work of the latter is due to the enlightened patronage of the Rajah of Travancore, who has thus placed himself in front of the princes of India, and given them an example which it is to be hoped they will follow. But this is only one step in the right direction; another must consist in subsidizing private meteorologists and magneticians in order to enable them to obtain the aid of computers in reducing the observations with which they have been furnished. The man of science would thus be able to devote his knowledge, derived from long study, to the methods by which results and the laws regulating them are to be obtained; he could be the architect and builder of a scientific structure without being forced to waste his energies on the work of a hodman.

Another hindrance consists in our deficient knowledge as to what observations of value in magnetism and meteorology have already been made. We ought to have an exhaustive catalogue of all that has been done in this respect in our globe, and of the conditions under which the various observations will be accessible to outside inquirers. A catalogue of this kind has been framed by a committee of this Association, but it is confined to the dominions of England, and requires to be supplemented by a list of that which has been done abroad.

A third drawback is the insufficient nature of the present facilities for the invention and improvement of instruments, and for their verification.

We have, no doubt, advanced greatly in the construction of instruments, especially in those which are self-recording. The names of Brooke, Robinson, Welsh, Osler, and Beckley, will occur to us all as improvers of our instruments of observation. Sir W. Thomson has likewise adapted his electrometer to the wants of meteorology. Dr. Roscoe has given us a self-recording actinometer, but a good instrument for observing the sun's heat is still a desideratum. It ought likewise to be borne in mind that the standard mercurial thermometer is by no means a perfect instrument.

In conclusion, it cannot be doubted that a great generalization is looming in the distance—a mighty law we cannot yet tell what, that will reach us, we cannot yet say when. It will involve facts hitherto inexplicable, facts that are scarcely received as such because they appear opposed to our present knowledge of their causes. It is not possible perhaps to hasten the arrival of this generalization beyond a certain point; but we ought not to forget that we *can* hasten it, and that it is our duty to do so. It depends much on ourselves, our resolution, our earnestness; on the scientific policy we adopt, as well as on the power we may have to devote ourselves to special investigations, whether such an advent shall be realized in our day and generation, or whether it shall be indefinitely postponed. If governments would understand the ultimate *material* advantages of every step forward in science, however inapplicable each may appear for the moment to the wants or pleasures of ordinary life, they would find reasons patent to the meanest capacities for bringing the wealth of mind, now lost on the drudgery of common labors, to bear on the search for those wondrous laws which govern every movement, not only of the mighty masses of our system, but of every atom distributed throughout space.—*Nature.*

## SUICIDE IN LARGE CITIES.

By ALLAN McLANE HAMILTON, M. D.

THE increased importance attached to the study of the relations of mind and body (the impetus to such study we have to thank Mr. Maudsley for) enables us to pursue our examination of certain psychical states to greater advantage than in former years. The investigation of suicide is now made much more clear as regards both the motive, behavior, and characteristics of the individual who takes his own life, and by the antecedents of his previous health, and other physical influences.

The object of this paper is to discuss the prevalence of this crime in large cities, its causes both moral and physical, and certain sanitary conditions which affect them. My observations have been made for the most part in New York, the largest city of the continent, and, as the most cosmopolitan, it offers an interesting field for research. I have made comparisons between the statistics of London and Paris, and, although it is impossible to obtain the most recent records of these two cities, I think a few hints may be gained that will be of value in preventing its increase. Statistics do not give us definite information upon the questions of heredity, cerebral injuries, neuroses, or other valuable aid in drawing conclusions, so that many important links are left out of the chain.

In all large cities the number of suicides is governed, to a great extent, by the habits, tastes, and moral culture of the people, and, back of this, by the national characteristics. For example, the French, notorious for their indifference to life, their general volatility, frequent political troubles, and exaggerated morbid sentimentality, are celebrated for the propensity to end life by their own hands.

Paris has been, and always will be, celebrated for the prevalence of this crime. The late Forbes Winslow, in his "Anatomy of Suicide," called particular attention to this national failing of the French. They pursue it as an agreeable mode of getting relief from their troubles, and, from the statesman, who blows his brains out to escape political disgrace, to the *grisette* of former days, who shut herself up with her little pan of charcoal, to seek oblivion from her ruin, the crime is a general one. Montesquieu, on the other hand, asserted that the English are notably a suicidal race, and that London, with its fogs and cheerlessness, is more of a city for suicides than Paris. Forbes Winslow denied this, and demonstrated that fogs had no influence whatever upon suicides; or, at least, that there were fewer suicides in foggy months than in more pleasant ones. Our own statistics substantiate this, as will be shown further on, and the months of April, May, June, July, and August, really the most pleasant of the year as regard sunshine, are those in which more people kill themselves.

The gravity and stolidity of the English people would rather show in their favor as regards this crime. In the year 1810 the number of suicides in London amounted to 188. Comparison with French statistics of the same year proved that five times as many Parisians as Londoners took this means for ending their days. French statistics show the excessive mortality from this cause. In the year 1806, 60 suicides were reported in Rouen, an extremely small city; in 1793, 1,300 in Versailles. Paris, from 1827 to 1830, furnished 6,900 suicides, an average of nearly 1.8 per year. In recent years, we have better statistical returns to work upon.

In the year 1858 the population of London was 2,720,607, and the number of suicides 283. The youngest of these was ten years, and the oldest eighty-five. In Paris, in 1853, the population was 1,053,262. There were 463 suicides, an immense number in excess of London several years later. In Turin, from 1855 to 1859, there were 108 suicides, making an average of 21 a year. In Rome, in 1871, there were only 15 suicides, showing that self-murder is very uncommon among the Italians. In the city of New York, between the years 1866 and 1872, there were 678 suicides, being an increase of 100 in the last year over the first; 511 males, 167 females. For the three years, 1870, 1871, and 1872, there were 359 suicides, 132 being Germans, a very large percentage. As regards matrimonial condition during these years, I find there were 17 married persons, 118 single, 43 widows and widowers, and 27 whose condition was not stated: 275 were males and 84 were females; the age of the oldest was eighty-six, and that of the youngest ten.

The cause for the suicide of the latter was remarkable. She was detected in a theft of fifty cents, by her mother, and, to seek escape from her shame, took Paris-green. The months in which suicide was most prevalent were those of summer. In August, 1870, there were 15 suicides, while in December only 7. In June, the following year, there were 14, and July of 1872 shows 20, and December only 4.

In regard to occupation, clerks commit suicide the most frequently, about 34 in 1870, 1871, and 1872, and but 10 laborers in the same time. The percentage of laborers abroad is greater than any other. The mode of suicide most often employed in the city of New York is that of poisoning—212 out of nearly 600 persons have died from some form of poisoning. The preference seems to be for arsenic; usually its commonest form—Paris-green. In 1872, of 50 poisoning cases, 22 took Paris-green; the others chose either opium, carbolic acid, or other irritants. In 1871, 14 took Paris-green. Nearly all of the suicides chose violent and painful poisons, there being but few exceptions. One individual ended his days by hydrate of chloral; the other, a druggist, with prussic acid. Three took chloroform. Shooting ended the lives of 147 persons; 135 hung themselves. In only one or two instances was any ingenuity shown in the suicides: one of these individuals first shot himself, and then jumped out of the window; the other threw himself in front of an advancing locomotive. In London, hanging seems to have been the method most in vogue, for, in the year 1858, 56 persons perished in this way.

A. Brierre de Boismont, in his "Recherches Médico-Légale sur Suicide," Paris, 1859, collected 4,595 cases, carbonic-acid gas and drowning being the favorite modes for self-murder with men, and strangulation with women. Of 463 suicides occurring in the year 1853, 92 men perished by carbonic-acid gas, 93 by drowning, and 131 women died by strangulation. The more ancient statistics show that voluntary starvation was a common form of suicide in the beginning of this century. The motive for suicide in the reported cases was extremely difficult to discover. Of the 463 cases in Paris in 1853, insanity produced the suicide of 53 men, 37 women; drunkenness, 48 men, 14 women; misery and grief, 20 men, 8 women; disappointed love, 28 men, 20 women; shame, 18 men, 9 women; domestic trouble, 18 men, 15 women; weariness of life, 20 men, 7 women; disease, 27 men, 19 women; fear of the law, 16 men, 2 women; ill-luck, 23 men, 14 women; trouble with parents, 5 men, 5 women; loss of situation, 8 men; loss of parents, 1 woman. By this table, it will be seen that insanity causes the largest number of suicides, both of men and women; drunkenness comes next, and disease third.

In regard to the form of suicide with fire-arms, Boismont shows, by a carefully-arranged table, that the greatest number shoot themselves in the mouth, seventy-five per cent. choosing this means.

Out of 368 cases, 234 shot themselves in the mouth, 71 in the abdomen and thorax, 26 in the temple, and but 1 in the ear, thus showing a knowledge of the vital parts of the body. In illustration of the coolness and resolution of these suicides, he found that 85 left wills. The chirography of letters and various communications written before death was steady and natural, not betraying any signs of weakness, trembling, or irresolution on the part of the writers. Parisian statistics prove that of 3,518 cases, 2,094 occurred in the daytime, 766 in the evening, and 658 at night, proving that daylight is most agreeable for this kind of work. The ages at which suicide seems to be most often resorted to are between forty and fifty among the men, and forty-five and fifty-five among the women.

The greatest number of suicides in the city of New York, as I have said, are by poison, and this mode of self-destruction being the favorite one, we are naturally led to inquire why it should be so. When we take into consideration the looseness of our present laws regarding the sale of poisonous drugs, and the comparative ease by which suicides can procure the agents for their destruction, we have very little cause for wonderment. The number of cases of accidental death which have occurred through the criminal carelessness of certain druggists, who deal the most deadly drugs to persons unknown to them, is worthy of serious comment. There appears to be no difficulty for the would-be suicide to buy just what poison he desires. A large proportion of the inhabitants of great cities are confirmed in certain pernicious habits. Among them are opium-eating and chloroform-taking, which they pursue to what extent they choose, as these articles are always to be had.

It is needless to say that the opium-habit, like alcoholism, frequently leads to self-destruction.

In this country, upon several occasions, certain individuals have taken their own lives after insuring them, that the policy might be paid to the family of the suicide. This is an example of a very interesting psychical condition. Alcohol and its secondary effects have swelled the number of suicides, and the victims who have died by their own hands have been equally of the higher and the lower classes in this country. I think a great increase in the returns of mortality of this especial variety of suicide would be observed if the reporting physicians would conscientiously state the cause of death. The shame attached to the procedure, particularly among people of position, has prompted the return to be made of "meningitis," "cerebral congestion," or other diseases. Within the last two years, I can call to my mind the suicide of six people of high social position, caused by drink. This vice is perhaps not entirely characteristic of large towns, but the facility for indulgence of the habit, and the numerous ways of drinking in private, are more perfect in the cities.

In smaller places, there is a certain amount of contact with one's fellows, which makes him the cynosure of all eyes, should he indulge too freely. As I have before said, the busy life men lead in the metropolis, and the necessity for brain-stimulus, accelerate the *facilis descensus*. The disgrace of men in high position, impending ruin and other facts, will often prompt suicide as a mode of relief.

A form of suicide which figures largely in American statistics is, jumping from an elevation. This may be chosen by the individual as an effectual method, if he hesitates to select one, or may be the result of a momentary state of delirium produced by the surroundings. This latter is a common form in some European cities that contain high churches, monuments, or towers. I have myself experienced a morbid desire of this character, after an ascent of the Mountain Corcovado, in the harbor of Rio de Janeiro. When looking over a steep precipice upon this bay, two thousand or more feet below, I felt a strange restlessness and distention of the blood-vessels, with an irresistible desire to leap out into the clear air. This disappeared when I looked upon some object near by. A medical friend relates a case in his own experience. He went with an acquaintance up into a very high, unfinished public building. There was no evidence of insanity in his acquaintance. When my friend's back was turned, his companion jumped far out into the air, and fell mangled to the sidewalk. In France this form of suicide is a very common one, 45 individuals in the year 1820 having precipitated themselves from heights. In the year 1852, 16 men and 19 women chose this means of self-murder. So prevalent were those suicides, that the authorities refused admission to the Column Vendôme. As I have before said, this method is not an unusual one. In New York, between the years 1866 and 1872, there were 21 victims.

Dr. C. P. Russell, of New York, has informed me of a friend who is to such an extent the subject of the impulse to throw himself from heights, that he will never sleep upon the third or fourth floor of any dwelling.

The impulse to commit suicide with sharp-cutting instruments has been more common in the European cities than those of this country, and, in the majority of instances, suicide by these weapons has been resorted to by insane subjects.

A most important study in connection with this subject is the influence of the mode of life of the poorer classes. I allude more particularly to the tenement-house system—to the colonization of many thousand people in a limited space, much too small for them. They are brought together so, that every vice becomes, to a great degree, contagious. Bad examples are followed by the younger generation, and it is much easier for a seed of sin to take root here than one of virtue. Families of several nationalities are closely packed together in front and rear houses. Ground and labor are so expensive, in the larger cities particularly, that this mode of living is unavoidable.

Despite the earnest efforts of an efficient health board in the city of New York, many radical defects exist, and ventilation, light, and drainage, are defective in the extreme. Diseases of the nervous system, principally of the trophic character, exist to a great extent, as results of imperfect lighting and ventilating.

In the five years preceding 1872 the deaths from nervous diseases in New York averaged 3,155.8, and for the years 1871 and 1872 were over 6,000, an unusually large proportion, the number of deaths from all causes being 59,623. The vices attending the colonization of the working-class (a great many do not work) are contagious, the moral contact of the vicious with the pure is certain to occur, the ruin of young girls, and depression of tone, are powerful inducers of suicide.

The American people partake of the characteristics of their transatlantic brethren. They are impulsive, energetic, enterprising, emotional, liable to excessive mental depression or exaltation. We have all the different bloods of Europe in our veins. We lead, however, an individual life of our own, a life as original and striking as other startling peculiarities of our country. We live too fast; we make and lose fortunes in a day; we acquire professional educations in a few years which take ordinary individuals as many more to get the rudiments of in Europe. It is any thing but *festina lente* here. The seeds of every national soil are sown, and take root before we can employ measures to suppress them. Every thing that can excite the emotions, make tense the mental faculties, and suddenly relax them, is among us. Speculations and stupendous schemes, which in older countries take several heads instead of one to mature, crush down the nervous system of men who work themselves to death, hardly taking time to eat, meanwhile living upon stimulants to enable them to stand the strain.

There is another class—I allude to the poor. The newspaper accounts of the miserable suicide in his upper attic tell this story every day. These subjects are chiefly foreigners, deluded to this country by unfounded expectations of fortunes to be made.

Only a few days ago I read in one of the daily papers that it was not an uncommon occurrence for immigrants to ask of the officials at Castle Garden, in perfect good faith, positions as insurance officers, bank officers, and other unattainable positions.

Many thousand Italians were sent here by rascally agents in their own country several years ago. They were promised work by these individuals, but on their arrival found none. They reached New York in mid-winter, and many of them found their way into the workshops and almshouses. Misery and suffering were prevalent. Among immigrants, particularly the Germans, there is a great disposition to suicide, and physical suffering doubtless awakens any hereditary tendency that may lie dormant. A great percentage remain at the seaport, looking for work. New York is particularly affected in this way. Immigrants come here, probably in most instances from occupations much more steady and remunerative in comparison to any found here; tradespeople, skilled workmen, and mechanics, often commit suicide, who find it difficult to obtain employment, and finally hunger and disappointment drive them to this step.

The prevalence of strikes, and trades-unions, with their dangerous restrictions and foolish oaths of allegiance, are fruitful causes of suicide. Men are afraid to work in opposition to the threats of their fellow trades-unionists, and, as poverty stares them in the face and they become desperate, they commit suicide.

A necessary attendant upon increase in population is immorality, engendered by vice attendant upon civilization. The more depraved forms of theatrical amusement found at the low theatre halls, two or three of which now exist in New York, wipe out all of the original purity from the nature of the weak-minded spectators. The low songs at some of these places, abounding in *double entendres* and suggestive gestures, inflame the dormant instincts of lust in the minds of the deeply-interested audience.

Prostitution is a very easy way leading to suicide. The attendant vices of this class very soon destroy the mind. Opium-eating, inebriety, and snuff-chewing, are habits which nearly all prostitutes follow after a time. The classification of these causes of suicide and their victims is very incomplete, and prostitution is placed on the records in only one instance in 1871, 1872, and 1873, as the calling of the individual.

The prevalence of seduction in large cities is perhaps greater among the lower classes—the workers in factories and shops. Indeed, the chance for this crime among the many thousand young girls and men who are herded together indiscriminately in the large tobacco, hoop-skirt, paper-box, and other factories of great cities, is often made use of. Suicide follows ruin, though not in as many cases as it would in France. I do not doubt but that the large rivers, upon which most American cities are built, give up a great many bodies of unfortunates who end their moral ruin by suicide. In fact, the number of cases reported as "found drowned" may be assumed in general to be suicidal.

In our own cities, as I have before shown, clerks seem to be the class that most often take their own lives. This seems reasonable when we consider the peculiar careers of a great many of them—the temptations of vice, the struggles for situation and support, and the pitfalls of a large city.

How shall we prevent the increase of this crime which advances at the rate of 300 per cent. in seven years? What sanitary measures can be taken to defeat its moral and physical causes?

It is a stupendous undertaking. To reduce its statistics would require an attack upon our whole social system.

I have pointed out the rapidity of our way of living, the excessive and unnatural strain upon the brains of business and professional men. To diminish this would be an almost impossible task. I can only suggest a diminution of working hours, the necessity for regular meals and habits, and means to prevent large cities from being overstocked by the agricultural classes, who imagine themselves in these days particularly fitted for business and professional pursuits. We should abolish immoral entertainments, advertising quacks, so-called anatomical museums, and obscene and sensational literature, as far as possible.

Legislation should strictly regulate the sale of poisonous drugs, and the police should enforce the laws. Friends and relatives of excitable and nervous persons should be alive to the necessity of keeping from their reach razors, cutting instruments, and poisons. They should also endeavor, as far as possible, to prevent the formation of the opium-habit, self-administration of chloroform, and alcoholic indulgence.

Careful watch should be kept on all persons who go up into high public buildings, church-spires, and other eminences. Physicians should employ caution lest their patients should habitually indulge in some narcotic drug originally prescribed. The boards of health of the different cities cannot be over-zealous in suggesting means for the improvement of the dwellings of the poor. Air, light, and ventilation, should be provided, if possible, for these are absolutely necessary for nervous development and healthy cerebration. I have always considered the system of small dwellings, that has succeeded so well in Philadelphia and other cities, an inestimable boon to the working-classes. A healthier moral and physical tone is engendered, both by elevating the self-reliance of heads of families, and the abolition of moral contamination so prevalent in tenement-house life.

The establishment of bureaus and other agencies for procuring work for immigrants, freeing the cities from the surplus of these people, would prevent much desperation, misery, and self-destruction.

## A HOME-MADE MICROSCOPE.

By JOHN MICHELS.

THE progress of science in recent times is in a great degree due to the employment of instrumental aids to observation; and whoever wishes to keep up with this advance, or indeed to gain an adequate notion of its extent and interest, can only do so by the use of similar means. In the study of chemistry, experiments and actual observation of the behavior of substances under various conditions, are indispensable; in physics, multifarious appliances for the illustration of principles are constantly required; in astronomy, the telescope is absolutely essential; and, in biology, vast departments can be brought within our reach only by the aid of the microscope. This latter instrument, especially, has a wide range of application. The investigations of the anatomist and physiologist cannot go on without it; the educated physician has it in daily use; the tradesman finds it an important aid in testing the purity of commodities; and the student in many departments of physical science is obliged to use it in his work. When to all these considerations we add that the manipulation of the microscope, for the purpose of ordinary observation, may be acquired without much difficulty, and that the instrument itself may be procured at a moderate cost, we have said enough to justify the assertion that every educated person ought to possess a microscope, even as he possesses a collection of books.

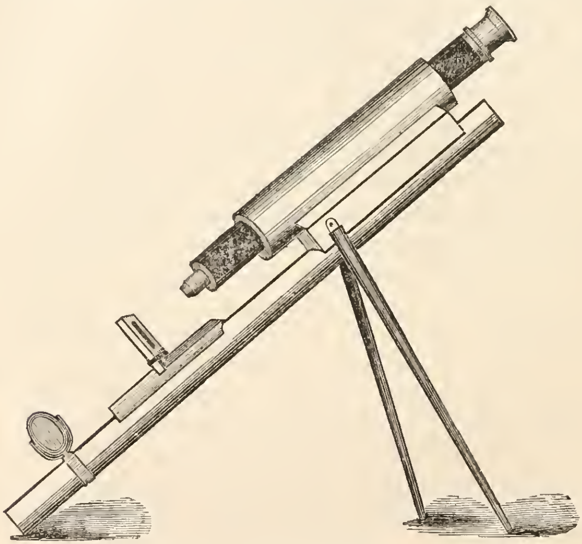


Fig. 1.—Complete Instrument.

To derive advantage from the use of the microscope, it is not necessary that one should master all the technicalities of the instrument, or be possessed of all the improved appliances for extremely minute observations. Professional microscopists have recognized the error of directing all one's efforts on such tasks as the resolution of test-plates, so long as really urgent work remains undone. Thus, the President of the "Quekett Microscopical Society" remarked:

"Our opticians have gone ahead of the observers, they have placed in our hands powerful means of research. I fear the account of the talent committed to our charge will not be one of which we may be proud. I fear we are too apt to pride ourselves as being the possessors of superior instruments; each man pits his instrument in rivalry against his neighbor's, and rejoices that he can beat him in the resolution of Nobert's test-plate."

Mr. Le Neeve Forster, in the above remarks, doubtless strikes at the root of an evil that is fast becoming a nuisance, to the utter detriment of useful and sound work; the test-slide and diatom fever has spread like an infection among all classes of microscopists, and has resulted in an extravagant system of expenditure foreign to true scientific research. I find that $1,650 is now asked for a first-class instrument and fittings, and as much as $40 apiece for diatom-slides.

These eccentricities of leading microscopists appear to have received protests from various quarters, for the President of the Royal Microscopical Society, in his last address, states:

"It has been cast at us, as Fellows of this Society, that we do nothing but improve our tools, or measure the markings on the frustules of a diatom." [1]

One reason for the confessed poverty of microscopical results may be ascribed to the want of sufficient workers to cover so vast a field of research. It is to be regretted that many professional men, whose occupation would seem to demand the daily use of the microscope, deny themselves the facilities it offers. I apprehend that the explanation of this apparent neglect will be found in the high price asked for first-class instruments, and the absence in the market of a good standard instrument that combines the advantages of being of the best workmanship, full-sized, portable in form, and moderate in price.

Messrs. Baker, Crouch, Collins, and especially Swift, all of London, produce such microscopes, but, as their importation doubles the cost, their chief merit of cheapness is lost. In our own country, opticians have proved that they can produce work that cannot be surpassed, provided that their patrons entertain the same views as Sir Charles Surface respecting the expense; but those of more moderate means, who wish to purchase a good working microscope at a moderate cost, are offered a pretentious display of foreign and domestic forms, totally unfit for professional or scientific use. If makers of microscopes would take a lesson from the best telescope-makers, and, instead of multiplying the number of their models, combine their energy in the production of a good standard instrument, filling the conditions that I have already stated, they would promote the cause of science and concentrate their business.

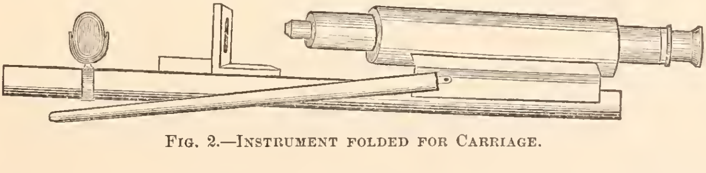


FIG. 2.—INSTRUMENT FOLDED FOR CARRIAGE.

Those who have read the biographical and obituary sketches of eminent microscopists have probably noticed that it was a favorite pursuit with many of them to make their own instruments. In the

[1] February 3, 1875.

*Monthly Microscopical Journal*, for March last, will be found such a notice included in the address of the President of the Royal Microscopical Society, referring to the death of a Fellow, Mr. John Williams, who was also Assistant Secretary of the Royal Astronomical Society. He said:

"He constructed more than one microscope out of odds and ends, which he put together with much skill and ingenuity. His most elaborate microscope was made with cardboard tubes and brass-screw adjustments. This instrument, when supplied with objectives by Ross and others, contrasted favorably, in point of utility, with constructions of a more costly character."

The perusal of this notice, followed by a communication to the effect that in some of the London scientific schools the students are required (when practicable) to make all the apparatus they use, has prompted me to describe a microscope made by myself about six years ago, and which is now but little the worse for wear.

So far as the stand is concerned, it can be easily made at home, at a trifling cost. The materials are of a humble character, but the optical arrangements are full-sized, and of the highest quality. Within the limits of its use this instrument will exhibit objects with much perfection. By a reference to the cuts, it will be observed that many of the parts are cylindrical, and may be turned on any ordinary lathe in a few minutes.

To make a microscope such as I shall now describe, requires little mechanical skill. If my directions are followed, and strict attention given to the drawings, no difficulty will be encountered, but neatness and precision are of course essential. First provide a wood rod about 15 inches long, and of the circumference of Fig. 3.

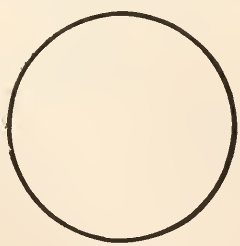


Fig. 3.

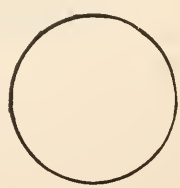


Fig. 4.

Then take some paper of firm texture, and wind it around the rod three or four times according to its thickness, applying mucilage all the time; immediately withdraw the paper casing, and place on one side to dry. This should form a perfectly true and firm tube. When dry, replace it on the rod, and with a sharp knife cut off from each end sufficient to leave the remainder $7\frac{1}{2}$ inches long.

The other parts are of wood. I suggest mahogany as the most appropriate, and susceptible of the best finish; but any well-seasoned, hard wood will do.

To proceed, make a rod, like an ordinary ruler, 13½ inches long, and of the diameter of Fig. 4. Now turn, or get turned, a tube, 4½ inches long, the walls of which shall be ¼ of an inch thick; Fig. 5 will give the diameter.

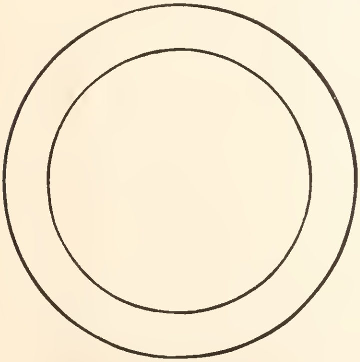


FIG. 5.

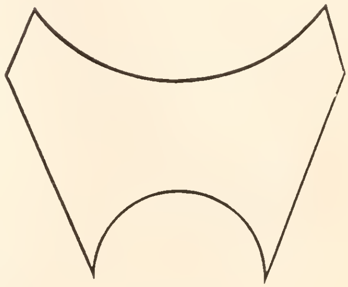


FIG. 6.

A part which I call the cradle can now be made; the form is shown in section, at Fig. 6; its length must be 3¾ inches.

The support for the stage requires no special explanation; a full-sized drawing is given at Fig. 7.

The stage itself can be made of wood, but gutta-percha is better,

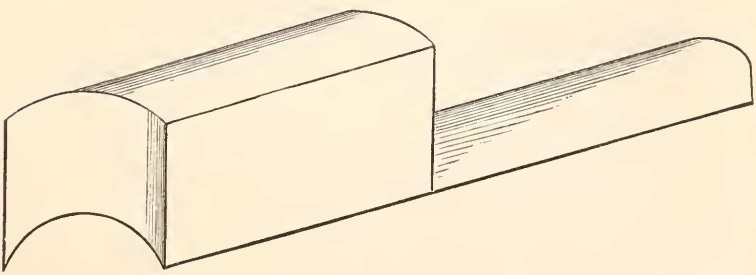


FIG. 7.

and, if placed in hot water, it can afterward be easily moulded to the pattern given at Fig. 9.

Smooth the surface while still warm with glass plates, and steady the back with two strips of wood. The shaded part at the lower edge shows a piece of wood fixed thereon to support a zoöphite trough or glass slides. Fig. 10 represents the upper and lower parts of a leg, two of which are required, 9¾ inches long, and the size shown in cut. On the upper portion the brass hinged attachment is fixed.

The appearance of the paper tube, with eye-piece and object-glass in position, can be seen at Fig. 11.

The parts which have been already described being completed, proceed to fix them together with glue. Their correct position can be seen at a glance by reference to Fig. 12.

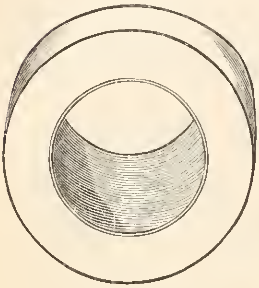


Fig. 8.

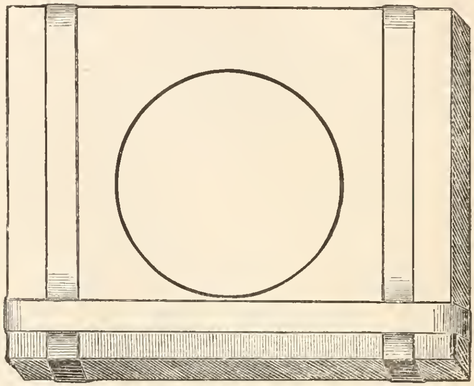


Fig. 9.

First fix the cradle, 6, upon the rod, 4—within three-quarters of an inch of the end—next the tube, 5, upon the cradle, as shown. The stage and support can next be fastened, but first insert the paper tube, Fig. 11, in wooden tube, 5, and measure the most convenient

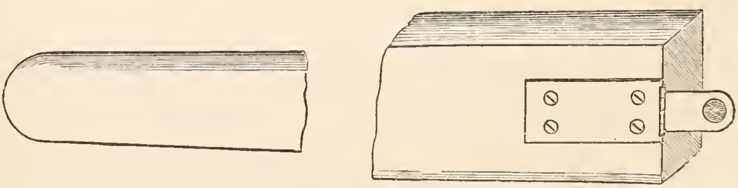


Fig. 10.

place to fix the stage, so that the object-glass can approach the object without bringing the tube too low down. A trial will at once fix the proper spot.

The legs are attached by screws to the cradle, as seen in Figs. 1 and 2. The whole being now in form, clean and French-polish.

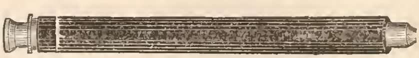


Fig. 11.

Also paint the inside of the paper tube a dull black, using drop-black, turpentine, and a little Japan varnish to fix color, and the outside with a mixture of Indian and common inks. Finally, line tube, 5, with a piece of fine cloth. If this is neatly done, the paper tube,

Fig. 11, will pass and repass as smoothly as the motion of a telescope, which is controlled in a similar manner.

There is no reason why the optical parts should not be made by the student, but necessary instructions would require a series of articles. Assuming, therefore, that such portions will be purchased, a few words on that head may be necessary.

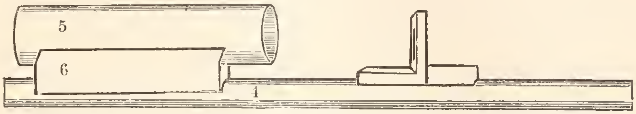



FIG. 12.

If only one eye-piece is required, select letter B. Next take tube, Fig. 11, to an optician, and ask him to fit a Royal Microscopical Society screw, Fig. 8, in the centre of a wood block. This block and screw must be fastened into one end of the paper tube, and will carry the object-glass.

The last fitting will be the mirror, a reduced drawing of which is shown at Fig. 13.

The mirror should be at least two inches in diameter, and the ring which passes over the rod, Fig. 4, should be split, and about half an inch in breadth, and, being made somewhat too small, will grip the rod, and be free from unsteady movement.

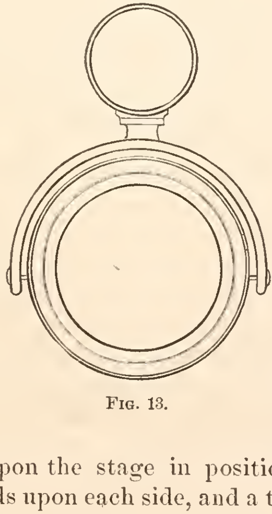


FIG. 13.

To hold the slide upon the stage in position, pass two moderate-sized India-rubber bands upon each side, and a third crosswise near the bottom; a very delicate movement can be given to a slide thus held.

In regard to object-glasses I have little to add. Such as I should have specially recommended are not to be obtained in this country;

but, to commence operations with, purchase the best 1-inch and $\frac{1}{2}$-inch your means will permit. I much regret that the objectives made by Gundlach, of Berlin, are not introduced. It would be a boon to those who cannot afford to purchase the best glasses. I have seen them tested at the Royal Microscopical Society with the most costly objectives, where their performance has elicited the highest praise. When I state that an immersion $\frac{1}{16}$ costs in London but £3 10*s.*, the price of the low powers can be calculated.

These $\frac{1}{16}$ths have wonderful definition, and can be used upon all slides, having the ordinary thin glass cover, a great advantage. Such a glass could be sold here for thirty dollars, and the 1-inch and $\frac{1}{2}$-inch for about ten dollars apiece. Except for special work, these objectives answer every purpose. The sketch at Fig. 1 is a correct drawing of the complete instrument, in position for use; and at Fig. 2, the same folded, showing its convenience and portability. The whole weighs about a pound, and can be carried, with eye-piece and object-glass ready for use, either in a bag or a light box 14 × 3$\frac{1}{2}$ × 3 inches.

Those who possess very large instruments will find this model a most useful addition for occasional use when traveling or demonstrating subjects away from home.

This form of microscope is offered as convenient for beginners, who, unable to purchase a complete instrument, still wish to make a beginning and start upon a right principle. Although a complete microscope can be purchased for about the same amount that the optical portions of this will cost, it will be wanting in the chief essentials of a good working instrument. Diminutive size, smallness of field, poor light, shortness of tube, absence of Society's screw, and other evils, will soon cause it to be cast aside, resulting in the loss of the original outlay; whereas the parts purchased under the above directions are portions of a first-class instrument, obtained in advance, which will never become obsolete.

The immense field of inquiry within the grasp of the microscopist is apt to disconcert and confuse the student. His course, however, should be well defined. First let him familiarize himself with what has been done by others, and then confine his attention strictly to those subjects which have reference to his profession or pursuit. If he has no special occupation, I would advise him to select a particular line of study, and let that be the thread on which to string his subsidiary matter, mounting his own objects, and carefully registering his observations. He will thus slowly but surely accumulate knowledge that will benefit the cause of science.

## IS ALCOHOL A FOOD?

CORN and wine were deemed indispensable to man from the remotest antiquity, just as beef and beer are so considered by the Briton; and scarcely a people has existed who did not possess a fermented liquor of some kind—all ascribing to it exalted virtue, such as befits the gift of the gods, as all believed it to be—not only from the bodily comfort and invigoration which it imparted, but also from its mysterious effects in the transient madness which it is capable of producing. Among all nations, consequently, wine, or alcoholic drinks of some sort, has always had its poets or its minstrels; and, had the ancients been acquainted with alcohol, or the essential product of fermentation as *we* know it, doubtless they would have made it the symbol of the soul, for which nothing could be more appropriate; for it is an *invisible power*, hidden in a grosser body, which it influences in every part, and from which it finally escapes into the "heaven above"—gone forever! Nor is that all. The analogy may be extended to the *qualities* of that image of the soul, which are good and bad united, as in other mystic unions. Had the ancients possessed this knowledge of the distinct yet intimately combining principle, it might have given more significance to their devotion when they poured libations to their gods—but how much greater would have been their sense of awe and wonder, had they known what the physiologist knows at the present day! Let us glance at this truly mysterious agent in action.

Alcohol is ever ready to enter the animal system. It can be introduced under the skin or into a vein. Exalted by heat into the form of vapor, it may be inhaled by man or other animal, when it will penetrate into the lungs, will diffuse itself through the bronchial tubes, will pass into the minute air-vesicles of the lungs, will travel through the minute circulation with the blood that is going over the air-vesicles to the heart, will condense in that blood, will go direct to the left side of the heart, thence into the arterial canals, and so throughout the entire body.

Again, when taken in by the more ordinary channel, the stomach, it finds its way by two routes into the circulation. A certain portion of it—the greater portion of it—is absorbed direct by the veins of the alimentary surface, finds its way straight into the larger veins, which lead up to the heart, and onward with the course of the blood. Another portion is picked up by small structures proceeding from below the mucous surface of the stomach, and from which originate a series of fine tubes that reach at last the lower portion of a common tube, termed the thoracic duct—a tube which ascends in front of the spinal column, and terminates at the junction of two large veins on the left side of the body, at a point where the venous blood, returning from the left arm, joins with the returning blood from the left side of the head on its way to the heart. It is so greedy for water that it will pick it up from all the watery textures of the body, and deprive them of it, until, by its saturation, it can take up no more, its power of reception being exhausted; after which it diffuses itself into the current of circulating fluid. When we dilute alcohol with water before drinking it, we quicken its absorption; and, if we do not dilute it sufficiently, it is diluted in the stomach by the transudation of water in the stomach, until the required reduction for its absorption is effected.

Now, after an investigation of a very elaborate character, Dr. Anstie and Drs. Thudichum and Dupré have satisfactorily proved that only a very small portion of the spirit which is taken into a living body is expelled out of that body as alcohol, in the secretions, and that there must be some other means by which the spirit is disposed of in the system. In one very remarkable and memorable experiment, Dr. Anstie gave a dog, weighing ten pounds, the liberal dose of two thousand grains of alcohol in ten days, and, on the last day of the ten, he administered ninety-five grains of the spirit as a final dose, and then two hours afterward killed the dog, and immediately subjected the whole body—blood, secretion, flesh, membranes, brain and bone—to rigorous analysis, and he found in the whole texture of the body only about 23½ grains of spirit. The other 1,976 grains had clearly, therefore, been turned into something else, within the living system.

These experiments directly refer to our query—the settlement of the food-power of alcohol as a doctrine of physiological science.

Before reasoning out this proposition, we must state certain facts which it seems impossible to reconcile with any other theory than that alcohol is a food. Dr. Anstie relates the case of an old soldier who was under his care at the Westminster Hospital in 1861, who had lived for twenty years upon a diet composed of a bottle of unsweetened gin and "one small finger-length of toasted bread" per day and who maintained the structures of his body for this long period upon that very remarkable regimen. Similarly an old Roman soldier admired by the Emperor Augustus, when asked how he managed to keep up such a splendid development, replied—*Intùs vino, extùs oleo*—"With wine within, and oil without."

Dr. Robert D'Lalor tells us that some thirty years ago, in foreign climes and in unhealthy districts, he lived for two years upon wine and brandy, with very little solid food; and at the end of the period was neither perceptibly poisoned, starved, nor emaciated. Laborers, navvies, coal-heavers, and others, who take no beer, eat nearly as much again as those who take a moderate allowance of beer. Dr. D'Lalor declares that he knows many vigorous and healthy men in London, not only waiters, potmen, publicans, and the like, but tradesmen and merchants, who eat but little solid food, but have plenty of wine, porter, gin, etc.

Liebig stated that, in temperance families where beer was withheld and money given in compensation, it was soon found that the monthly consumption of bread was so strikingly increased that the beer was twice paid for—once in money, and a second time in bread. He also reported the experience of the landlord of the Hôtel de Russie, at Frankfort, during the Peace Congress; the members of the Congress were mostly teetotalers, and a regular deficiency was observed every day in certain dishes, especially in farinaceous dishes, pudding, etc. So unheard of a deficiency, in an establishment where for years the amount of dishes for a given number of persons had so well been known, excited the landlord's astonishment. It was found that the men made up in pudding what they neglected in wine. Finally, every one knows how little the drunkard eats.

Again, in cases of disease, there are numerous instances which it is difficult to refer to any thing but the food-property of alcohol. Dr. Anstie refers to one very instructive case of the kind, which also came under his care in 1861, and which obviously left a great impression upon his mind. A young man, only eighteen years of age, was so reduced by a severe attack of acute rheumatism, that he was unable to retain food of any kind upon his stomach. He was sustained for several days upon an allowance of twelve ounces of water and twelve ounces ($\frac{3}{4}$ pint) of gin per day. His recovery under this treatment was very rapid and complete, and almost without any trace of the emaciation and wasting that ordinarily follow upon such a disease. The lad, previous to this illness, was of a strictly sober and temperate habit, and, during the use of gin, the abnormal frequency of the pulse and of the breathing came gradually down to the proper standard of ordinary health; and there was never at any time the slightest tendency to *intoxication*—which is a very notable point in such cases.

Dr. D'Lalor, before quoted, also mentions the case of a child only fourteen months old, suffering from inflammation of the lungs, and whose stomach could retain nothing but port wine. For twelve days it subsisted entirely upon wine; it was rapidly cured, with no wasting of any account; nor, although it drank large quantities of alcohol, was it ever intoxicated.

These cases are very important on account of their exceptional character; but they are quite in accordance with the well-established power of brandy and wine to sustain the life of sinking men in the critical periods of exhausting fevers; and they afford ground for the familiar and popular belief that there is support in wine and spirituous drink—as held of old and exemplified in the well-known recommendation of St. Paul to his ailing disciple.

Dr. Anstie's conclusion from such evidence, and from a very large hospital experience, is that, beyond all possibility of doubt, pure alcohol, with the addition of only a small quantity of water, will prolong life greatly beyond the period at which it would cease if no nourishment is given; that, during the progress of acute diseases, it very commonly supports not only life, but also the bulk of the body, during many days of abstinence from common foods; and that, although the physician and physiologist fail to explain chemically how it is that the result is brought about, it may, nevertheless, be safely affirmed that the influence exerted over the body by alcohol is, essentially, of a *food-character*.

"It may be well," observes a writer in the *Edinburgh Review*, "for even advanced and accomplished physiologists to bear in mind that there may be 'more things in heaven and earth than are dreamt of in their philosophy.' There would at least be nothing more startling in the discovery that the physiological dogma which affirms that the products of the reduction of complex organic substances (such as alcohol) cannot be employed as the food of animal life had to be *reconsidered*, and in some particulars reversed, or revised, than there has been in the recent reversal of the Liebig dogma, that *nitrogenous* principles alone can be used for constructive purposes, and the simpler hydrocarbons alone for the production of animal warmth."

And, in this point of view, Dr. Anstie argues that many substances which are ranked as even "poisonous" to the system must not be taken to be absolutely "foreign" to the organism, except in a relative sense, when even such agents as mercury and arsenic, given in small doses for long periods, produce what is termed a tonic influence, improving the quality of the blood and the tissues, and do this in such a way that it is scarcely possible to maintain that they contract no organic combination.

Dr. Anstie frequently dwells on the notable fact that in all cases of disease where alcohol is used successfully as a medicinal support—as in the case of exhaustive fevers—its presence as an alcoholic emanation, whether in the breath or in other secretions, is absent altogether, as if, in those cases, the whole force of the agent was absorbed in its beneficent operation. He also declares that in such instances its exciting and intoxicating powers appear to be in abeyance, and that the recovery from acute disease where this medicine has been successfully employed is invariably more rapid and complete than it is in altogether similar cases which have been treated without alcohol.

If alcohol be *only* a heat-producing food, it may be remarked that nowadays Liebig's well-known theory is no longer absolute, since it is established that great labor may be performed for a short period without the use of a nitrogenous diet—that is, with one exclusively carbonaceous. Hence, perhaps, the claim of alcohol to constitute a food. Although forming none of the constituents of blood, alcohol limits the combination of those constituents, and in this way it is equivalent to so much blood. As Moleschott says: "He who has little can give but little, if he wish to retain as much as one who is prodigal of his wealth. Alcohol is the *savings-bank of the tissues.* He who eats little, and drinks alcohol in moderation, retains as much in his blood and tissues as he who eats more, and drinks no alcohol."

But, while we thus know that alcohol supplies the place of a certain quantity of food, we do not know how it does so. It is said to be "burnt" in the body, and to make its exit as carbonic acid and water; but no proof has yet been offered of this assertion. Some of it escapes in the breath, and in certain of the secretions; but how much escapes in this way, and what becomes of what remains—in the very large proportion, in the case of the dog previously mentioned—is at present a mystery.

In Steinmetz's "History of Tobacco," p. 97, occurs the following surmise, published nearly twenty years ago, but now established as a matter of fact. He says: "I feel compelled to believe, in advance of Liebig, that *alcohol is absolutely generated in the digestive process of all animals.* Startling as the theory may seem, the consideration of corroborating facts may, perhaps, induce the reader to think it probable, if not certain. It is well known that all the vegetables we eat contain starch; all the fruits contain sugar. Now, starch can easily be converted into sugar; the process of malting is a familiar instance. . . . The natural heat of the body is precisely adapted, in the healthy state, to effect a fermentation after having changed the starch into *sugar*, which last is constantly found in the blood. That alcohol has not been found seems to result simply from the fact that it must be sought in arterial blood, or blood which has not lost a portion of its carbon *in transitu*, through the lungs in the respiratory process."

Now, it happens that Dr. Dupré, in the course of his investigations, discovered that alcohol is found in small quantity in the excretions even of persons who do not touch fermented beverage in any form—that is, the healthy system of the teetotaller *brews, so to speak, a little drop for itself.* But, if this be the case, it would seem that we have enough already in the system, and therefore there can be no need of having recourse to the bottle or the tap for more, unless the system be a prey to disease. And this applies especially to those who live mostly on vegetable or farinaceous food, who, it may be remarked, are naturally less inclined to alcoholic drinks than those who use animal food—when it becomes particularly dangerous. So that, if the Alliance and the supporters of the Permissive Bill would succeed in their aim, they should convert us all into vegetarians. To drunkards who are anxious to reform, this is a most important consideration.

In conclusion, the most reliable opinion respecting alcoholic drinks appears to be, that the relation of their actions to food is such that, when *they are required* by the system, they cause a necessity for increased food; but, when not required, they lessen the necessity for food. Now, as Dr. Edward Smith emphatically remarks, the tendency of *all* food, but particularly of animal food, is precisely in the same direction; so that the skin is drier after than before dinner, other things being equal. In like manner, the hands and feet, and the skin generally, become hot and dry after taking alcoholic drinks, and an intoxicated man in a state of perspiration would be an unheard-of phenomenon.

The direct tendency of alcohol is to diminish muscular power in a state of health, but indirectly it may have the contrary effect by improving the tone of the system through the appetite and digestion of food. In the state of body in which alcohol has reduced muscular contractibility, all the vital actions temporarily languish; and so far the action of alcohol is opposed to foods, and it is not a food.

While the food-action of beer and wine may be accounted for by their known nutritive ingredients, other than alcohol, which they contain, much difference of opinion exists as to the true action of alcohol itself, and the problem to be solved is, whether it acts physically or chemically. The known actions of alcohol in man are physical in their character, and so they are upon food immersed in alcohol, or alcohol-and-water, when it is hardened, and the process of digestion retarded.

If it has been shown that alcohol is capable of supporting a few persons, it is certain that it kills in its own way ten thousand persons a year in Russia, and fifty thousand in England; but its method of killing is slow, indirect, and by painful disease.

Finally, two things must always be borne in mind. First, we use alcohol not on account of its importance as a nutriment, but on account of its effects as a stimulant or relish; and secondly, the border-line between its use and abuse is so hard to be defined that it becomes a dangerous instrument even in the hands of the strong and wise, a murderous instrument in the hands of the foolish and weak.—*Food and Fuel Reformer.*

## SKETCH OF DR. H. C. BASTIAN.

PROMINENT among the contemporaneous explorers of biological and physiological science, the investigation of which is so active in the present age, is the subject of this notice, who, though still a young man, has achieved an undoubted eminence in the departments of study to which he has devoted himself. Dr. Bastian has done a good deal of excellent scientific work in the medical field, and has gained the wide respect of the profession; but he is more generally known by his researches into the origin of life; and is the author of perhaps the ablest work that has yet appeared on the question of the generation of the lowest animate forms. The careful readers of The Popular Science Monthly are quite aware that the subject of so-called "spontaneous generation" has latterly not only occupied the increasing attention of scientific men, but has been pushed forward by an unprecedented refinement of experimental investigation. The researches recently carried out may have settled it, or they may not, as further determinations and verifications will show; but, whatever may be the fact on this point, the inquiry has certainly been remarkably narrowed, and the whole subject placed in a new attitude, which gives better promise of a decisive solution. Dr. Bastian, as is well understood, is a leading representative of the doctrine of the spontaneous origin of the lowest living forms. He has made an extensive series of delicate and ingenious experiments which, he holds, establish the principle, and which are freely admitted to give the problem a new aspect; and in his elaborate two-volumed work on the "Beginnings of Life," and his subsequent volume on "Evolution and the Origin of Life," he has given us the most comprehensive exposition we have of the philosophy and present position of this highly interesting and important question.

Henry Charlton Bastian was born at Truro, in Cornwall, April 26, 1837. His father, a merchant, died while the son was quite young. He was educated at a private school in Falmouth; and, when about eighteen years of age, began the study of medicine with an uncle, who was a leading medical man of the town of Falmouth.

Young Bastian had already begun to acquire strong tastes for natural-history studies, principally in the direction of botany and marine zoölogy; these tastes having been much stimulated and encouraged by a retired London surgeon, Mr. W. P. Cocks, who had for some years energetically devoted himself to the fauna and flora of Falmouth and its neighborhood. Dr. Bastian recognizes a profound indebtedness to this gentleman for his influence in urging him to independent inquiry, inciting him to accept nothing on mere authority. During the three years of young Bastian's apprenticeship to his uncle, besides preparing for the matriculation examination of the University of London, he made a special study of botany, and in 1856 published "A Flora of Falmouth and Surrounding Parishes." His educational career was brilliant, and among the numerous university honors which he received may be mentioned the gold medal in botany; the gold medal in comparative anatomy; the gold medal in anatomy and physiology; the gold medal in pathological anatomy; and the gold medal in medical jurisprudence. He took his degree of M. D. in 1866, and became Fellow of the Royal Society in 1868. In 1860, Dr. Bastian became Assistant Curator of the Museum of Anatomy and Pathology under Prof. Sharpey. This office was retained for three years. In 1863, principally on account of his liking for cerebral physiology and philosophical subjects generally, he decided to devote himself to the study of insanity, with the view of becoming a consultant in London in this department of medicine. At the end of 1863 he went as assistant medical officer to the newly-opened State

Asylum for Criminal Lunatics at Broadmoor; and here for two years he carried on his investigations concerning the nematoids, which led to a monograph, in which one hundred new species were described. During this time and afterward, Dr. Bastian conducted an interesting and important series of investigations on the specific gravity of the brain. In 1866 he left Broadmoor, came to London, married, became lecturer on pathology and curator of the museum at St. Mary's Hospital Medical School. He now took up the study of the diseases of the nervous system as a whole, rather than the section of it met with in asylums. He was elected Assistant Physician to St. Mary's Hospital, and then shortly left it to accept the professorship of Pathological Anatomy and the position of Assistant Physician to the Hospital of University College. The same year he was also appointed Assistant Physician to the National Hospital for the Paralyzed and Epileptic. He has thus been in the midst of active and pressing professional studies, but Dr. Bastian has still found time for those laborious and purely scientific inquiries for which he is most extensively known. The following is a list of his chief memoirs and works, in the order of their publication:

"On the Structure and Nature of the Dracunculus or Guinea-Worm." "Trans. of Linn. Soc.," vol. xxiv.

"Monograph on the Anguillulidæ, or Free Nematoids, Marine, Land, and Freshwater; with Descriptions of 100 New Species." "Trans. of Linn. Soc.," vol. xxv.

"On the Anatomy and Physiology of the Nematoids, Parasitic and Free; with Observations on their Zoölogical Position and Affinities to the Echinoderms." "Philosophical Transactions," 1866.

"On the Mode of Origin of Secondary Cancerous Growths." *Medical Mirror*, vol. i., No. x.

"On the Specific Gravity of the Different Parts of the Human Brain." *Journal of Mental Science*, January, 1866.

"On the so-called Pacchionian Bodies." "Trans. of the Microsc. Soc.," July, 1866.

"On the Pathology of Tubercular Meningitis." *Edinburgh Journal of Medical Science*, April, 1867.

"On a Case of Concussion-Lesion of the Spinal Cord, with Extensive Ascending and Descending Secondary Degenerations." "Trans. of Medico-Chir. Soc.," 1867.

"On Cirrhosis of the Lungs." "Reynolds's System of Medicine," vol. iii.

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Also the sections on "Pathology and Morbid Anatomy" of the following joint articles (by Dr. Reynolds and Dr. Bastian) appeared in "System of Medicine," vol. ii.: "Cerebritis;" "Non-Inflammatory Softening of the Brain;" "Congestion of the Brain;" "Hypertrophy of the Brain;" "Adventitious Products in the Brain."

"Modes of Origin of Lowest Organisms." *Macmillan*, May, 1871.

"The Beginnings of Life," 2 vols., Appletons, 1872.

"Evolution and the Origin of Life," Macmillan, 1874.

"On Paralysis from Brain-Disease in its Common Forms," Appletons, 1875.

# CORRESPONDENCE.

## A CORRECTION.

*To the Editor of The Popular Science Monthly.*

SIR: Please allow me to correct some errors in the notice (on page 760 of this journal for October) of the paper on "American Ganoids," read at the Detroit meeting of the American Association for the Advancement of Science.

The *very* young gar-pike (*Lepidosteus*), less than an inch long, has only *one* tail; a symmetrical organ like that of existing *Amphioxus* and *Polypterus*, and the fossil *Glyptolæmus*.

While from one to ten inches long, the growing gar manifests a *lower lobe of the caudal*. In this state it resembles the existing sturgeons and sharks, and many fossil Ganoids.

The filamentary original tail gradually decreases and finally disappears, while the lower lobe increases and becomes the functional tail of the adult *Lepidosteus* and *Amia*. In this respect, therefore, these forms are *modern* types of an ancient group.

In describing the peculiar vibratory movement of the caudal filament of the young gar, I compared it to the rapid vibration of the tail in many if not all serpents, and notably in the rattlesnake, and suggested that, in view of the ball-and-socket articulations of the vertebræ of *Lepidosteus* and some other reptilian features, the resemblance between the motions of *Lepidosteus* and *Crotalus* may have a deeper origin and significance than mere functional similarity; that they may have had a common ancestry not very remote. But I had no idea that "the ancestor of the gar was a reptile."

This correction seems to me the more desirable, since the other paper noticed by you (on the *Sirenia*) was chiefly to show that a retrograde metamorphosis had taken place with that group.

BURT G. WILDER.

ITHACA, N. Y., *September* 27, 1875.

## FORESTS AND RAINFALL.

*To the Editor of the Popular Science Monthly.*

WHILE recently traveling among the mountains of this State, the threatening approach of a storm obliged me to find a shelter, whence my attention busied itself in watching the clouds gathering upon the slopes that reached at least two thousand feet above the valleys.

Some portions of them, I observed, became quickly covered; others more slowly. In due time the storm broke away, and, relieved partially of their watery burdens, the clouds commenced to lift and move off, but some more tardily than others. Moreover, I remarked that, where they had first collected, there they remained the longest, and that those parts of the acclivities concealed the last were the first to become visible.

Such a singular coincidence led me on further to the consideration of its cause. I think it may be extracted from the following facts: 1. The day had been very warm, as had also been the weather for a week before. 2. Of those portions of the slopes that had become hidden, the timbered lands were the first and, as mentioned above, the last to be seen again; the contrary happening to the rock-exposures. 3. The valley in which I was is formed by mountains over four thousand feet above sea-level, their opposing acclivities being very near to each other. It is therefore narrow, and it was shielded from the cooling influences of winds outside. 4. The radiation of heat from the bare sides and precipices.

Generalizing the conclusions that may be drawn from these, it may be said that sometimes clouds passing over barren surfaces, like some of those I had been viewing, will become lightened as the cohesion of their particles is weakened by the warmer ascending currents of air; they may be dispersed, and, even if they settle down, will be more likely to rise again before those covering forests.

With the latter it will be otherwise. Every leaf, like a miniature sun-shade, protects a part, small though it be, of the soil from the direct warmth of the sun. Forests thus are like great canopies sheltering from the sun's rays those sections upon which they grow. Lands so covered possess a capacity for holding much moisture. Contained in the leaves and trunks of trees, and more particularly in the spongy moss and numerous streams, it is saved from rapid evaporation, and consequently lowers the temperature of the atmosphere over it.

Vapors, then, attracted toward mountains by gravity, or carried thither by winds, will at times collect first over those sections which are wooded, and will have a tendency to remain there, be condensed, and deposit rain.

It may not be out of place to notice here another fact coming under my observation. Winds sweeping across a country, when they encounter mountains, are crowded against them, and, by the pressure from behind, are forced up along their sides and over their crests. Clouds that are in their paths, and which are borne onward to the slopes of such mountains, are sometimes carried up to and over their tops. Slopes which are destitute of timber present very few obstacles to such a result. Forests, on the other hand, break or lessen the mechanical strength of wind, and so increase the probability of their augmenting the volume of rainfall. P. F. Schofield.

New York, *September*, 1875.

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# EDITOR'S TABLE.

## *WHICH UNIVERSE SHALL WE STUDY?*

A CERTAIN class of astronomers have aimed to persuade us that there are "more worlds than one;" and those ingenious speculators Stewart and Tait have recently argued for two universes: the present universe, open to the sense, and an "unseen universe" beyond the range of direct scientific investigation but open to intrepid scientific faith. From another point of view this idea of two universes comes out in a much more definite and practical way; and that is when considered with reference to the two great orders of knowledge that are now making rival claims on the attention of mankind as means of education. This conception of two universes as objects of thought was very instructively set forth by the able author of the articles we have published under the title of "The Deeper Harmonies of Science and Religion," in his third paper, and the passage defining the distinction is so well drawn that it will bear repetition. The writer says:

"There is something which sets itself up as a just reflection of the universe, and which it is possible to study as if it were the universe itself; that is, the multitude of traditional unscientific opinions about the universe. These opinions are, in one sense, part of the universe; to study them from the historic point of view is to study the universe; but when they are assumed as an accurate reflection of it so as to divert attention from the original, as they are by all the votaries of authority or tradition, then they may be regarded as a spurious universe outside and apart from the real one, and such students of opinion may be said to study, and yet not to study the universe.

"This spurious universe is almost as great as the genuine one. There are many profoundly learned men whose whole learning relates to it and has no concern whatever with reality. The simplest peasant, who, from living much in the open air, has found for himself, unconsciously, some rules to guide him in divining the weather, knows something about the real universe; but an indefatigable student, who has stored a prodigious memory with what the schoolmen have thought, what the philosophers have thought, what the fathers have thought, may yet have no real knowledge; he may have been busy only with the reflected universe. Not that the thoughts of dead thinkers stored up in books are not part of the universe as well as wind and rain; not that they may not repay study quite as well; they are deposits of the human mind, and by studying them much may be discovered about the human mind, the ways of its operation, the stages of its development. Nor yet that the thoughts of the dead may not be of the greatest help to one who is studying the universe: he may get from them suggestions, theories, which he may put to the test, and thus convert, in some cases, into real knowledge. But there is a third way in which he may treat them which makes books the very antithesis to reality, and the knowledge of books the knowledge of a spurious universe. This is when he contents himself with storing their contents in his mind, and does not attempt to put them to any test, whether from superstitious reverence or from an excessive pleasure in mere language. He may show wonderful ability in thus assimilating books, wonderful retentiveness, wonderful accuracy, wonderful acuteness; nay, if he clearly understands that he is only dealing with opinions, he may do good service in that department, for opinions need collecting and classifying as much as botanical specimens. But one often sees such collectors mistaking opinions for truths, and depending for their views of the universe entirely upon these opinions, which they accept implicitly without testing them. Such men may be said to study, but not to study the universe."

This discrimination is both true and highly significant. Old opinions, old languages, and antiquated learning, are fit subjects of study as a part of archæology, like old buildings, old costumes, old coins, ear-rings, pictures, etc., which are not without a certain historic interest. But from this point of view they are parts of the universe to be explored and explained, like all the rest of it, by scientific methods. This, however, is a widely different thing from setting up old knowledges and thoughts of the dead as systematic and exclusive objects of study, and the sufficient means of mental cultivation. Yet the advocates of education by traditional, unscientific studies habitually slur over this distinction, and, declaring that old languages and old traditional ideas are as much parts of the universe as the rocks and stars, proceed to install them into a separate world in which the great multitude of students are made to pass their whole intellectual lives. It is no exaggeration or mere figure of speech to characterize this realm of antiquated thought and dead language as a spurious universe. No one will deny that the broad and distinctive object of scientific study is the real and present universe of phenomena, fact, and law, which is open to the direct, immediate action of the human mind. The study of it in all its phases, by observation, experiment, analysis, synthesis, and classification, has given rise to a vast body of truths and principles known as scientific knowledge, or modern scientific thought, and by which and through which the actual living universe is to be interpreted and known. Obviously the keys to the knowledge of the real universe are held by science, and it is inevitable that, if scientific knowledge be left out of any educational scheme, the genuine universe is omitted from that scheme. And when this subtraction has been accomplished what remains? An unreal sham, an illusive, discordant representation of things which may now be justly termed a "spurious universe." We say it may *now* be justly so termed, although, before the true universe was discovered, there could have been no knowledge of its counterfeit. The mass of pre-scientific opinion concerning the world and its contents, the course of Nature, man, life, and society, when taken in relation to what is now known of these subjects, and when regarded as a body of thought to be employed for purposes of culture, must be held as representing not the universe of reality, but only a distorted and spurious semblance of it.

The question of scientific education, then, undoubtedly the greatest question of our time, is simply this: "Shall we study the genuine or the spurious universe? Shall the minds of students be developed and moulded by direct exercise upon the phenomena and problems of Nature and present human experience, or shall they be cut off from the living world and trained in the acquisition of old knowledges, just as if science had never arisen?" This question may seem to many a futile one, as they will say that in this age the influence of science cannot be escaped. Nevertheless it is an urgent and a practical question. For, although the influence of science cannot be escaped by society, it can be and it is extensively evaded and escaped in education. In this our schools and colleges do not represent the age; they are out of harmony with it; they are far behind it. The genuine universe is not the supreme object of study; it is only partially recognized or not recognized at all. The spurious universe is still in the saddle. It has not been displaced; it has hardly been disturbed. Science is still begging of our colleges for a few crumbs; and, when snubbed, is trying here and there to organize schools of its own, which are generally looked upon as mere technological shops where needy youths are apprenticed to bread-and-butter occupations a grade or two above the workshops of artisans and mechanics. The dignity of being liberally educated, the honors of scholarship, and the prestige of culture, are reserved for those who, passing by all the grand results of modern science, give themselves to the study of the spurious universe.

The latest illustration that comes to us of the extent to which this statement is true, is furnished by the condition of the great public or preparatory schools of England. An official report has been made upon this subject, which represents the state of things after a quarter of a century of vehement agitation for some reformatory change that shall bring the popular culture of that country into greater harmony with the present state of knowledge. The case is thus forcibly presented by the London *Spectator*, a journal that will not be suspected of extreme views upon the subject:

"During the past three hundred years, the spread of scientific knowledge has revolutionized European modes of thought, has fundamentally altered the European idea of the universe, of the earth's place in the grand whole, and of man's place on the earth, and has profoundly modified European social life and political institutions; but, to our great schools, science has been as if it had made no progress. To those who have regulated the studies of those places of learning, it has not appeared at all important that English gentlemen should be able to follow with intelligence the fruitful researches to which the pioneers of modern thought were devoting themselves, should be capable of appreciating the discoveries which were abridging space, approximating classes, and calling into existence industries, activities, and relations, that are gradually transforming the ancient order of things—in a word, that they should be in sympathy with the modern spirit. . . . Of course, such a state of things has not been allowed to continue without protest and controversy, and some little has been done to make room for science-teaching in our schools. It has, however, been very little. The sixth report of the Royal Commission on scientific instruction now lies before us. It is confined exclusively to an examination into the provision made in the various secondary schools throughout the country for the teaching of science, and this is what appears: Returns, more or less complete, were received from one hundred and twenty-eight endowed schools in all, and, out of this total, 'science is taught in only sixty-three, and of these only thirteen have a laboratory, and only eighteen apparatus, often very scanty.' Even these figures, however, give but a very imperfect notion of the neglect with which science is treated. It will hardly be believed that there are no more than eighteen of these schools which devote as much as four hours in the week to scientific instruction, that sixteen actually afford no longer time than two hours a week, and seven think an hour sufficient. These, however, are the good examples. There are thirty schools in which no definite time whatever is allotted to scientific study. Again, out of the one hundred and twenty-eight schools, only thirteen give any place at all to science in their examinations, and 'only two attach a weight to science in the examinations equal to that of classics or mathematics.'

"If, now, we attempt to account for this extraordinary neglect of science, in a country whose greatness, if not its very independence, depends upon the skill of its population in using the forces of Nature as their servants, we find the blame to rest in a very great measure on the universities. The older universities were founded and attained celebrity at a time when natural science did not exist, and they have never admitted science to an equality with classics and mathematics. The feeling of Oxford and Cambridge has naturally guided the public schools. The masters are, almost without exception, even to-day, Oxford and Cambridge men, and are penetrated with the Oxford and Cambridge spirit. Moreover, the parents of the boys, and the boys themselves, necessarily attach importance to the studies which will win honors and distinction at the universities, while they disregard studies that will in no way help them in their careers. Lastly, the neglect of science at the universities causes the schools to suffer from a want of competent teachers. Most of the head-masters in their evidence refer to this difficulty, but, at the same time, they are unwilling to look elsewhere for the kind of men they want. Thus the head-master of Rugby says: 'I would here observe that a mere chemist, geologist, or naturalist, however eminent in his own special department, would hardly be able to take his place in a body of masters composed of university men, without some injurious effect upon the position which science ought to occupy in the school. . . . In preferring the two older universities, I do so only by reason of their stronger general sympathies with public-school teaching. I am aware that if I merely wanted a highly-scientific man in any branch, I might find him equally in Dublin, London, or at a Scotch university.' In plain language, trades-unionism forbids an ugly competition."

It thus appears that the policy of one hundred and twenty-eight of the leading schools of England, in regard to the admission of scientific studies, is powerfully influenced, if not controlled, by the universities, so that, in the foremost nation in the world, there is a vast, compactly-organized educational system which ignores the universe, as disclosed by modern science, and employs as its means of mental cultivation a spurious universe of dead traditions, languages, methods, and opinions.

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## LITERARY NOTICES.

First Book of Zoölogy. By Edward S. Morse, Ph. D., late Professor of Comparative Anatomy and Zoölogy in Bowdoin College. New York: D. Appleton & Co. Pp. 188. Price, $1.25.

The genius for good school-book making is incontestably American. Our best school-books exemplify art in two directions: in that which goes to the getting up of the book, materially, and that which concerns its intellectual self; that is, its way of putting things—such a handling of teaching processes as recognizes that good teaching is an art, and the true teacher an artist. As good tools for teacher and learner, American school geographies, arithmetics, readers, and lately grammars, are not excelled abroad. It is noteworthy, however, that hitherto so much could not be said of American efforts in the matter of elementary school-books on science. Herein has England set us an example. The "Science Primers," reprinted by the Appletons, are very remarkable books as showing how a high knowledge in these departments may be set before a little child. However, in this matter of American science-teaching of the little ones, the tide is setting in. It must be admitted that in every thing pertaining to books, and elementary teaching of animated Nature, we are far behind England. Dr. Hooker's "Child's Book of Nature" is the best of its class, though sadly needing rewriting. But when we come to zoölogy proper, a history of our efforts at elementary book-making is more interesting than creditable. The earliest serious effort is that of Daniel Haskel—"The Juvenile Class-Book of Natural History," 1841. It is for children, and the author boasts in the following style over its systematic arrangement: "The classification, which forms an important feature of the work, is founded on external resemblance and visible habits. . . . This classification is much more simple, and better adapted to the young mind, than that of Linnæus, which is founded on occult resemblances, and ranks the cow and the whale, animals which inhabit different elements, and are otherwise very unlike, in the same general class, *Mammalia*." As to man, he says, "Buffon divides mankind into six classes," and he does likewise. But the word "class," though often used, has no certain sense in this little book. Leaving man, the work is divided into Quadrupeds, Birds, Fishes, Reptiles, and Insects. The quadrupeds are divided into thirteen classes, as first class, second class, etc. Then come the "Unclassed Animals," viz., "the elephant, rhinoceros, hippopotamus, tapir, camel, Arabian camel, llama, camelopard, bear, badger, raccoon, kangaroo, opossum, ant-eater, sloth, jerboa." He says these "are animals which cannot be classed, but each of which by itself forms a distinct species." The birds are given in like manner in six classes, with "unclassed birds, the ostrich, cassowary, dodo." The fishes are in four classes. The first class embraces the cachelot, grampus, porpoise, dolphin, whale." As for the sword-fish, he is left out in the cold. The "fourth class" of fishes embraces the lobster, crab, tortoise, oysters, snails, and such.

The next attempt at a natural history for schools was (we speak from memory) by Abram Ackerman. It was a mere compilation, with not a particle of science behind it or in it. It had the credit, however, of not being the injurious book that Haskel's was. In 1849 appeared "Class-Book of Zoölogy: designed to afford to Pupils in Common Schools and Academies a Knowledge of the Animal Kingdom. By Prof. B. Jaeger." The educational plane was not then up to this little book, which, as a classification, or systematic exhibit of the animal kingdom, had not its equal; and, besides this, much of it was really American, but zoölogy proper it utterly failed to teach. Prof. Worthington Hooker's "Natural History, for the Use of Schools and Families," appeared in 1860. It is a good book, and holds its own in the market because of its pleasant and readable style. As a classification it is too meagre, and of zoölogy it contains but little. We must not pass unmentioned the Ruschenberger series of "First Books in Natural History," begun in 1842. These were little else than translations from the text of Milne Edwards and Achille Comte. Very excellent little manuals they were, but extending, as they did, to eight volumes, they lost all claim to be called a "Primer of Natural History." "Principles of Zoölogy, by Agassiz and Gould," 1848, is a high text-book; and of a like nature must be regarded "A Manual of Zoölogy," by Sanborn Tenney, 1865, with its smaller companion by the same author; both good books so far as systematizing goes.

It is evident, then, that a good, true American book, worthy of being called a "Primer of Zoölogy," had not appeared. In the fullness of belief, we avow our conviction that it has come at last. We do not allude to Mrs. Stevenson's "Biology for Boys and Girls;" it occupies a widely-different field. "First Book of Zoölogy," by Prof. Morse, is the little work which we wish to consider. It has some points on which we would for a moment dwell. First, it really teaches zoölogy. It deals with the morphology and actual structure of familiar things. It advises you to get snails or insects, and shows how to get them. Now, every one should know that this is just what a child wants to do. Every child is naturally a collector. Then comes the study of form. Here are simple outline drawings. The external parts are laid out, and each part is shown to the pupil, and its name as a part is given. Now the child must draw these parts on his slate, and then name them for himself; and every child with a little patient help can do all this. But, when this is done, the morphology of a shell, or whatever else, is well learned, albeit the little pupil has never heard the big word used above. And what an eye-opener, and mind-expander, and tongue-loosener, half an hour of such work with a child is! The little child becomes at once a naturalist, intent upon his snail, he sees things, and thinks things, and asks things, that are all new to him. This little book utterly eschews technicalities, and even classification. An intelligent boy will make a collection, and then will attempt to sort it into groups or sets of real or fancied similitudes. This is instinctive classification. But it is plain that the collection must come first; that is, that intelligent classification must stand related to things more than words. A blind man could not classify the stars. Here, then, is the blunder which our author shuns: of beginning to teach systematic classification with no knowledge or sight of the objects. The author's method is that of Nature. It is the word-method in reading instead of the old A B C plan. Get your object, then learn its parts, and, thus trained, classification will be sought for, and can then be entered upon; and even its systematic names will be learned with delight, because they have a real significance; that, of course, will be the work of a "Second Book." The first is just such as any teacher can handle, and that too with pleasure, for it unfolds the objects of Nature precisely in Nature's own way. A real excellence in a primer is, that it is small. This little book reminds us of the pinhole in the card to which the eye is applied; it takes in a very little bit of Nature, but that bit is wonderfully amplified with good, clear, achromatic light. In this wise it is that one who has done a long service in teaching natural history to children hails Dr. Morse's little book. S. L.

Money, and the Mechanism of Exchange. By W. Stanley Jevons, F. R. S., Professor of Logic and Political Economy in the Owens College, Manchester. No. XVII. "International Scientific Series." New York: D. Appleton & Co. 350 pages. Price, $1.50.

There is, beyond question, a most important scientific side to the complex subject of money. It has its observable phenomena, its analyzable relations, and its deducible laws; and, as it pertains to the operations of human society, it is a legitimate branch of social science. For this reason it was entirely proper that the subject should be treated in an independent monograph in the "International Scientific Series." One of the ablest and clearest logical heads in Europe, author of a masterly treatise on the philosophy of science, and a special and thorough student of political economy, was chosen to execute the work. Again there were permanent, general, and what we may term cosmopolitan reasons for taking up the subject with a view simply to the exposition, improvement, and extension of valuable knowledge.

But for us the subject has also quite another aspect. There were urgent American reasons why it should be treated. We believe in the glorious leadership of our country; we are in advance, and bound to be in advance, of civilization, and in this case the American people furnish ample evidence that they are quite ahead of the world in their ignorance of every thing like principles or laws relating to money. The American voter, with his hands full of greenbacks, has about as much understanding of the science which treats of them as the Indian of the science of wampum. That they can buy things with them, and that they are therefore desirable to be got, exhaust the knowledge of both. With all our vaunted enlightenment, we have a currency bedeviled by politicians in the interest of selfish greed and rampant speculation, and maintained by a demagoguism as unscrupulous and vicious as the world has ever seen. With so much gross ignorance and stupid superstition among the people in regard to the nature of money, and the laws of its use and influence, that the present state of things is openly defended and its continuance demanded, it becomes in the highest degree desirable that sounder views should be disseminated as rapidly and as widely as possible. We want a knowledge of money as a branch of natural history. We want to know how its use has grown up; what wants it answers to in human societies; what laws it is subject to that spring from the very nature of things; what are its imperfections, and how they may be supplemented; what are its dangers, and what the delusions and impostures of which it is made the means by calculating men and unprincipled governments. Prof. Jevons's work deals with the subject very much from this point of view. He offers us what a clear-sighted, cool-headed, scientific student has to say on the nature, properties, and natural laws of money, without regard to local interests or national bias. His work is popularly written, and every page is replete with solid instruction of a kind that is just now lamentably needed by multitudes of our people who are victimized by the grossest fallacies.

Religion and Science in their Relation to Philosophy. By Charles W. Shields, D. D. New York: Scribner, Armstrong & Co. Pp. 69. Price, $1.00.

This essay consists of two parts, in the first of which are stated the scientific hypotheses and the religious dogmas that have been offered for the solution of such problems as the origin of the universe, the formation of geological strata, the origin of man, the nature of mind and of matter. The case for both sides is stated fairly enough. In the second part the author endeavors to show that these problems are neither exclusively scientific nor exclusively religious, but philosophical. "It is not too much to say that they can never be decided by any merely scientific process. . . . And it is safe to say that by no purely religious method can they ever be settled." The author regards these problems as "partly scientific and partly religious," but "strictly philosophical." Hence philosophy is the umpire when religion and science are in conflict. "Paramount as religion must be in her own sphere with her inspired Bible and her illumined Church," she cannot judge the theories of science; but no more will religious men accept from mere scientists a judgment upon their doctrines. The author thinks that in the "broad plain of philosophy" the religionist should accept scientific truth resting upon "foundations of proof that cannot be shaken;" and that the scientist should no longer ignore "that vast body of truths, doctrines, dogmas, backed by evidences which have been accumulating for eighteen centuries under the most searching criticism." There appears to be no reason why men of science should reject the arbitration of philosophy.

Proceedings of the American Academy of Arts and Sciences; from May, 1874, to May, 1875. Selected from the Records. Boston: John Wilson & Son, 1875.

This is the second octavo volume of "Proceedings" of the "New Series," and the tenth of the "Whole Series" published by the American Academy; Volume I. having been published in 1848. Besides the octavo *Proceedings*, the Academy has long published quarto volumes of *Memoirs* which are of the highest value. This volume contains 535 pages, of which 462 are devoted to scientific papers, 13 to brief notes of the several stated meetings, 41 to the Report of the Council (into which are incorporated the obituaries of deceased members or associates), six pages to the list of the members, etc., and the rest of the volume to a very copious index.

We learn that the Academy contains 195 Fellows, 91 Associate Fellows, and 70 Foreign Honorary Members. The losses by death during 1874 have been painfully large, and many of them will not be felt by Massachusetts alone, but by the world at large. Short biographical notices are given of the following deceased members: B. R. Curtis, ex-Judge Supreme Court; George Derby, M. D., Professor, Harvard College; F. C. Lowell;

Charles G. Putnam, M. D.; Nathaniel B. Shurtleff; James Walker, ex-President Harvard College; Jeffries Wyman, Professor, Harvard College; F. W. A. Argelander, Professor, University of Bonn; Elie de Beaumont, Secretary Paris Academy of Sciences; Sir William Fairbairn, F. R. S., etc.; F. P. G. Guizot; Sir Charles Lyell.

Of the scientific papers given, ten are devoted to Chemistry and Physics, four to Botany, four to Astronomy and Astronomical Physics, two to pure Mathematics, etc. But such an enumeration does not convey any adequate idea of the amount of original research represented by this volume, which is in every way creditable to American science, and fully equal to similar publications in Europe. It is not possible within the limits of our space to attempt any analysis of individual papers, for a knowledge of which reference must be made to the volume itself; but it is impossible to avoid a renewed notice of the remarkable freshness of the volume as a whole. It bears the evidence of being the systematized results of faithful work in the laboratory, the field, and the study, and it has in this and in other respects an advantage not common to all American publications of the same kind.

American State Universities. With a Particular Account of the Rise and Development of the University of Michigan. By Andrew Ten Brook. 418 pages. Price, $3.50. Cincinnati: R. Clarke & Co.

The author of this work, in his first chapter, presents a sketch of the early progress of academic education in the Atlantic States. Next he describes the state of culture in the West at the beginning of the congressional land-grant policy and subsequently. The history of congressional land-grants for universities is given in the third chapter. The remainder of the book is more specially devoted to the subject of education in Michigan, and the matters treated in the successive chapters are: Michigan's early condition as to culture and education; early organization for higher education in that Territory; grant of the present university fund, and its administration by the board of trustees; organization of the school system and administration of the endowment fund; rise of union schools; opening of the Ann Arbor University; review of the period from 1844 to 1852; the administration of President Tappan; administration of President Haven and his successors. Finally, the author essays to forecast the future of American universities. He is in favor of retaining the study of ancient languages as the dominant feature, the very backbone of the university system. "The long-agitated question," he says, "of the place which the Latin and Greek languages should hold in education, the University of Michigan settled originally by giving them the same prominence which they had in the old colleges of this country, and the State universities generally have inclined to this course. This action needs no comment or defense beyond a statement of the reasons which have been supposed to justify it. The relation of the study of these languages to that of other subjects has been greatly changed by the introduction of new branches of study, but not by any special change of views in regard to the value of languages themselves." Science, according to Mr. Ten Brook, is of little or no importance except for specialists. "Language is of all studies the most practical. The useful and sublime sciences, such as chemistry, botany, geology, and astronomy, *are of little immediate use even to the learned.* Their main facts and generalizations are indeed well employed in literature, in philosophy, and in social life; *but beyond these they are only to be pursued by the special student.*" Again, he says: "It was the ancient classics, and the Hebrew and Greek Scriptures in their originals, which awakened Europe from the sleep of the middle ages. They are adapted to just that kind of work, and they will probably hold their place for ages to come, as for centuries past, in the course of higher education." Our own views on this question are fully stated in the leading editorial of the present number.

Annual Report of the Directors of the St. Louis Public Schools. Pp. 398.

Besides the usual statistics, the various annual reports contained in this volume convey a large amount of valuable information on school management in general. The idea of having attached to the Normal School a "School for Observation" appears to be original to the St. Louis system. This school for observation differs from the "Model School" in that the Normal scholars here simply observe the process of managing a school as conducted by highly-competent teachers, while in the Model School they make experiments in teaching. The school selected for observation is one of the district schools of the city. The members of the senior and middle classes of the Normal School are sent regularly to the "School for Observation" in order to acquire a more thorough knowledge of their future profession.

The experiment begun two years ago, of establishing a Kindergarten in connection with one of the public schools, has, according to the Report, proved a decided success. Like every effort toward new and improved methods in education, the project, at the outset, met with strong opposition. It was urged that children enough would not attend to justify the expense. The younger children of three and four could not be sufficiently interested; small children would not attend regularly; the training would unfit for ordinary primary work; the physical exercises would be injurious to health; and so on, to the end of the string of imaginary difficulties that objectors are forever ready to throw in the way. The result was that, when the school opened, the room was quickly filled. At the beginning of the second year nearly all the children of the previous year reëntered, and a second room of equal capacity was found necessary, and this also was filled. The average attendance was ninety-five per cent., exceeding that in the primary rooms. The children advanced to the primary department made rapid progress in its studies, excelling rather than falling behind their fellows. The physical exercise produced a marked improvement in the health and general appearance of the pupils; and, finally, it has been determined to establish Kindergartens in two more of the public schools.

This and other parts of the Report show what preceding reports from the same source had previously shown, that the authorities in St. Louis are alive to the necessity for improvement in our methods of primary instruction, and it would be well if school-officers in Eastern towns could be charged with a similar spirit. The streets of New York, for example, are swarming with children from three to six years old, receiving at the most impressible period of their lives the lessons that only the streets can teach. If, in place of these abominable associations, they were gathered into Kindergartens, the formation of habits that later become actual obstacles in education would be in great part prevented, while a positive advantage would be gained in the training which such schools afford.

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## PUBLICATIONS RECEIVED.

Reference and Dose Book. By C. Henri Leonard. 16mo, 80 pages. Price, 75 cents; and Vest Pocket Anatomist. By same. 16mo. Price, 50 cents. Detroit, 1875. Pp. 56.

The Origin of the Sun's Heat and the Chemical Constitution of the Matter of his System. By William Coutie. Troy, 1875. Pp. 23.

Tinnitus Aurium. A Consideration of the Causes upon which it depends, and an Attempt to explain its Production in Accordance with Physical Principles. By Samuel Theobald, M. D. Baltimore: Innes & Co., Printers. 1875. Pp. 13.

Circulars of Information of the Bureau of Education. No. 6. Washington: Government Printing-Office, 1875. Pp. 208.

On the Flexure of Continuous Girders. By Mansfield Merriman, C. E. 1875. Pp. 12.

Printing for the Blind. Reply to the Report of a Committee of the American Social Science Association. By the Trustees of the American Printing-House for the Blind. Louisville, Ky., 1875. Pp. 16.

Have we Two Brains? Soul and Instinct, Spirit and Intellect. Address by Rector of St. Mary's Church, Station O, N. Y. 1875. Pp. 12. Price, 10 cents.

Alimentation of Infants and Young Children. By B. F. Dawson, M. D. New York: William Wood & Co. 1875. Pp. 22.

Catalogue of the Iowa State University for 1874–'75.

A Graphic Method for solving certain Algebraic Problems. By George L. Vose. New York: D. Van Nostrand. 1875. Pp. 62. Price, 50 cents.

Manual for the Use of the Globes. By Joseph Schedler. New York: E. Steiger. 1875. Pp. 34. Price, 25 cents.

Consciousness in Evolution. A Lecture delivered before the Franklin Institute, Philadelphia. By E. D. Cope, 1875. Pp. 16.

Our Teeth and their Preservation. By L. P. Meredith. Cincinnati, 1875. Pp. 43.

History of the Philadelphia School of Anatomy. By William W. Keen, M. D. Philadelphia: Lippincott & Co., 1875. Pp. 32.

Anatomical, Pathological, and Surgical Uses of Chloral. By same. 1875. Pp. 11.

Experiments on the Laryngeal Nerves and Muscles of Respiration in a Criminal executed by Hanging. By W. W. Keen, M. D. 1875. Pp. 8.

Matter and the Laws of Matter; and The Self-Existence of Matter inconsistent with the Existence of God. By William H. Williams. Each ten pages.

Iowa Weather Review, September, 1875. Edited and published by Dr. Gustavus Hinrichs, Iowa City, Iowa.

A Study of the Normal Movements of the Unimpregnated Uterus. By Ely Van De Warker, M. D. New York: D. Appleton & Co., 1875. Pp. 26.

On the Transcendental Curves whose Equation is, $\sin y \sin my = a \sin x \sin nx + b$. By H. A. Newton and A. W. Phillips. Reprinted from Transactions of Connecticut Academy.

A New Basis for Uterine Pathology. By A. F. A. King, M. D. New York: William Wood & Co., 1875. Pp. 20.

The Uranian and Neptunian Systems investigated with the 26-Inch Equatorial of the United States Naval Observatory. By Simon Newcomb. Washington, 1875. Pp. 74.

The Relation of the Patent Laws to American Agriculture, Arts, and Industries. Address by James A. Whitney before the New York Society of Practical Engineering. New York, 1875. Pp. 37.

Annual Report of the Superintendent of Public Instruction, on the Public Schools of New Hampshire. Concord, 1875.

Nature and Culture. By Harvey Rice. Boston: Lee & Shepard, 1875. Pp. 202. Price, $1.50.

A Manual of Metallurgy. By William H. Greenwood, F. C. S. New York: G. P. Putnam's Sons. Pp. 370. Price, $1.50.

Cholera Epidemic of 1873 in the United States. Pub. Doc. Washington, 1875. 1025 pages.

Vision: Its Optical Defects and the Adaptation of Spectacles. By C. S. Fenner, M. D. Philadelphia: Lindsay & Blakiston, 1875. Pp. 300. Price, $3.50.

Scripture Speculations. By H. R. Stevens. Newburg, N. Y., 1875. Pp. 415. Price, $2.00.

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## MISCELLANY.

We present below brief abstracts of some of the more interesting papers read at the last meeting of the British Association for the Advancement of Science. Others will follow in succeeding numbers.

**Ice-Action.**—The subject of ice-action was considered in a paper read by D. Mackintosh, F. G. S. He first discussed the question whether the so-called continental ice of Greenland was a true ice-sheet formed independently of mountains, or merely the result of a confluent system of glaciers. He then considered the state of the surface of the Greenland ice-sheet, and believed that the amount of moraine matter was locally limited and of small extent. He defended the idea of the internal purity of existing ice-sheets, and gave reasons for doubting whether glaciers are capable of persistently pushing forward the large stones they may find in their beds, though he admitted that the base of glaciers is charged with finer *débris*, by means of which they grind and striate rock-surfaces. He mentioned that in the lake district of England he had never seen a sharply-bordered groove on a glaciated rock-surface which might not have been produced by a stone smaller than a walnut.

He saw no reason for doubting that revolving icebergs were capable of scooping out hollows in the rocky bottom of the sea, and thought that lake-basins on the rocky summits of hills or on water-sheds might have been produced in this way. He then gave reasons for supposing that the drift-knolls called *eskers*, where their forms were very abrupt, might have been partly formed by eddying currents with waves generated or intensified by ice-movements, which sometimes would set the sea in motion as much as sixteen miles off.

According to Mr. Mackintosh, floating coast-ice is the principal transporter and glaciator of stones, and the uniformly striated stones found in the bowlder-clay were both glaciated and transported by coast-ice. He entered minutely into a consideration of how stones, previously more or less rounded, became flattened and uniformly grooved on one, two, or more sides, the grooves on the various sides differing in their directions. He believed that many of the stones found in the bowlder-clay of Cheshire must have been frequently dropped and again picked up by coast-ice during the passage from their original positions.

**Ancestors of the British.**—Another paper by the same author was devoted to the discussion of certain ethnological questions connected with the history of the people of Britain. He believed that the inhabitants of different parts of England and Wales differed so much in their physical and mental characteristics that many tribes must have retained their peculiarities since their colonization of the country, by remaining in certain localities with little mutual interblending, or through the process of amalgamation failing to obliterate the more hardened characteristics. The first type noticed was the Gaelic. In Cæsar's time, probably the great mass of the people of Gaul were comparatively dark in complexion and small in stature; and the race characterized by Cæsar as of tall stature, reddish hair, and blue eyes, were most likely German colonists of Gaul. There still exists in England, Wales, and Ireland, a distinct race, possessed of some of the mental characteristics anciently attributed to the Gaels. In mental character the Gaels are excitable, and alternately lively and melancholy. The Gael is also by temperament an excellent soldier, but he needs to be commanded by a race possessed of moral determination, tempered by judgment and foresight. Another characteristic of the Gaelic race is sociability.

In North Wales there are several distinct ethnological types, but by far the most prevalent is the type to which the term Cymrian may be applied. The Cymri appear to have entered Wales from the north. They are an industrious race, living on scanty fare without murmuring. Mr. Mackintosh gave a minute description of the physical and mental peculiarities of Saxons, and showed the difference between Saxons and Danes. With Worsaae, he believes that the Danes have impressed their character on the inhabitants of the northeastern half of England. He endeavored to show that between the northeast and southwest the difference in the character of the people is so great as to give a semi-nationality to each division. Restless activity, ambition, and commercial speculation, predominate in the northeast; contentment and leisure of reflection in the southwest. He concluded by a reference to the derivation of the settlers of New England from the southwest, mentioning the fact that, while a large proportion of New England surnames are still found in Devon and Dorset, there is a small village, called Boston, near Totnes, and in its immediate neighborhood a place called Bunker Hill.

**Changes in the Courses of Rivers.**—Major Herbert Wood spoke on the cause of the change of direction in the lower course of the river Oxus, by which its mouth had been diverted from the Caspian to the Aral. In the opinion of Major Wood this change is to be attributed to the abstraction of the water of the river for the purposes of irrigation, which has been practised from time immemorial. The quantity of water thus diverted has never been calculated, but, from data obtained by Major Wood during the Russian Expedition, he concludes that, between June 23 and September 10, 1874, an average of 62,350 cubic feet per second was absorbed by the irrigation canals of Khiva, an amount equal to nearly one-half the total volume of the

Oxus. At the time when the river emptied itself into the Caspian the conditions of its *régime* were such that the volume and velocity of its summer or flood water were sufficient to clear away annually from its bed the deposits of mud resulting from the smaller volume of its winter course. From certain data it is concluded that the difference of the delivery of water between winter and summer is as one to three: thus the bed would not undergo any deterioration, its course would remain unchanged, and the river would continue to discharge itself into the Caspian. But, as soon as the volume and velocity of its summer waters were diminished by the action of irrigation canals, those compensatory arrangements of Nature would be upset, and a proportion of the muddy deposits of winter would escape the annual scouring. In course of time bars would form in the bed of the river, and in the end prevent it extending its course to the Caspian. That the Oxus has changed its lower course is proved by numerous historical documents.

**Antiquity of the Divining-Rod.**—A paper on "Rabdomancy" (or the use of the "divining-rod") and "Belomancy" (or divination by means of arrows) was read by Miss A. W. Buckland. According to the author, the staff as a sceptre was probably a later form of the horn which was thus used in prehistoric times, and in that character adorned the heads of gods. From this use of rods or horns arose a veneration for them as possessing the power of healing. Hence their use by magicians, whose chief instruments have always been a ring and a staff. These symbols conjoined are found in Egyptian, Assyrian, and Peruvian sculptures, and may be traced in some of the stone circles of Britain and in the shape of ancient Irish brooches. Belomancy, or divination by marked arrows, said to be of Scythian origin, was practised in Babylon, Judea, and Arabia, and traces of it may still be found in the popular tales of Russia and Siberia. "That the arts of magic and divination are a remnant of pre-Aryan religion is proved," said the author, "by their present existence among aboriginal non-Aryan races; and they might even be used as a test of race, so that those who in the counties of Somerset and Cornwall claim the power of divination by the rod might possibly have some remote affinity with the aboriginal inhabitants of Britain."

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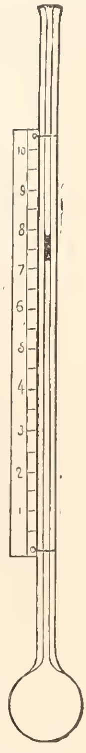
**The Clinical Thermoscope.**—Dr. Seguin, of this city, has devised an ingenious little instrument, called the clinical thermoscope, to be used as an aid in diagnosis. It is employed for detecting the variations of temperature on the surface of the body, and estimating the rate of radiation going on therefrom. In the words of the inventor, it is "intended as a quicker and more delicate test of differential temperatures than the thermometer; and less to give the degree of heat than the velocity of its radiation." We present a cut of the instrument half the actual size. It consists of a glass tube seven inches long, with a minute bore open at one end, and terminating at the other in a bulb. An adjustable scale is attached to the outside of the tube. To prepare it for use, immerse the bulb in hot water, which rarefies the air inside. The open end is then plunged into cold water and quickly withdrawn, when a drop or two will be found to have entered the tube. This forms a "water-index," which should become stationary within an inch or two of the bulb. If it falls into the bulb, or does not approach it sufficiently, too much or too little heat was applied in the first instance, and it will be necessary to jar the water from the tube and try again. When the index is provided, adjust the scale, bringing its lowest figure on a level with the top of the column of water in the tube, and it is then ready for use. It may be applied to any part of the surface, where disturbance of temperature is suspected, but its habitual place in the hands of Dr. Seguin is, not the axilla, but the shut hand. The claims



for it are, that it gives by contact indications of the volume of heat escaping by radiation, and the velocity of loss; also, that by blowing on the bulb the degree of combustion that takes place in the lungs is shown. It is likewise serviceable as a means of detecting the exact position of deep-seated local trouble, giving valuable indications where the thermometer fails.

**A New Fossil Crustacean.**—A new crustacean species, allied to *Eurypterus* and *Pterogotus*, has been described by A. R. Grote and W. H. Pitt, under the name of *Eusarcus scorpionis*. The specimen was found in the water-lime group at Buffalo, N. Y. Its length is 250 millimetres, and its greatest width 110 millimetres. The cephalo-thoracic portion appears to be separate from the body; the legs are in the same number as in *Eurypterus*; the swimming-feet appear to differ by the straighter, less rounded outer margins; the spines of the anterior feet appear to be long, curved, and to have an anterior direction. The absence of chelate appendages to the posterior margin of the feet is particularly noticeable. The first seven broad segments of the abdomen form a large ellipse. There is an evident and remarkable narrowing of the succeeding caudal segments. The interest which attaches to this remarkable crustacean arises from the discovery of a form which may be allowed to be higher than *Eurypterus* and *Pterogotus*.

**Reptilian Affinities of Birds.**—Prof. E. S. Morse has for a long time made a study of the bones of embryo birds. At this year's meeting of the American Association he recalled briefly the evidence he had shown last year regarding the existence of the intermedium in birds, by citing the embryo tern, in which he had distinctly found it. This year he had made a visit to Grand Menan, expressly to study the embryology of the lower birds, and was fortunate in finding the occurrence of this bone in the petrel, sea-pigeon, and eider-duck. This additional evidence showed beyond question the existence of four tarsal bones in birds as well as four carpal ones. In these investigations he had also discovered embryo claws on two of the fingers of the wing—the index and middle finger. Heretofore in the adult bird a single claw only had occurred in a few species, such as the Syrian blackbird, spur-winged goose, knob-winged dove, jacana, mound-bird, and a few others; and in these cases it occurred either on the index or middle finger, or on the radial side of the metacarpus. All these facts lent additional proofs of the reptilian affinities of birds.

**American Pedigree of the Camel.**—Though the evolutional pedigree of the horse may be distinctly traced in the succession of equine genera whose remains are found in the Tertiary strata of our Western Territories, nevertheless, the horse, as he at present exists, is not indigenous to this continent, but has been imported from Europe. The pedigree of the camel may also be constructed from materials supplied by American paleontology. Prof. Cope has recently unearthed a number of genera which must be regarded as the ancestors of the camel. And it is worthy of note that, although the more prominent genera of the series which resulted in the horse, for instance *Anchitherium* and *Hippotherium*, have been found in European formations, no well-determined form of the ancestral series of the camel has up to the present time been found in any formation of the Palæarctic region. "Until such are discovered," says Prof. Cope, "there will be much ground for supposing that the camels of the Old World were derived from American ancestors."

**Arctic Meteorology.**—During Weyprecht and Payer's expedition to the north-polar regions the air in winter seemed always to contain particles of ice. This was seen not only by parhelia and paraselenæ when the sky was clear, but also in astronomical observations. The images of celestial objects were hardly ever as clear and well defined as at lower latitudes, although the actual moisture in the atmosphere was far less than is usual in temperate climes. It happened very often that, with a perfectly clear sky, needles of ice were deposited in great quantities upon all objects. It was impossible to determine the quantity of atmospheric deposits, as during the snow-storms no distinction could be made between the snow actually falling and that raised from the ground by the storm. It was remarkable, however, that during the first winter the quantity of snow was small compared with that of the second winter, when the snow almost completely buried the ship. The same proportion was repeated in the quantity of rain during the first and second summer; in the first only a little rain fell and that late in the year, while in July, 1874, it rained in torrents for days.

**Life in Elevated Areas.** — The general belief in the invigorating effect of mountain-air is not absolutely justified by facts: at least there are some elevated regions the inhabitants of which show none of the vigor and *élan* which we should expect to find, were the common opinion correct. Dr. Jourdanet, of Paris, writes of the inhabitants of the table-land of Anahuac, Mexico, that they appear quite languid, with pale complexion, ill-developed muscles, and feeble circulation. The mortality of infants is 30 per cent. in the first year after birth. Dr. Jourdanet is satisfied that, while the proportion of red corpuscles in the blood is normal, there is a diminution of oxygen, the result of insufficient condensation of that gas under the slight pressure of the air. For this condition of the blood he proposes the name of *anoxyhæmia*. In Mexico, at the height of about 2,300 metres (7,500 feet) above the sea, the debilitating effects of the rarefied air are manifest. This is noticeable in brutes as well as in men. Again, the annual growth of population is scarcely ever more than three per 1,000 on the uplands, while nearer the sea-level it is six or seven. Dr. Jourdanet asserts his belief that, in countries where cold is not of itself an obstacle to life, rarefaction of the air will prevent the founding of durable states at a level higher than 4,000 metres.

**Chinese Wheelbarrows.**—In commenting on an improved style of wheelbarrow, a correspondent of the *Gardener's Chronicle* praises the Chinese for the ingenuity they display in diminishing to the last degree the labor of the man who propels the barrow. The Chinese barrow has but one wheel, but it is large, and placed in the centre of the bed of the vehicle; the entire load rests on this central wheel. In Shanghai, thousands of these vehicles ply for hire in the streets, the usual load being two persons, who sit on a wooden platform on each side of the wheel, resting one arm on a framework which rises above the top of the wheel, and planting one foot in a stirrup made of rope. "It is by no means uncommon, however," he adds, "to see as many as four persons conveyed without any particular effort (the ground being level) by a stalwart coolie;" garden and farm produce is transported in the same way, and even live-stock: the Chinese farmer being too sensible to attempt to drive his pigs to market, the barrow is often seen laden with a live fat hog on each side of the wheel.

**Cave-Habitations in Kentucky.** — That some of the great caves of Kentucky were, temporarily at least, used as places of human habitation, is conclusively shown by Prof. Putnam's exploration of Salt Cave. This cave, says Prof. Putnam, approaches the Mammoth Cave in the size of its avenues and chambers. Throughout one of the principal avenues, for several miles, were to be traced the ancient fireplaces both for hearths and lights. Bundles of fagots were found in several places in the cave. But the most important discovery was made in a small chamber, about three miles from the entrance. On the dry soil of the floor were to be seen the imprints of the sandaled feet of the former race who had inhabited the cave, while a large number of cast-off sandals were found, neatly made of finely-braided and twisted rushes.

**The Use of Bushy Tails.**—It is easy to see the usefulness to the opossum, monkey, and other animals, of their prehensile tails. So, too, we can recognize the value to the horse and the ox of the switches by means of which these animals repel the attacks of insects. But there are other forms of the tail the uses of which are less evident, for instance, the bushy tail seen in the fox, dog, wolf, cat, etc. Mr. Lawson Tait holds that the use of this bushy appendage is completely analogous to that of the respirator worn by persons troubled with lung-complaints, the object being to abstract from the expired air, by means of fur in the one case, and wire gauze in the other, the heat which is being taken out with it; so that the cold air inspired shall be raised in temperature before it reaches the lungs, and thereby conduce to a conservation of the bodily heat. Some interesting considerations bear on this. Animals provided with bushy tails seem to be so as a matter of correlation of growth, their bodies being always provided with thickly-set and more or less soft fur. "I cannot," says Mr. Tait, "find an animal with a bushy tail which cannot, and does not, lie curled up when asleep. I went round the Zoölogical Gardens at Dublin on a very cold morning in February, and found the civet cat, and some other bushy-tailed animals, coiled up with their noses buried in the fur of their tails.

"In the squirrel this use of the tail is very marked, and in birds the same object is accomplished by their burying their heads in the down of the shoulders. Animals provided with bushy tails are all solitary in their method of living, so far as I can find; and, therefore, an essential for their survival is some method by which variations of temperature shall be resisted. The use of the tail for this purpose is, I think, best of all illustrated in the great ant-eater (*Myrmecophaga jubata*), in which the hairs of the tail reach a very great size, and cover up the animal when reposing, so that he looks like a bundle of dried grass. It may also serve as a protection by mimicry in this case. Mr. Wallace states also that this animal uses its tail as an umbrella in a shower, and that the Indians divert its attention from themselves by rustling the leaves in imitation of a falling shower, and while he is putting up his umbrella they kill him. Of the quadrumana, the marmosets afford a striking instance of a bushy tail as a probable provision for protecting these delicate creatures from depressions of the temperature."

**Remedy for Boiler Incrustations.**—"Apparatine" is the name given to a substance said to be effectual in preventing incrustation in boilers, and also useful wherever gelatine and gelatine-like substances are required, as in sizing textile fabrics. It is a colorless, transparent material, obtained by treating any amylaceous substance with a caustic alkali. It is best made, however, with potato-starch, treated with a lye of caustic potash or soda. The best method of preparing the apparatine is as follows: 16 parts of potato-starch are put into 76 parts of water, and kept in a state of suspension by stirring; then 8 parts of potash or soda-lye at 25° Baumé are added, and the whole thoroughly mixed. In a few seconds the mixture suddenly clears, forming a thick jelly, which must be beaten up vigorously. It is now a colorless, transparent substance, slightly alkaline in taste, but odorless, and of a stringy, glue-like consistency. Exposed to the air, it dries slowly, but without decomposing; and even when heated to dryness, although it thickens and swells, it continues unchanged, as when air-dried.

To prevent incrustation, the apparatine may be placed in the boiler or added to the feed-water in the tank; but the best results have been obtained by placing it directly in the boiler. Applied to silk, woolen, and cotton goods, it gives them a smoothness hitherto unattainable. When once applied to the goods, and become dry, it appears to be virtually insoluble. Diaphanous or coarsely-woven fabrics, when dressed with apparatine, are rendered stiff and rigid. It may be used as a thickening in calico-printing

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## NOTES.

A correspondent of the *Scientific American* states that in Minneapolis a supply of water for extinguishing fires is obtained in localities beyond the reach of the city water-works by sinking four drive-wells at distances thirty feet apart, or fifteen feet from a centre. The pipes (2½ inches) of the four wells are brought together at the top, where the suction-hose of the fire-engine is attached. On trial an engine threw a continuous stream from a 1¼-inch nozzle for one hour. The water in the tubes was then at the same height as at the beginning.

The chaparral-hen is described by a sportsman in Texas as a very pretty bird. The female lays one egg, and then commences sitting. While sitting she lays four more, the first being the largest and the fifth the smallest. The birds, when grown, seem to be of the same size. By the time the fifth egg is hatched the first is nearly a full-fledged bird. The first egg is about the size of a pheasant's; the others range in size between the pheasant's and the quail's egg.

A mass of native copper, in weight 6,000 pounds, and taken from an ancient mine on Isle Royal, Lake Superior, is now on exhibition in St. Louis. The mass had evidently been detached from its bed by the ancient miners.

From calculations made by Dr. J. T. Luck, of St. Louis, it appears that the death-rate among officers of the United States Navy is astonishingly high, being last year 25.45 per thousand. Assuming the average age of naval officers to be thirty, the death-rate is three times as high as that of civilians.

The growing appreciation of American scientific work in France is evidenced by the action of the Minister of Public Works authorizing an exchange of the *Annales des Mines* with sundry American journals and publications of scientific bodies.

To encourage local collectors and amateurs of science in the work of determining the ichthyology of Indiana, Prof. D. S. Jordan, of the State Geological Survey, has published a preliminary list of the fishes which he has himself found, and adds a list of those likely to occur in Indiana waters.

At the initial meeting of the Khedival Society of Geography, held June 2d, the Khedive was represented by his second son, Hussein Pasha, and there were present most of the prominent representatives of the foreign colony in Cairo. The president, Dr. Schweinfurth, addressed the meeting in French. "Science," said he, "which had been carried from Egypt into Greece and Italy, and thence into Central Europe, was now returning to its birthplace. By the munificence of the Khedive, a society had now been established whose object it would be to advance the oldest, the most universal, and the most popular of the sciences. Unlike its sister associations in Europe and America, which have their field of research in distant lands, the Khedival Society had all its work to do at home, so to speak."

In a lecture at Edinburgh on carnivorous plants, Dr. Balfour stated that young plants of *Dionœa muscipula* under bell-glasses do not thrive so well as those left free, and that while a piece of beef wrapped in another leaf becomes putrid, a piece inclosed by the *Dionœa* remains perfectly inodorous, but soon loses its red color, and is gradually disintegrated more and more till it is reduced to a pulp.

Palladium, when coated with palladium-black, becomes saturated with hydrogen much more rapidly than the clean metal. If, when thus saturated, it be wrapped in gun-cotton, an explosion ensues after a few seconds, and the platinum plate burns for a short time with a feeble flame.

Experiments made by Pfaff show ice to be by no means a bad conductor of heat. Taking the conductivity of gold as 1,000, platinum is 981, silver 973, iron 374, ice 314, and tin 303. Dr. Pfaff suggests that his results will modify our views of the physical condition of the interior of a mass of ice.

From the observations of Ebermeyer it appears that, in a given species of tree, the size of the leaves differs in proportion to the elevation. With equal strength of soil, the leaves decrease with height. Again, the entire amount of ash in the leaves decreases with the height; and the proportion of phosphoric acid in the ash is much less in high positions than on low ground.

Statuettes and other artistic forms in plaster are made very closely to resemble silver in appearance by being covered with a thin coat of powdered mica. This powder is mixed with collodion and then applied to the objects in plaster with a brush, after the manner of paint. The mica can be easily tinted in various colors. It can be washed in water, and, unlike silver, is not liable to become tarnished by sulphuretted gases.

In Great Britain and Ireland, the excise duties on liquors for the year ending March, 1875, amounted to £31,917,849, being an increase of £600,000 over the previous financial year.

"So popular are Mr. Darwin's books," says the *English Mechanic*, "and so widely read, that a countryman with a basket of round-leaved sundews (*Drosera rotundifolia*) has stationed himself near the Royal Exchange in London, and there daily drives a very good trade."

The excellent Abbé Moigno, editor of *Les Mondes*, and general manager of the Catholic enterprise for diffusing a knowledge of science among the laboring-classes in France, has issued a work entitled "Explosions of Freethinking in August and September, 1874," containing the discourses of Tyndall, Du Bois-Reymond, R. Owen, Huxley, Hooker, and Sir John Lubbock. The abbé appends annotations of his own. This is as it should be: poison and antidote!

It is asserted by E. Heckel, as the result of experiments made upon certain rodents and marsupials, that these animals, when fed on the leaves of poisonous solanaceous plants, are not subject to any injurious effects.

A committee appointed for the purpose of investigating the working of the government telegraph system in England reports that the present rate, one shilling per message, is too low, and recommends that it be increased fifty per cent. The *Examiner*, on the contrary, asserts that only by a *reduction* of fifty per cent. can the telegraph service be made self-sustaining. Such reduction, it is claimed, would have the same result as cheap postal rates.

From experiments made on a large number of animals belonging to different orders, Rudolph Pott concludes that, of all animals, birds exhale the greatest amount, proportionately, of carbonic acid; after birds rank the mammalia, and then insects. Worms, amphibia, fishes, and snails, exhale much less carbonic acid than birds, mammals, or insects. The influence of age on carbonic-acid excretion is very marked: thus, for example, an old mouse exhaled in a given time 3.873 grammes, a young one 4.349. But with insects the case is different, old individuals exhaling more carbonic acid than young.

In Turkey, Russia, and Peru, the number of pupils receiving primary instruction in schools forms from $\frac{1}{4}$ to $\frac{1}{2}$ per cent. of the population; in Spain, 1 per cent.; in Italy, 6; in Hungary, $7\frac{1}{2}$; in Austria, 9; in England and in Norway, 12; in France, 13; in Prussia, 15; in the United States, 17.

On subjecting fishes to a pressure of ten atmospheres, Moreau found that the operation produced no injurious effects whatever. He then suddenly withdrew the pressure, and the fishes succumbed quickly from hæmorrhage, the blood having a frothy appearance. This phenomenon is due to the disengagement of the gases which, under the high pressure, had been taken up by the blood in great quantities.

It is stated in *Iron* that De la Bastie's glass loses its molecular cohesion under a repetition of blows, and then breaks like common glass. Tempered glass, submitted to hammering, presents an appearance on fracture similar to that of *fatigué* steel, a molecular disintegration having taken place. It is feared that this alteration of structure and loss of temper may not only follow from shock, but may happen spontaneously from interior change in the lapse of time.

A recent examination of the hull of the steamship Great Eastern showed a comparative absence of barnacles, though the stern-post, rudder, and screw were covered with them. The rest of that portion of the hull, which as a rule is below water, was clad with an enormous number of mussels, a surface of 52,000 feet being coated in parts to a depth of six inches. The total weight of the mussels is estimated at about 300 tons.

The income of the French Association last year was 37,126 francs, and its capital fund now amounts to 174,731 francs. The Association gained 500 new members at its last meeting. Though the strictest economy must needs have been practised to accumulate so considerable a fund as 175,000 francs, nevertheless the *material* encouragement of scientific investigators is not neglected. Last year 12,350 francs were distributed for purposes of research.

Hitherto batrachians of existing types have been regarded as of recent geological date—not earlier than the Tertiary epoch. Recently, however, batrachian remains were discovered in palæozoic rocks at Igornay (Saône-et-Loire), France. These remains have been described by A. Gaudry, who discovers in them affinities with the salamanders. Though the specimens appear to be adult, they are very small—a little over one inch in length. They occur in bituminous schists of the Permian age.

As a substitute for the dredge in removing sand-banks and other deposits from rivers, a French engineer proposes to employ metal pipes pierced with holes; these pipes are inserted into the mass of the sand-bank and water driven through them at considerable pressure. In this way the sand and mud would be raised and agitated, and carried away by the current of the river or by the ebb-tide, if the operation were conducted at the ebb.

According to Boillot, a French chemist, the bleaching effects usually attributed to chlorine are in reality due to ozone. Ozone employed directly acts as an oxidizing agent, laying hold of the hydrogen of the substance with which it is in contact, whence results bleaching if the body is colored. On allowing chlorine to act upon any animal or vegetable matter, it decomposes a certain quantity of water and seizes its hydrogen, forming hydrochloric acid. The oxygen set free by this reaction is transformed into ozone, which in its turn lays hold of hydrogen present in organic matter.

Actual experiment in England has demonstrated the great advantages of the hammock system of conveying invalids by railway. The invalid suffers neither jar nor jolt. It is proposed to extend the benefits of the hammock system to the general traveling public, thus reducing the discomfort of railway-travel to the minimum.

The cultivation of tea is making rapid progress in Ceylon, and extensive clearings of forest-land were made during the past year for forming new plantations. The seed is generally imported from India, though the Assam hybrid and China teas are also cultivated extensively.

PRINCIPAL J. W. DAWSON.

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## MARTINEAU AND MATERIALISM.[1]

By JOHN TYNDALL, F. R. S., LL. D.

PRESENTED in the order of their publication, these Fragments will, I think, make it plain that, within the last two years, I have added no material iniquity to the list previously recorded against me. I have gone carefully over them all this year in Switzerland, bestowing special attention upon the one which has given most offense. To the judgment of thoughtful men I now commit them: the unthoughtful and the unfair will not read them, though they will continue to abuse them.

I have no desire to repay in kind the hard words already thrown at them and me; but a simple comparison will make clear to my more noisy and unreasonable assailants how I regard their position. To the nobler Bereans of the press and pulpit, who have honored me with their attention, I do not now refer. Webster defines a squatter as one who settles on new land without a title. This, in regard to anthropology and cosmogony, I hold to have been the position of the older theologians; and what their heated successors of to-day denounce as "a raid upon theology," is, in my opinion, a perfectly legal and equitable attempt to remove them from ground which they have no right to hold.

If the title exist, let it be produced. It is not the revision of the text of Genesis by accomplished scholars that the public so much need, as to be informed and convinced how far the text, polished or unpolished, has a claim upon the belief of intelligent persons. It is, I fear, a growing conviction that our ministers of religion, for the sake of peace, more or less sacrifice their sincerity in dealing with the cosmogony of the Old Testament. I notice this in conversation, and it is also appearing in print. Before me, for example, is a little *brochure*, in which a layman presses a clerical friend with a series of

[1] Preface to the forthcoming edition of "Fragments of Science."

questions regarding creation—the six-day period of divine activity, the destruction of the world by a flood, the building of an ark, the placing of creatures in it by pairs, and the descent from this ancestry of all living things, "men and women, birds and beasts." He asks his friend, "Do you, *without any mental reservation*, believe these things?" "If you *do*," he continues, "then I can only say that the accumulated and accepted knowledge of mankind, including the entire sciences of astronomy, geology, philology, and history, are [as far as you are concerned] naught and mistaken. If you do *not* believe those events to have so happened, or do so with some mental reservation, which destroys the whole sense and meaning of the narrative, *why do you not say so from your pulpits?*"

The friend merely parries and evades the question. According to Mr. Martineau, the clergy speak very differently indeed from their pulpits. After showing how the Mosaic picture of the genetic order of things has been not only altered but inverted by scientific research, he says: "Notwithstanding the deplorable condition to which the picture has been reduced, it is exhibited fresh every week to millions taught to believe it as divine." It cannot be said that error here does no practical harm, or that it does not act to the detriment of honest men. It was for openly avowing doubts which, it is said, others discreetly entertain, that the Bishop of Natal suffered persecution; it was for his public fidelity to scientific truth, as far as his lights extended, that he was branded, even during his recent visit to this country, as an "excommunicated heretic." The courage of Dean Stanley and of the Master of Balliol, in reference to this question, disarmed indignation, and caused the public to overlook a wrong which might not otherwise have been endured.

The liberal and intelligent portion of Christendom must, I take it, differentiate itself more and more, in word and act, from the fanatical, foolish, and more purely sacerdotal portion. Enlightened Roman Catholics are more specially bound to take action here; for the travesty of heaven and earth is grosser, and the attempt to impose it on the world is more serious, in their community than elsewhere. That they are more or less alive to this state of things, and that they show an increasing courage and independence in their demands for education, will be plain to the reader of the "Apology for the Belfast Address." The "Memorial" there referred to was the impatient protest of barristers, physicians, surgeons, solicitors, and scholars, among the Catholics themselves. They must not relax their pressure nor relinquish their demands. For their spiritual guides live so exclusively in the prescientific past, that even the really strong intellects among them are reduced to atrophy as regards scientific truth. Eyes they have, and see not; ears they have, and hear not; for both eyes and ears are taken possession of by the sights and sounds of another age. In relation to science, the ultramontane brain, through lack of exercise, is virtually the undeveloped brain of the child. And thus it is that as children in scientific knowledge, but as potent wielders of spiritual power among the ignorant, they countenance and enforce practices sufficient to bring the blush of shame to the cheeks of the more intelligent among themselves.

Such is the force of early education, when maintained and perpetuated by the habits of subsequent life; such the ground of peril in allowing the schools of a nation to fall into ultramontane hands. Let any able Catholic student, fairly educated, and not yet cramped by sacerdotalism, get a real scientific grasp of the magnitude and organization of this universe. Let him sit under the immeasurable heavens, watch the stars in their courses, scan the mysterious nebulæ, and try to realize what it all is and means. Let him bring the thoughts and conceptions which thus enter his mind face to face with the notions of the genesis and rule of things which pervade the writings of the princes of his Church, and he will see and feel what drivelers even men of strenuous intellect may become, through exclusively dwelling and dealing with theological chimeras.

But, quitting the more grotesque forms of the theological, I already see, or think I see, emerging from recent discussions, that wonderful plasticity of the theistic idea, which enables it to maintain, through many changes, its hold upon superior minds; and which, if it is to last, will eventually enable it to shape itself in accordance with scientific conditions. I notice this, for instance, in the philosophic sermon of Dr. Quarry, and more markedly still in that of Dr. Ryder. "There pervades," says the Rector of Donnybrook, "these atoms and that illimitable universe, that 'choir of heaven and furniture of earth,' which of such atoms is built up, a certain *force*, known in its most familiar form by the name of 'life,' *which may be regarded as the ultimate essence of matter*." And, speaking of the awful search of the intellect for the infinite Creator, and of the grave difficulties which encompass the subject, the same writer says: "We know from our senses finite existences only. Now we cannot *logically* infer the existence of an infinite God from the greatest conceivable number of finite existences. There must always obviously be more in the conclusion than in the premises." Such language is new to the pulpit, but it will become less and less rare. It is not the poets and philosophers among our theologians—and in our day the philosopher who wanders beyond the strict boundary of Science is more or less merged in the poet—it is not these, who feel the life of religion, but the mechanics, who cling to its scaffolding, that are most anxious to tie the world down to the untenable conceptions of an uncultivated past.

Before me is another printed sermon of a different character from those just referred to. It is entitled "The Necessary Limits of Christian Evidences." Its author, Dr. Reichel, has been frequently referred to as an authority, particularly on personal subjects, during recent discussions. The sermon was first preached in Belfast, and afterward, in an amplified and amended form, in the Exhibition Building in Dublin. In passing, I would make a single remark upon its opening paragraph. This contains an argument regarding Christ which I have frequently heard used in substance by good men, though never before with the grating emphasis here employed. "The resurrection of our Saviour," says Dr. Reichel, "is the central fact of Christianity. Without his resurrection, his birth and his death would have been alike unavailing: nay more, if he did not rise from the dead, his birth was the birth of a bastard, and his death the death of an impostor." This may be "orthodoxy;" but entertaining the notions that I do of Christ, and of his incomparable life upon the earth, if the momentary use of the term "blasphemy" were granted to me by my Christian brethren, I should feel inclined to employ it here.

Better instructed than he had been at Belfast, the orator in Dublin gave prominence to a personal argument which I have already noticed elsewhere. He has been followed in this particular by the Bishop of Meath and other estimable persons. This is to be regretted, because in dealing with these high themes the mind ought to be the seat of dignity—if possible of chivalry—but certainly not the seat of littleness. "I propose," says the preacher, "making some remarks on the doctrine thus propounded" [in Belfast]. "And, first, lest any of you should be unduly impressed by the mere authority of its propounder, as well as by the fluent grace with which he sets it forth, it is right that I should tell you, that these conclusions, though given out on an occasion which apparently stamped them with the general approbation of the scientific world, do not possess that approbation. The mind that arrived at them, and displayed them with so much complacency, is a mind trained in the school of mere experiment, not in the study, but in the laboratory. Accordingly, the highest mathematical intellects of the Association disclaim and repudiate the theories of its president. In the mathematical laws to which all material phenomena and substances are each year more distinctly perceived to be subordinated, they see another side of Nature, which has not impressed itself upon the mere experimentalist."[1]

In view of the new virtue here thrust upon the mathematician, D'Alembert and Laplace present a difficulty, and we are left without a clew to the peculiar orthodoxy of Prof. Clifford and other distinguished men. As regards my own mental training, inasmuch as my censors think it not beneath them to dwell upon a point so small, I may say that the foregoing statement is incorrect. The separation, moreover, of the "study" from the "laboratory" is not admissible,

[1] "Es ist ihre Taktik, die Gegner, gegen welche sie nichts sonst auszurichten vermögen, verächtlich zu behandeln, und allmählich in der Achtung des Publikums herabzusetzen." This was written of the Jesuits in reference to their treatment of Dr. Döllinger. It is true of others.

because the laboratory *is* a "study" in which symbols give place to natural facts. The word Mesopotamia is said to have a sacred unction for many minds, and possibly the title of my "Inaugural Dissertation" at Marburg may have an effect of this kind on my right reverend and reverend critics of the new mathematical school. Here accordingly it is: "Die Schraubenfläche mit geneigter Erzeugungslinie, und die Bedingungen des Gleichewichts auf solchen Schrauben." A little tenderness may, perhaps, flow toward me, after these words have made it known that I began my narrow scientific life less as an experimentalist than as a mathematician.

If, as asserted, "the highest mathematical intellects of the Association disclaim and repudiate the theories of its president," it would be their bounden duty to not rest content with this mere second-hand utterance. They ought to permit the light of life to stream upon us directly from themselves, instead of sending it through the polemoscope[1] of Dr. Reichel. But the point of importance to be impressed upon him, and upon those who may be tempted to follow him in his adventurous theories, is, that out of mathematics no salvation for theology can possibly come.

By such reflections I am brought face to face with an essay to which my attention has been directed by several estimable, and indeed eminent persons, as demanding serious consideration at my hands. I refer with pleasure to the complete accord subsisting between the Rev. James Martineau and myself on certain points of biblical cosmogony. "In so far," says Mr. Martineau, "as church belief is still committed to a given cosmogony and natural history of man, it lies open to scientific refutation." And again: "It turns out that with the sun and moon and stars, and in and on the earth, before and after the appearance of our race, quite other things have happened than those which the sacred cosmogony recites." Once more: "The whole history of the genesis of things Religion must surrender to the Sciences." Finally, still more emphatically: "In the investigation of the genetic order of things, Theology is an intruder, and must stand aside." This expresses, only in words of fuller pith, the views which I ventured to enunciate in Belfast. "The impregnable position of Science," I there say, "may be stated in a few words. We claim, and we shall wrest from Theology, the entire domain of cosmological theory." Thus Theology, so far as it is represented by Mr. Martineau, and Science, so far as I understand it, are in absolute harmony here.

But Mr. Martineau would have just reason to complain of me, if, by partial citation, I left my readers under the impression that the agreement between us is complete. At the opening of the eighty-ninth session of the Manchester New College, London, on October 6, 1874, Mr. Martineau delivered the Address from which I have quoted. It

[1] "An oblique perspective glass, for seeing objects not directly before the eyes."— *Webster.*

bears the title "Religion as affected by Modern Materialism;" and its references and general tone make evident the depth of its author's discontent with my previous deliverance at Belfast. I find it difficult to grapple with the exact grounds of this discontent. Indeed, logically considered, the impression left upon my mind by an essay of great æsthetic merit, containing many passages of exceeding beauty, and many sentiments which none but the pure in heart could utter as they are uttered here, is vague and unsatisfactory—the author appears at times so brave and liberal, at times so timid and captious, and at times so imperfectly informed regarding the position he assails.

At the outset of his address, Mr. Martineau states with some distinctness his "sources of religious faith." They are two—"the scrutiny of Nature" and "the interpretation of sacred books." It would have been a theme worthy of his intelligence to have deduced from these two sources his religion as it stands. But not another word is said about the "sacred books." Having swept with the besom of Science various "books" contemptuously away, he does not define the sacred residue; much less give us the reasons why he deems them sacred. His references to "Nature," on the other hand, are magnificent tirades against Nature, intended, apparently, to show the wholly abominable character of man's antecedents if the theory of evolution be true. Here, also, his mood lacks steadiness. While joyfully accepting, at one place, "the widening space, the deepening vistas of time, the detected marvels of physiological structure, and the rapid filling-in of the missing links in the chain of organic life," he falls, at another, into lamentation and mourning over the very theory which renders "organic life" a "chain." He claims the largest liberality for his sect, and avows its contempt for the dangers of possible discovery. But immediately afterward he damages the claim, and ruins all confidence in the avowal. He professes sympathy with modern science, and almost in the same breath he treats, or certainly will be understood to treat, the atomic theory, and the doctrine of the conservation of energy, as if they were a kind of scientific thimble-riggery.

His ardor, moreover, renders him inaccurate; causing him to see discord between scientific men, where nothing but harmony reigns. In his celebrated address to the Congress of German Naturforscher, delivered at Leipsic, three years ago, Du Bois-Reymond speaks thus: "What conceivable connection subsists between definite movements of definite atoms in my brain, on the one hand, and on the other hand such primordial, indefinable, undeniable facts as these: I feel pain or pleasure; I experience a sweet taste, or smell a rose, or hear an organ, or see something red? . . . It is absolutely and forever inconceivable that a number of carbon, hydrogen, nitrogen, and oxygen atoms, should be otherwise than indifferent as to their own position and motion, past, present, or future. It is utterly inconceivable how consciousness should result from their joint action."

This language, which was spoken in 1872, Mr. Martineau "freely" translates, and quotes against me. The act is due to a misapprehension of his own. Evidence is at hand to prove that I employed the same language twenty years ago. It is to be found in the *Saturday Review* for 1860; but a sufficient illustration of the agreement between my friend Du Bois-Reymond and myself is furnished by the discourse on "Scientific Materialism," delivered in 1868, then widely circulated, and reprinted here. With a little attention, Mr. Martineau would have seen that, in the very address his essay criticises, precisely the same position is maintained. "You cannot," I there say, "satisfy the human understanding in its demand for logical continuity between molecular processes and the phenomena of consciousness. This is a rock on which materialism must inevitably split whenever it pretends to be a complete philosophy of the human mind."

"The affluence of illustration," writes an able and sympathetic reviewer of this essay, in the *New York Tribune*, "in which Mr. Martineau delights often impairs the distinctness of his statements by diverting the attention of the reader from the essential points of his discussion to the beauty of his imagery, and thus diminishes their power of conviction." To the beauties here referred to I bear willing testimony; but the excesses touched upon reach far beyond the reader, to their primal seat and source in Mr. Martineau's own mind; mixing together *there* things that ought to be kept apart; producing vagueness where precision is the one thing needful; poetic fervor where we require judicial calm; and practical unfairness where the strictest justice ought to be, and I willingly believe is meant to be, observed.

In one of his nobler passages, Mr. Martineau tells us how the pupils of his college have been educated hitherto: "They have been trained under the assumptions—1. That the universe which includes us and folds us round is the life-dwelling of an Eternal Mind; 2. That the world of our abode is the scene of a moral government, incipient but not complete; and, 3. That the upper zones of human affection, above the clouds of self and passion, take us into the sphere of a Divine communion. Into this overarching scene it is that growing thought and enthusiasm have expanded to catch their light and fire."

Alpine summits must kindle above the mountaineer who reads these stirring words; I see their beauty and feel their life. Nay, in my own feeble way, at the close of one of the essays here printed, I thus affirm the "communion" which Mr. Martineau calls "Divine:" "'Two things,' said Immanuel Kant, 'fill me with awe—the starry heavens, and the sense of moral responsibility in man.' And in his hours of health and strength and sanity,[1] when the stroke of action

[1] In the first preface to the Belfast Address I referred to "hours of clearness and vigor" as four years previously I had referred to hours of "health and strength and

has ceased, and the pause of reflection has set in, the scientific investigator finds himself overshadowed by the same awe. Breaking contact with the hampering details of earth, it associates him with a power which gives fullness and tone to his existence, but which he can neither analyze nor comprehend."

Though "knowledge" is here disavowed, the "feelings" of Mr. Martineau and myself are, I think, very much alike. But, notwithstanding this mutual independence of religious feeling and objective knowledge thus demonstrated, he censures me—almost denounces me—for referring religion to the region of emotion. Surely he is inconsistent here. The foregoing words refer to an inward hue or temperature, rather than to an external object of thought. When I attempt to give the power which I see manifested in the universe an objective form, personal or otherwise, it slips away from me, declining all intellectual manipulation. I dare not, save poetically, use the pronoun "he" regarding it; I dare not call it a "mind;" I refuse to call it even "a cause." Its mystery overshadows me; but it remains a mystery, while the objective frames which my neighbors try to make it fit, simply distort and desecrate it.

It is otherwise with Mr. Martineau, and hence his discontent. He professes to *know* where I only claim to *feel*. He could make his contention good against me if he would transform, by a process of verification, the foregoing three assumptions into "objective knowledge." But he makes no attempt to do so. They remain assumptions from the beginning of his address to its end. And yet he frequently uses the word "unverified," as if it were fatal to the position on which its incidence falls. "The scrutiny of Nature" is one of his sources of "religious faith:" what logical foothold does that scrutiny furnish on which any one of the foregoing three assumptions could be planted? Nature, according to his picturing, is base and cruel: what is the inference to be drawn regarding its author? If Nature be "red in tooth and claw," who is responsible? On a mindless Nature, Mr. Martineau pours the full torrent of his gorgeous invective; but could the "assumption" of "an Eternal Mind"—even of a beneficent Eternal Mind—render the world objectively a whit less mean and ugly than it is? Not an iota. It is man's feelings, and not external phenomena, that are influenced by the assumption. It adds not a ray of light nor a strain of music to the objective sum of things. It does not touch the phenomena of physical Nature—storm, flood, or fire—nor diminish by a pang the bloody combats of the animal world. But it does add the glow of religious emotion to the human

sanity;" and brought down upon myself, in consequence, a considerable amount of ridicule. Why I know not. For I am still bound in honesty to confess that it is not when sleepy after a gluttonous meal, or suffering from dyspepsia, or even possessed by a physical problem demanding concentrated thought, that I care most for the "starry heavens, or the sense of responsibility in man."

soul, as represented by Mr. Martineau. Beyond this I defy him to go; and yet he rashly—it might be said petulantly—kicks away the only philosophic foundation on which it is possible for him to build his religion.

He twits incidentally the modern scientific interpretation of Nature because of its want of cheerfulness. "Let the new future," he says, "preach its own gospel and devise, if it can, the means of making the tidings *glad*." This is a common argument: "If you only knew the comfort of belief!" My reply to it is that I choose the nobler part of Emerson, when, after various disenchantments, he exclaimed, "I covet *truth!*" The gladness of true heroism visits the heart of him who is really competent to say this. Besides, "gladness" is an emotion, and Mr. Martineau theoretically scorns the emotional. I am not, however, acquainted with a writer who draws more largely upon this source, while mistaking it for something objective. "To reach the cause," he says, "there is no need to go into the past, as though being missed here he could be found there. But when once he has been apprehended by the proper organs of divine apprehension, the whole life of humanity is recognized as the scene of his agency." That Mr. Martineau should have lived so long, thought so much, and failed to recognize the entirely subjective character of this creed, is highly instructive. His "proper organs of divine apprehension"—denied, I may say, to some of the greatest intellects and noblest men in this and other ages—lie at the very core of his emotions.

In fact, it is when Mr. Martineau is most purely emotional that he scorns the emotions; and it is when he is most purely subjective, that he rejects subjectivity. He pays a just and liberal tribute to the character of John Stuart Mill. But in the light of Mill's philosophy, benevolence, honor, purity, having "shrunk into mere unaccredited subjective susceptibilities, have lost all support from Omniscient approval, and all presumable accordance with the reality of things." If Mr. Martineau had given them any inkling of the process by which he renders the "subjective susceptibilities" objective; or how he arrives at an objective ground of "Omniscient approval," gratitude from his pupils would have been his just meed. But as it is, he leaves them lost in an iridescent cloud of words, after exciting a desire which he is incompetent to appease.

"We are," he says, in another place, "forever shaping our representations of invisible things into forms of definite opinion, and throwing them to the front, as if they were the photographic equivalent of our real faith. It is a delusion which affects us all. Yet somehow the essence of our religion never finds its way into these frames of theory: as we put them together it slips away, and, if we turn to pursue it, still retreats behind; ever ready to work with the will, to unbind and sweeten the affections, and bathe the life with reverence, but refusing to be seen, or to pass from a divine hue of thinking into a human pattern of thought." This is very beautiful, and mainly so because the man who utters it obviously brings it all out of the treasury of his own heart. But the "hue" and "pattern" here so finely spoken of are neither more nor less than that "emotion" and that "objective knowledge" which have drawn this suicidal fire from Mr. Martineau's battery.

I now come to one of the most serious portions of Mr. Martineau's pamphlet—serious far less on account of its "personal errors," than of its intrinsic gravity, though its author has thought fit to give it a witty and sarcastic tone. He analyzes and criticises "the materialist doctrine, which, in our time, is proclaimed with so much pomp, and resisted with so much passion. 'Matter is all I want,' says the physicist; 'give me its atoms alone, and I will explain the universe.'" It is thought, even by Mr. Martineau's intimate friends, that in this pamphlet he is answering me. I must therefore ask the reader to contrast the foregoing travesty with what I really do say regarding atoms: "I do not think that he (the materialist) is entitled to say that his molecular groupings and motions *explain* every thing. In reality, they explain nothing. The utmost he can affirm is the association of two classes of phenomena, of whose real bond of union he is in absolute ignorance." This is very different from saying, "Give me its atoms alone, and I will explain the universe." Mr. Martineau continues his dialogue with the physicist: "'Good,' he says; 'take as many atoms as you please. See that they have all that is requisite to Body' [a metaphysical B], 'being homogeneous extended solids.' 'That is not enough,' he replies; 'it might do for Democritus and the mathematicians, but I must have something more. The atoms must not only be in motion, and of various shapes, but also of as many kinds as there are chemical elements; for how could I ever get water if I had only hydrogen elements to work with?' 'So be it,' Mr. Martineau consents to reply, 'only this is a considerable enlargement of your specified datum' [where, and by whom specified?]—'in fact, a conversion of it into several; yet, even at the cost of its monism' [put into it by Mr. Martineau] 'your scheme seems hardly to gain its end; for by what manipulation of your resources will you, for example, educe consciousness?'"

This reads like pleasantry, but it deals with serious things. For the last seven years the question proposed by Mr. Martineau and my answer to it have been accessible to all. Here, briefly, is the question: "A man can say 'I feel, I think, I love,' but how does consciousness infuse itself into the problem?" And here is the answer: "The passage from the physics of the brain to the corresponding facts of consciousness is unthinkable. Granted that a definite thought and a definite molecular action in the brain occur simultaneously; we do not possess the intellectual organ, nor apparently any rudiment of the organ, which would enable us to pass, by a process of reasoning, from one to the other. They appear together, but we do not know why. Were our minds and senses so expanded, strengthened, and illuminated, as to enable us to see and feel the very molecules of the brain; were we capable of following all their motions, all their groupings, all their electric discharges, if such there be; and were we intimately acquainted with the corresponding states of thought and feeling, we should be as far as ever from the solution of the problem, 'How are these physical processes connected with the facts of consciousness?' The chasm between the two classes of phenomena would still remain intellectually impassable."[1]

Compare this with the answer which Mr. Martineau puts into the mouth of *his* physicist, and with which I am generally credited by Mr. Martineau's readers: "'It (the problem of consciousness) does not daunt me at all. Of course you understand that all along my atoms have been affected by gravitation and polarity; and now I have only to insist with Fechner on a difference among molecules; there are the *inorganic*, which can change only their *place*, like the particles in an undulation; and there are the *organic*, which can change *their order*, as in a globule that turns itself inside out. With an adequate number of these, our problem will be manageable.' 'Likely enough,' we may say ['entirely unlikely,' say I], 'seeing how careful you are to provide for all emergencies; and if any hitch should occur in the next step, where you will have to pass from mere sentiency to thought and will, you can again look in upon your atoms, and fling among them a handful of Leibnitz's monads, to serve as souls in little, and be ready, in a latent form, with that Vorstellungsfähigkeit which our picturesque interpreters of Nature so much prize.'"

"But surely," continues Mr. Martineau, "you must observe that this 'matter' of yours alters its style with every change of service: starting as a beggar, with scarce a rag of 'property' to cover its bones, it turns up as a prince when large undertakings are wanted. 'We must radically change our notions of matter,' says Prof. Tyndall; and then, he ventures to believe, it will answer all demands, carrying 'the promise and potency of all terrestrial life.' If the measure of the required 'change in our notions' had been specified, the proposition would have had a real meaning, and been susceptible of a test. It is easy traveling through the stages of such an hypothesis; you deposit at your bank a round sum ere you start, and, drawing on it piecemeal at every pause, complete your grand tour without a debt."

The last paragraph of this argument is forcibly and ably stated. On it I am willing to try conclusions with Mr. Martineau. I may say, in passing, that I share his contempt for the picturesque inter-

[1] Bishop Butler's reply to the Lucretian in the Belfast Address is all in the same strain.

pretation of Nature, if accuracy of vision be thereby impaired. But the term Vorstellungs-fähigkeit, as used by me, means the power of definite mental presentation, of attaching to words the corresponding objects of thought, and of seeing these in their proper relations, without the interior haze and soft penumbral borders, which the theologian loves. To this mode of "interpreting Nature" I shall to the best of my ability now adhere.

Neither of us, I trust, will be afraid or ashamed to begin at the alphabet of this question. Our first effort must be to understand each other, and this mutual understanding can only be insured by beginning low down. Physically speaking, however, we need not go below the sea-level. Let us, then, travel in company to the Caribbean Sea, and halt upon the heated water. What is that sea, and what is the sun which heats it? Answering for myself, I say that they are both *matter*. I fill a glass with the sea-water and expose it on the deck of the vessel; after some time the liquid has all disappeared, and left a solid residue of salts in the glass behind. We have mobility, invisibility—apparent annihilation. In virtue of

"The glad and secret aid
The sun unto the ocean paid,"

the water has taken to itself wings and flown off as vapor. From the whole surface of the Caribbean Sea such vapor is rising; and now we must follow it—not upon our legs, however, nor in a ship, nor even in a balloon, but by the mind's eye—in other words, by that power of Vorstellung which Mr. Martineau knows so well, and which he so justly scorns when it indulges in loose practices.

Compounding, then, the northward motion of the vapor with the earth's axial rotation, we track our fugitive through the higher atmospheric regions, obliquely across the Atlantic Ocean to Western Europe, and on to our familiar Alps. Here another wonderful metamorphosis occurs. Floating on the cold, calm air, and in presence of the cold firmament, the vapor condenses, not only to particles of water, but to particles of crystalline water. These coalesce to stars of snow, and afterward fall upon the mountains in forms so exquisite that, when first seen, they never fail to excite rapture. As to beauty, indeed, they put the work of the lapidary to shame, while as to accuracy they render concrete the abstractions of the geometer. Are these crystals "matter?" Without presuming to dogmatize, I answer for myself in the affirmative.

Still, a *formative power* has obviously here come into play which did not manifest itself in either the liquid or the vapor. The question now is, Was not the power "potential" in both of them, requiring only the proper conditions of temperature to bring it into action? Again I answer for myself in the affirmative. I am, however, quite willing to discuss with Mr. Martineau the alternative hypothesis, that an imponderable formative soul unites itself with the substance after its escape from the liquid. If he should espouse this hypothesis, then I should demand of him an immediate exercise of that Vorstellungsfähigkeit, with which, in my efforts to think clearly, I can never dispense. I should ask, At what moment did the soul come in? Did it enter at once or by degrees; perfect from the first, or growing and perfecting itself contemporaneously with its own handiwork? I should also ask whether it was localized or diffused? Does it move about as a lonely builder, putting the bits of solid water in their places as soon as the proper temperature has set in? or is it distributed through the entire mass of the crystal? If the latter, then the soul has the shape of the crystal; but if the former, then I should inquire after its shape. Has it legs or arms? If not, I would ask it to be made clear to me how a thing without these appliances can act so perfectly the part of a builder? (I insist on definition, and ask unusual questions, if haply I might thereby abolish unmeaning words.) What were the condition and residence of the soul before it joined the crystal? What becomes of it when the crystal is dissolved? Why should a particular temperature be needed before it can exercise its vocation? Finally, is the problem before us in any way simplified by the assumption of its existence? I think it probable that, after a full discussion of the question, Mr. Martineau would agree with me in ascribing the building power displayed in the crystal to the bits of water themselves. At all events, I should count upon his sympathy so far as to believe that he would consider any man unmannerly who would denounce me for rejecting this notion of a separate soul, and for holding the snow-crystal to be "matter."

But then what an astonishing addition is here made to the powers of matter! Who would have dreamed, without actually seeing its work, that such a power was locked up in a drop of water? All that we needed to make the action of the *liquid* intelligible was the assumption of Mr. Martineau's "homogeneous extended atomic solids," smoothly gliding over one another. But had we supposed the water to be nothing more than this, we should have ignorantly defrauded it of an intrinsic architectural power, which the art of man, even when pushed to its utmost degree of refinement, is incompetent to imitate. I would invite Mr. Martineau to consider how inappropriate his figure of a fictitious bank-deposit becomes under these circumstances. The "account current" of matter receives nothing at my hands which could be honestly kept back from it. If, then, "Democritus and the mathematicians" so defined matter as to exclude the powers here proved to belong to it, they were clearly wrong, and Mr. Martineau, instead of twitting me with my departure from them, ought rather to applaud me for correcting them.

The reader of my small contributions to the literature which deals with the overlapping margins of science and theology will have noticed how frequently I quote Mr. Emerson. I do so mainly because in him we have a poet and a profoundly religious man, who is really and entirely undaunted by the discoveries of science, past, present, or prospective. In his case Poetry, with the joy of a bacchanal, takes her graver brother Science by the hand, and cheers him with immortal laughter. By Emerson scientific conceptions are continually transmuted into the finer forms and warmer hues of an ideal world. Our present theme is touched upon in the lines—

> "The journeying atoms, primordial wholes
> Firmly draw, firmly drive by their animate poles."

As regards veracity and insight these few words outweigh, in my estimation, all the formal learning expended by Mr. Martineau in these disquisitions on force, in which he treats the physicist as a conjurer, and speaks so wittily of atomic polarity. In fact, without this notion of polarity—this "drawing" and "driving"—this attraction and repulsion, we stand as stupidly dumb before the phenomena of crystallization as a Bushman before the phenomena of the solar system. The genesis and growth of the notion I have endeavored to make clear in my third lecture on "Light," and in the article "Crystals and Molecular Force," published in this volume.

Our future course is here foreshadowed. A Sunday or two ago I stood under an oak planted by Sir John Moore, the hero of Corunna. On the ground near the tree little oaklets were successfully fighting for life with the surrounding vegetation. The acorns had dropped into the friendly soil, and this was the result of their interaction. What is the acorn? what the earth? and what the sun, without whose heat and light the tree could not become a tree, however rich the soil, and however healthy the seed? I answer for myself as before—all "matter." And the heat and light which here play so potent a part are acknowledged to be motions of matter. By taking something much lower down in the vegetable kingdom than the oak, we might approach much more nearly to the case of crystallization already discussed, but this is not now necessary.

If, instead of conceding the sufficiency of matter here, Mr. Martineau should fly to the hypothesis of a vegetative soul, all the questions before asked in relation to the snow-star become pertinent. I would invite him to go over them one by one, and consider what replies he will make to them. He may retort by asking me "Who infused the principle of life into the tree?" I say in answer that our present question is not this, but another—not who made the tree, but what *is* it? Is there any thing besides matter in the tree? If so, what, and where? Mr. Martineau may have begun by this time to discern that it is not "picturesqueness," but cold precision, that my Vorstellungs-fähigkeit demands. How, I would ask, is this vegetative soul to be presented to the mind; where did it flourish before the tree grew, and what will become of it when the tree is sawn into planks, or consumed in fire?

Possibly Mr. Martineau may consider the assumption of this soul to be as untenable and as useless as I do. But, then, if the power to build a tree be conceded to pure matter, what an amazing expansion of our notions of the "potency of matter" is implied in the concession! Think of the acorn, of the earth, and of the solar light and heat—was ever such necromancy dreamed of as the production of that massive trunk, those swaying boughs and whispering leaves, from the interaction of these three factors? In this interaction, moreover, consists what we call *life*. It will be seen that I am not in the least insensible to the wonder of the tree; nay, I should not be surprised if, in the presence of this wonder, I feel more perplexed and overwhelmed than Mr. Martineau himself.

Consider it for a moment. There is an experiment, first made by Wheatstone, where the music of a piano is transferred from its sound-board, through a thin wooden rod, across several silent rooms in succession, and poured out at a distance from the instrument. The strings of the piano vibrate, not singly, but ten at a time. Every string subdivides, yielding not one note, but a dozen. All these vibrations and subvibrations are crowded together into a bit of deal not more than a quarter of a square inch in section. Yet no note is lost. Each vibration asserts its individual rights; and all are, at last, shaken forth into the air by a second sound-board, against which the distant end of the rod presses. Thought ends in amazement when it seeks to realize the motions of that rod as the music flows through it. I turn to my tree and observe its roots, its trunk, its branches, and its leaves. As the rod conveys the music, and yields it up to the distant air, so does the trunk convey the matter and the motion—the shocks and pulses and other vital actions—which eventually emerge in the umbrageous foliage of the tree. I went some time ago through the greenhouse of a friend. He had ferns from Ceylon, the branches of which were in some cases not much thicker than an ordinary pin—hard, smooth, and cylindrical—often leafless for a foot or more. But at the end of every one of them the unsightly twig unlocked the exuberant beauty hidden within it, and broke forth into a mass of fronds, almost large enough to fill the arms. We stand here upon a higher level of the wonderful: we are conscious of a music subtiler than that of the piano, passing unheard through these tiny boughs, and issuing in what Mr. Martineau would opulently call the "clustered magnificence" of the leaves. Does it lessen my amazement to know that every cluster, and every leaf—their form and texture—lie, like the music in the rod, in the molecular structure of these apparently insignificant stems? Not so. Mr. Martineau weeps for "the beauty of the flower fading into a necessity." I care not whether it comes to me through necessity or through freedom, my delight in it is all the same. I see what he sees with a wonder superadded. To me as to him—nay, to me more than to him—not even Solomon in all his glory was arrayed like one of these.

I have spoken above as if the assumption of a soul would save Mr. Martineau from the inconsistency of crediting pure matter with the astonishing building power displayed in crystals and trees. This, however, would not be the necessary result; for it would remain to be proved that the soul assumed is not itself matter. When a boy, I learned from Dr. Watts that the souls of conscious brutes are mere matter. And the man who would claim for matter the human soul itself, would find himself in very orthodox company. "All that is created," says Fauste, a famous French bishop of the fourth century, "is matter. The soul occupies a place; it is inclosed in a body; it quits the body at death, and returns to it at the resurrection, as in the case of Lazarus; the distinction between hell and heaven, between eternal pleasures and eternal pains, proves that, even after death, souls occupy a place and are corporeal. God only is incorporeal." Tertullian, moreover, was quite a physicist in the definiteness of his conceptions regarding the soul. "The materiality of the soul," he says, "is evident from the evangelists. A human soul is there expressly pictured as suffering in hell; it is placed in the middle of a flame, its tongue feels a cruel agony, and it implores a drop of water at the hands of a happier soul. *Wanting materiality*," adds Tertullian, "*all this would be without meaning.*" One wonders what would have happened to this great Christian father amid the roaring lions of Belfast. Could its excellent press have shielded him from its angry pulpits, as it sheltered me? [1]

I have glanced at inorganic Nature—at the sea, and the sun, and the vapor, and the snow-flake—and at organic Nature as represented by the fern and the oak. That same sun which warmed the water and liberated the vapor, exerts a subtiler power on the nutriment of the tree. It takes hold of matter wholly unfit for the purposes of nutrition, separates its nutritive from its non-nutritive portions, gives the former to the vegetable, and carries the others away. Planted in the earth, bathed by the air, and tended by the sun, the tree is traversed by its sap, the cells are formed, the woody fibre is spun, and the whole is woven to a texture wonderful even to the naked eye, but a million-fold more so to microscopic vision. Does consciousness mix in any way with these processes? No man can tell. Our only ground

[1] The foregoing extracts, which M. Alglave recently brought to light for the benefit of the Bishop of Orleans, are taken from the sixth lecture of the "Cours d'Histoire Moderne" of that most orthodox of statesmen, M. Guizot. "I could multiply," continues M. Guizot, "these citations to infinity, and they prove that in the first centuries of our era the materiality of the soul was an opinion not only permitted, but dominant." Dr. Moriarty, and the synod which he recently addressed, obviously forget their own antecedents. Their boasted succession from the early Church renders them the direct offspring of a "materialism" more "brutal" than any ever enunciated by me.

for a negative conclusion is the absence of those outward manifestations from which feeling is usually inferred. But even these are not entirely absent. In the greenhouses of Kew we may see that a leaf can close, in response to a proper stimulus, as promptly as the human fingers themselves; and while there Dr. Hooker will tell us of the wondrous fly-catching and fly-devouring power of the Dionæa. No man can say that the feelings of the animal are not represented by a drowsier consciousness in the vegetable world. At all events, no line has ever been drawn between the conscious and the unconscious; for the vegetable shades into the animal by such fine gradations, that it is impossible to say where the one ends and the other begins.

In all such inquiries we are necessarily limited by our own powers: we observe what our senses, armed with the aids furnished by science, enable us to observe; nothing more. The evidences as to consciousness in the vegetable world depend wholly upon our capacity to observe and weigh them. Alter the capacity, and the evidence would alter too. Would that which to us is a total absence of any manifestation of consciousness be the same to a being with our capacities indefinitely multiplied? To such a being I can imagine not only the vegetable, but the mineral world, responsive to the proper irritants; the response differing only in degree from those exaggerated manifestations which, in virtue of their grossness, appeal to our weak powers of observation.

Our conclusions, however, must be based, not on powers that we can imagine, but upon those that we possess. What do they reveal? As the earth and atmosphere offer themselves as the nutriment of the vegetable world, so does the latter, which contains no constituent not found in inorganic nature, offer itself to the animal world. Mixed with certain inorganic substances—water, for example—the vegetable constitutes, in the long-run, the sole sustenance of the animal. Animals may be divided into two classes, the first of which can utilize the vegetable world immediately, having chemical forces strong enough to cope with its most refractory parts; the second class use the vegetable world mediately; that is to say, after its finer portions have been extracted and stored up by the first. But in neither class have we an atom newly created. The animal world is, so to say, a distillation through the vegetable world from inorganic nature.

From this point of view all three worlds would constitute a unity, in which I picture life as immanent everywhere. Nor am I anxious to shut out the idea that the life here spoken of may be but a subordinate part and function of a higher life, as the living, moving blood is subordinate to the living man. I resist no such idea as long as it is not dogmatically imposed. Left for the human mind freely to operate upon, the idea has ethical vitality; but, stiffened into a dogma, the inner force disappears, and the outward yoke of a usurping hierarchy takes its place.

The problem before us is, at all events, capable of definite statement. We have on the one hand strong grounds for concluding that the earth was once a molten mass. We now find it not only swathed by an atmosphere, and covered by a sea, but also crowded with living things. The question is, How were they introduced? Certainty may be as unattainable here as Bishop Butler held it to be in matters of religion; but in the contemplation of probabilities the thoughtful mind is forced to take a side. The conclusion of Science, which recognizes unbroken causal connection between the past and the present, would undoubtedly be that the molten earth contained within it elements of life, which grouped themselves into their present forms as the planet cooled. The difficulty and reluctance encountered by this conception arise solely from the fact that the theologic conception obtained a prior footing in the human mind. Did the latter depend upon reasoning alone, it could not hold its ground for an hour against its rival. But it is warmed into life and strength by the emotions—by associated hopes, fears, and expectations—and not only by these, which are more or less mean, but by that loftiness of thought and feeling which lifts its possessor above the atmosphere of self, and which the theologic idea, in its nobler forms, has through ages engendered in noble minds.

Were not man's origin implicated, we should accept without a murmur the derivation of animal and vegetable life from what we call inorganic nature. The conclusion of pure intellect points this way and no other. But this purity is troubled by our interests in this life, and by our hopes and fears regarding the life to come. Reason is traversed by the emotions, anger rising in the weaker heads to the height of suggesting that the compendious shooting of the inquirer would be an act agreeable to God and serviceable to man. But this foolishness is more than neutralized by the sympathy of the wise; and in England at least, so long as the courtesy which befits an earnest theme is adhered to, such sympathy is ever ready for an honest man. None of us here need shrink from saying all that he has a right to say. We ought, however, to remember that it is not only a band of Jesuits, weaving their schemes of intellectual slavery, under the innocent guise of "education," that we are opposing. Our foes are to some extent they of our own household, including not only the ignorant and the passionate, but a minority of minds of high calibre and culture, lovers of freedom, moreover, who, though its objective pull be riddled by logic, still find the ethic life of their religion unimpaired. But while such considerations ought to influence the *form* of our argument, and prevent it from ever slipping out of the region of courtesy into that of scorn or abuse, its *substance*, I think, ought to be maintained and presented in unmitigated strength.

In the year 1855 the chair of Philosophy in the University of Munich happened to be filled by a Catholic priest of great critical penetration, great learning, and great courage, who bore the brunt of battle long before Döllinger. His Jesuit colleagues, he knew, inculcated the belief that every human soul is sent into the world from God by a separate and supernatural act of creation. In a work entitled "The Origin of the Human Soul," Prof. Froschammer, the philosopher here alluded to, was hardy enough to question this doctrine, and to affirm that man, body and soul, comes from his parents, the act of creation being, therefore, mediate and secondary only. The Jesuits keep a sharp lookout on all temerities of this kind, and their organ, the *Civiltà Cattolica*, immediately pounced upon Froschammer. His book was branded as "pestilent," placed in the Index, and stamped with the condemnation of the Church.[1]

It will be seen in the "Apology for the Belfast Address" how simply and beautifully the great Jesuit Perrone causes the Almighty to play with the sun and planets, desiring this one to stop, and another to move, according to his pleasure. To Perrone's Vorstellung God is obviously a large Individual who holds the leading-strings of the universe, and orders its steps from a position outside it all. Nor does the notion now under consideration err on the score of indefiniteness. According to it, the Power whom Goethe does not dare to name, and whom Gassendi and Clerk Maxwell present to us under the guise of a "Manufacturer" of atoms, turns out annually, for England and Wales alone, a quarter of a million of new souls. Taken in connection with the dictum of Mr. Carlyle, that this annual increment to our population are "mostly fools," but little profit to the human heart seems derivable from this mode of regarding the Divine operations.

But if the Jesuit notion be rejected, what are we to accept? Physiologists say that every human being comes from an egg, not more than $\frac{1}{120}$th of an inch in diameter. Is this egg matter? I hold it to be so, as much as the seed of a fern or of an oak. Nine months go to the making of it into a man. Are the additions made during this period of gestation drawn from matter? I think so undoubtedly. If there be any thing besides matter in the egg, or in the infant subsequently slumbering in the womb, what is it? The questions already asked with reference to the stars of snow may be here repeated. Mr. Martineau will complain that I am disenchanting the babe of its wonder; but is this the case? I figure it growing in the womb, woven by a something not itself, without conscious participation on the part of either father or mother, and appearing in due time, a living miracle, with all its organs and all their implications. Consider the work accomplished during these nine months in forming the eye alone

[1] King Maximilian II. brought Liebig to Munich; he helped Helmholtz in his researches, and loved to liberate and foster science. But he did far more damage to the intellectual freedom of his country through his concession of power to the Jesuits in the schools, than his superstitious predecessor Ludwig I. Priding himself on being a German prince, Ludwig would not tolerate the interference of the Roman party with the political affairs of Bavaria.

—with its lens, and its humors, and its miraculous retina behind. Consider the ear with its tympanum, cochlea, and Corti's organ—an instrument of three thousand strings, built adjacent to the brain, and employed by it to sift, separate, and interpret, antecedent to all consciousness, the sonorous tremors of the external world. All this has been accomplished not only without man's contrivance, but without his knowledge, the secret of his own organization having been withheld from him since his birth in the immeasurable past, until the other day. Matter I define as that mysterious thing by which all this is accomplished. How it came to have this power is a question on which I never ventured an opinion. If, then, Matter starts as "a beggar," it is, in my view, because the Jacobs of theology have deprived it of its birthright. Mr. Martineau need fear no disenchantment. Theories of evolution go but a short way toward the explanation of this mystery; while, in its presence, the notion of an atomic Manufacturer and Artificer of souls raises the doubt whether those who entertain it were ever really penetrated by the solemnity of the problem for which they offer such a solution.

There are men, and they include among them some of the best of the race of men, upon whose minds this mystery falls without producing either warmth or color. The "dry light" of the intellect suffices for them, and they live their noble lives untouched by a desire to give the mystery shape or expression. There are, on the other hand, men whose minds are warmed and colored by its presence, and who, under its stimulus, attain to moral heights which have never been overtopped. Different spiritual climates are necessary for the healthy existence of these two classes of men; and different climates must be accorded them. The history of humanity, however, proves the experience of the second class to illustrate the most pervading need. The world will have religion of some kind, even though it should fly for it to the intellectual whoredom of "spiritualism." What is really wanted is the lifting power of an ideal element in human life. But the free play of this power must be preceded by its release from the torn swaddling-bands of the past, and from the practical materialism of the present. It is now in danger of being strangled by the one, or stupefied by the other. I look, however, forward to a time when the strength, insight, and elevation, which now visit us in mere hints and glimpses during moments "of clearness and vigor," shall be the stable and permanent possession of purer and mightier minds than ours—purer and mightier, partly because of their deeper knowledge of matter and their more faithful conformity to its laws.

# OPOSSUMS AND THEIR YOUNG.

BY PROF. W. S. BARNARD.

IN the "Perfect Description of Virginia," 1649, the opossum was noticed as "a beast that hath a bagge under her belly, into which she takes her young ones, if at any time affrighted, and carries them away." Lawson says: "She is the wonder of all animals. The female doubtless breeds her young at her teats, for I have seen them stick fast thereto, when they have been no bigger than a small raspberry, and seemingly inanimate. She has a pouch or false belly wherein she carries her young, after they are from those teats, till they can shift for themselves. . . . If a cat has nine lives, this creature surely has nineteen; for if you break every bone in their skin, and mash their skull, leaving them for dead, you may come an hour after, and they will be gone quite away. . . . Their fur is not esteemed nor used, save that the Indians spin it into girdles and garters." Aside from its curious appearance and habits, the opossum (Fig. 1) possesses an unusual interest from being our typical, and the only North American representative of that large order of peculiar mammals known as marsupials. Its mode of reproduction long remained a mystery, and even at

FIG. 1.—COMMON VIRGINIA OPOSSUM (*Didelphys Virginiana*).

this day almost nothing is known of its development, which, when thoroughly understood, must explain the origin of the pouch and other parts characterizing marsupials, and their relationship to allied groups. Having had some experience with these animals, and examined seven sets of young ones,[1] at important stages of development, I think it may be worth while to record some of the observations made.

With the general proportions of (but a longer nose than) the common rat, almost the size of a domestic cat, it presents a rather disagreeable appearance and odor. A dense coat of light-gray wool, with scattered long hairs interspersed, covers the body, while the short ears,

[1] The writer is indebted to Prof. Wilder, of Cornell University, and to Mr. Alexander Agassiz, Curator of the Museum of Comparative Zoölogy, at Cambridge, Massachusetts, for specimens kindly loaned him for examination.

the eyes, the long pointed nose, the feet and tail, are colored quite dark. The strong, round, slender tail is destitute of hair, but covered, like the beaver's, with scales. But the most peculiar feature of this animal is the mammary pocket, or marsupium, formed by a folding-in of the skin on the abdomen. Its character is marked by wonderful cunning and stupidity combined. The daytime it spends in slothful idleness, but prowls about nocturnally seeking for food. Walking or slowly ambling at an awkward gait, it proceeds from place to place, usually following the borders of streams and ponds, often wading where the water is shallow. But its limbs seem best adapted to climbing; the plantigrade, hand-like feet, with thumbs [1] opposable to the fingers, and the long, prehensile tail, strongly indicate scansorial habits and arboreal life. Among the trees it manifests astonishing agility, climbing or swinging from branch to branch with perfect safety, and may be seen hanging by one or more of its feet, or by its tail alone, while busily engaged gathering and eating the wild-grapes, or haw, or persimmon, of which it is peculiarly fond, or robbing birds'-nests of their eggs or young. A varied diet suits its omnivorous appetite, and it fares promiscuously on fruits, vegetables, eggs, insects, worms, reptiles, small quadrupeds, and birds, often stealing domestic fowls. It commonly hides among vines and branches, in hollow trees or logs, or in holes in the ground. In these places also its nests of grass and leaves are found. In autumn, the opossums become excessively fat, and are then prized for food in the Southern States, especially by the negroes, whose fondness for hunting them and eating their flesh has already exterminated them from many localities where they abounded plentifully before. Their flesh, when cooked, resembles roast-pig. The animal is usually sullen, stupid, and slow, but if attacked assumes a terribly fierce attitude, snarls, utters a kind of hiss and low growl, and will often bite ferociously, though at the first blow will usually feign death, and no amount of torture will make it revive or show a sign of suffering, but when beaten and left for dead it will

[1] In the October "Miscellany" (p. 758) of this Journal, some of the facts concerning my contributions to the myology of the apes and man appeared incorrectly reported. Since the opossum's foot was wrongly referred to as being typical and unlike the hand of man, the mistake may be corrected here. The comparison of man's foot with the opossum's was unfortunate; the right idea was expressed, but a wrong illustration chosen. The fact is, the opossum is *pedimanous*, having an opposable thumb, as was stated in a paper presented at the same time with the above. It has a rather highly-differentiated foot, whereas the contrary was supposed.

Few, if any, animals outside the groups of the quadrumana and the opossum family have the parts of their muscles so specialized that one toe can be used without moving all the others.

Instead of "one *communis* muscle," there are several in every typical foot. My papers show that the so-called "proprius" muscles, such as the special extensors of the index, thumb, little finger, etc., which characterize the hands of man and some of the apes, are but parts differentiated off from one or another of the "communis" muscles, and are found as parts of those muscles in lower animals with more typical feet often crawl away as soon as its enemy is gone. Its great endurance is also shown by the fact that when fat it can live for three or four weeks without food or water.

The female is very fond of her young, enjoying with them that domestic felicity portrayed by Florian in his happy fable, "La Sarigue

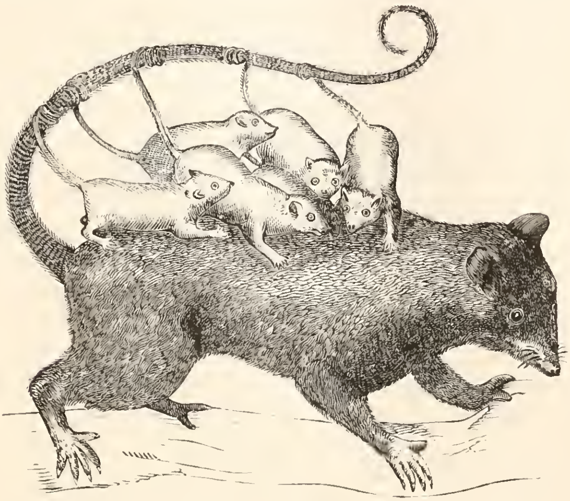


FIG. 2.—MERIAN'S OPOSSUM (*Didelphys Dorsigera*) WITH YOUNG.

et ses petits," and she will offer every resistance, and suffer greatly, to prevent any one looking into her pouch to examine her offspring.

In Europe, Asia, and Africa, not a single marsupial exists. Our only species, *Didelphys Virginiana*, the opossum, is found from the Great Lakes to the Gulf, and from ocean to ocean; but it has several relatives in South America, where about twenty species exist, such as the sarigue, shupati, and carigueya, of Brazil. In some of these the pouch is rudimentary, affording little protection to the young, which hang fast to the nipples until able to jump about, and then are carried on the back of the female, where they cling to her wool and gain additional support by coiling their tails around hers. Perhaps the most cunning of this sort is the so-called Merian's oppossum (*Didelphys dorsigera*), of Surinam, represented in Fig. 2. Also, the yopock (*Cheironectes palmatus*) is peculiarly interesting on account of its aquatic habits and webbed feet, adapted to swimming. Its foot also has a long tubercle, which has been mistaken for a sixth toe, and the mouth is furnished with large cheek-pouches. It inhabits holes along the streams of Brazil, and lives on small aquatic animals, spawn of fish, etc. Its mode of life reminds one of the ornithorhynchus and the otter. A specimen of this species was caught alive near Pará, in a fish-trap similar to the kind of basket with a funnel-shaped opening used for catching eels. Although marsupial animals are so exceedingly rare in other parts of the world, the kangaroos and almost all of the great variety of animals of Australia belong to this group. Thus it appears they are mostly tropical.

The earliest fossil mammals known appear to be marsupials allied to the opossum. In the bone-caverns of Brazil quantities of bones of opossums, such as live in that country now or similar, are found. One species of *Didelphys* was found fossil in the Paris Basin, of Eocene formation. Other relatives of the opossum have been found in a fossil state, associated with the palæotherium, anoplotherium, and other extinct pachydermous quadrupeds; but the most remarkable are found in Jurassic rocks, as the earliest fossil mammals known. Their discovery in this ancient reptilian age in the limestone of Stonesfield was so extraordinary that attempts were made, on the one hand, to prove that their remains were reptilian; on the other, to prove that the rocks were of Tertiary origin; but it has been established, beyond all doubt, that these animals originated in this early reptilian age, and, probably, by descent, either directly or indirectly, from not very remote reptilian ancestry. This relationship is indicated, not only by the fossil remains of marsupials, but also by the anatomical and embryonic characters of marsupials and monotremes, so far as known. The organization of marsupials seems to be a kind of reptilian and mammalian combination, as has been shown by the valuable investigations of Prof. Owen, Dr. Coues, and others.

The monotremes present the lowest grade of mammalian organization, in many respects approaching closely to the oviparous classes of birds and reptiles. It is probably through these that the marsupials have gained some reptilian characters. The opossum, for example, has "a genuine reptilian skull," as Dr. Coues has remarked in his estimable memoir on the anatomy of this animal.

The main difficulty in tracing out the genealogy of marsupials is that our knowledge of them is confined chiefly to the living forms, while these must be but a small remnant of the whole group as it existed in ancient times, when its members inhabited every land on the face of our globe. Even in the imagination we cannot resurrect the manifold varieties of the past. But, in all probability, Prof. Haeckel is right in believing that this group affords a series of forms connecting the lower apes or lemuroids above them with the monotremes below. This would bring some of the marsupials within the lineage of human ancestry, and, before all others, the opossums seem most closely allied to the lemuroid apes. Indeed, they have already been grouped with man and the apes, although their structure hardly warrants such a classification. Storr congregated into one group all mammals with an opposable thumb. Also, Ogilby adopted the name cheiropeds for the same group, and subdivided it into Bimana (men), Quadrumana (monkeys), and Pedimana (Semiadæ and opossums).

The characters of groups are generally arranged into categories intended to show how groups are distinct from each other; but, if it is equally fair to arrange those characters in such a way as to show the affinities of groups with each other, and what they have in common, we may say briefly that the placental mammals are connected with the marsupials by having—1. Nipples; 2. Free clavicles; 3. An embryonal cloaca, and by these characters both groups are distinguished from the monotremes below them; the marsupials and monotremes are united by having in common—1. Marsupial bones; 2. Undeveloped bigeminal bodies; 3. No placenta, and by these characters

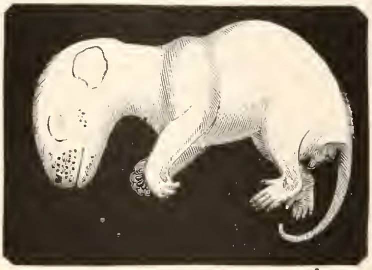


FIG. 3.—YOUNG OPOSSUM. Natural Size.

are distinguished from the placental mammals above; while the monotremes join with the reptiles in possessing—1. United clavicles; 2. A permanent cloaca; 3. No nipples, and by these characters are distinguished from the marsupials above. A great many more characters and facts from the comparative anatomy, embryology, and palæology, could have been used in this comparison; but those given are enough to show how characters usually regarded as *distinctive* only may also at the same time be viewed as *connective.*

The order of living marsupials presents remarkable diversity of structure and habits, containing herbivorous, insectivorous, and carnivorous species; yet we find all these traits combined in one and the same species, the opossum. It is probable that, by adaptation to similar modes of life, the marsupials have developed groups parallel to those of the placental mammals. However, it is certain the Quadrumana seem represented by the Phalangers, the Carnivora by the Dasyuri, Insectivora by the Phascogales, Ruminantia by the kangaroos, and Edentata by the Monotremes. Rodents and bats are numerous in Australia, but only one of the former is marsupial, and none of the latter. The subdivisions of the order are indicated by the modifications of the extremities and digestive system. A gradual transition is found passing from the Phalangers through the Paramelidæ to the kangaroos. All arboreal species have an opposable thumb. This thumb is rudimentary or wanting in the terrestrial species, but in both the carnivorous and herbivorous groups we find a gradual transition to the species possessing a well-developed thumb; thus the

Didelphidæ (opossums) have a well-developed thumb; in some of the Dasyuridæ it becomes very small, while a tolerably distinct thumb characterizes the Phascogales; a rudimentary thumb in Dasyurus; no external thumb in *D. Maujei*, but its metatarsal exists, while in Thylacinus even its metatarsal is gone.

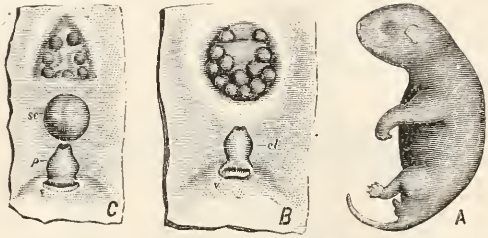


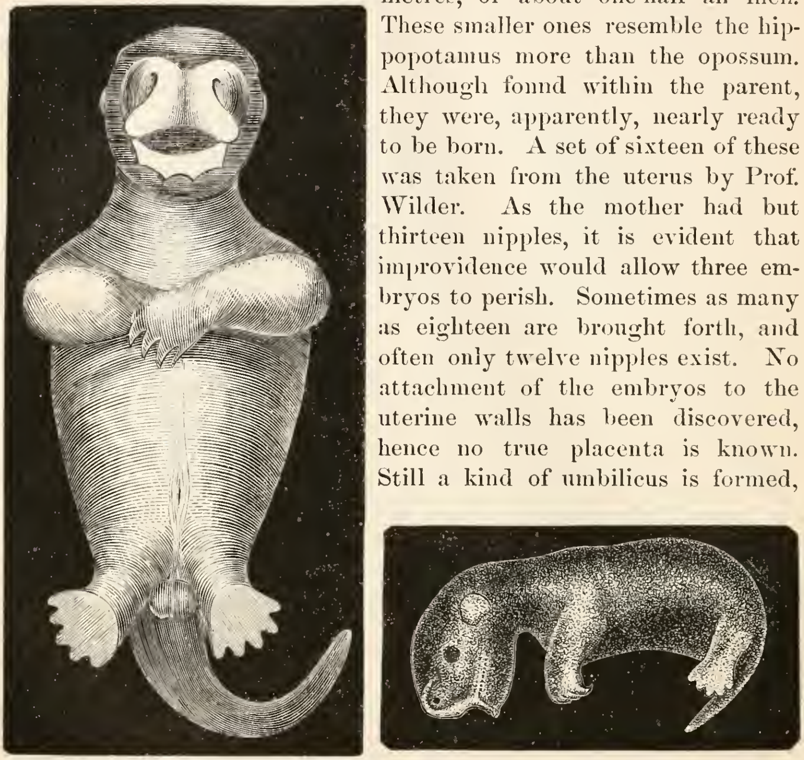

Fig. 4.—A, Young Female Opossum (*Didelphys Virginiana*). Natural Size. B, Marsupium, clitoris, and vent of the same, enlarged; C, Marsupium, penis, and vent of a male of the same litter, enlarged.

Below the marsupials stands the group of Monotremes, including the remarkable Australian Ornithorhynchus and Echidna. In the former the openings of the milk-glands on the abdomen are not marked by any elevation or depression; but in Echidna we find a similar pair of glands, the opening of each becoming depressed at maturity, so as to form a small pit, into which the nose of the young is inserted and attached, where it remains pendant and nourished while its development advances. This pair of little pits may be regarded as the beginning of the bilateral pocket so largely developed in some marsupials. If we can imagine that these depressions have become so deep as to envelop not only the nose of the young, but also its whole body, we can understand the evolution of a marsupial from something lower. At the same time we should notice that these depressions are just the opposite of what we find in the higher mammalia, where the mammary glands form larger or smaller abdominal or pectoral prominences. The milk-glands of Ornithorhynchus seem primitive, while the depressed glands of Echidna and the marsupials, and the elevated glands of higher mammals, may be viewed as differentiations of the same.

The opossum is the animal on which the first observations of marsupial reproduction were made. At first the young, found in an imperfect condition within the pouch, were not examined closely enough to disclose their real nature. They were regarded as formless and inanimate. Even in the "Natural History of New York," Part I., the young is spoken of as "a small gelatinous body, not weighing more than a grain." But these ideas of the early observers still exist in the popular mind, and are as imperfect as their explanations as to how the young originated. The peculiar character of the young led to the belief that they must have developed from the parents' teats, by a kind of metamorphosis or budding process. This gemmiparous theory existed already in Tyson's time, and was discussed by him. But to-day we have a more correct knowledge of their mode of reproduction, which so long remained clouded with mystery.

An animal born so premature as the little opossum must necessarily perish from exposure, were it not for the curious provision for its protection and the constant supply of milk afforded in the pouch of the female. The internal cavity of the adult female marsupium seems to be formed by an infolding of the external skin. From its opening on the median line of the abdomen the pouch extends backward and laterally, forming a kind of bilateral pocket. From the posterior wall of this about thirteen teats project. To these the young are attached after birth. The two so-called marsupial bones are found in both the male and female Virginian opossums, as well as in some of the South American opossums, which have only a rudimentary pouch, and the monotremes, which have no pouch at all. The investigations of Prof. Owen have shown that these bones are no essential part of the marsupium, although formerly regarded as such; they attach to the anterior border of the pelvis and lie against the mammary glands, where the cremaster muscle winds around them, and makes them act to compress the glands and force out the milk into the throats of the young, which at first seem too feeble to suck.

The young opossums are born as almost helpless little bodies, with mouth and fore-limbs well developed. The transfer of the embryo from the uterus to the pouch has not been observed, but this must be done as with the kangaroo, where it is believed that the mother takes each new-born embryo between her lips and places it upon one of the nipples, which it grasps firmly with its mouth and the claws of its fore-feet. Immediately after birth, the young opossums are found hanging upon the mammary glands fixed in the above manner, each with the hind part of its body free and pendant. At first, the mouth is a transverse, gaping fissure; but, when attached to the nipple, its corners soon grow up, leaving only a small, round pore surrounding the neck of the teat, which enlarges, so that the suckling cannot let go nor fall off, but hangs on without any exertion. Each of the largest fœtal specimens (Fig. 3) I have examined was covered with scattered hairs. The nose was large and blunt, unlike that of the adult. These measured, from the tip of the nose to the ear, 17 millimetres; from the ear to the base of the tail, 39 millimetres; length of the tail, 20 millimetres. Those of the second size (Fig. 4, A) were much smaller, and, in general appearance, looked more like opossums than the next larger size. Perhaps they were of a different species. These were, from the tip of the nose to the ear, 8 millimetres; from the ear to the base of the tail, 27 millimetres; length of the tail, 10 millimetres. The other specimens formed a very good series down to those of the smallest size, which were taken from the uterus. These smallest specimens (Figs. 5, 6) measured, from the tip of the nose to the ear, 3.1 millimetres; from the ear to the tail, 8.0 millimetres; the tail, 3.2 millimetres. Thus the total length of the smallest was 14.3 millimetres, or about one-half an inch. These smaller ones resemble the hippopotamus more than the opossum. Although found within the parent, they were, apparently, nearly ready to be born. A set of sixteen of these was taken from the uterus by Prof. Wilder. As the mother had but thirteen nipples, it is evident that improvidence would allow three embryos to perish. Sometimes as many as eighteen are brought forth, and often only twelve nipples exist. No attachment of the embryos to the uterine walls has been discovered, hence no true placenta is known. Still a kind of umbilicus is formed,



Figs. 5, 6.—Front and Side Views of Smallest Embryo Opossum (*D. Virginiana*). Enlarged; entire length when straightened out, one-half inch.

and its cicatrix marks the embryo as it did in Prof. Owen's kangaroo, where it wrongly led to the supposition that a placenta might have been attached. At birth, the hind-limbs appear as short stumps, with their flattened ends presenting slight marginal elevations, the beginnings of toes. These toes and legs gradually elongate. Soon each toe has one joint, and the inner toe becomes set off from the rest. Later, the two longer fingers show two joints, and, finally, the inner toe becomes a thumb with two joints, while each finger has three; and now the hind-foot closely resembles the hand of the higher quadrumana and man, while its fore-feet, much earlier developed, remain more animal-like, the great-toe being set off not so far from the others, but the fingers quite long. The hind-limbs are primarily much shorter than the front, but, developing faster, soon equal and afterward outgrow the others. The same is true of the young kangaroo, where the hind-limbs, shortest at first, finally become many times longer than those in front. Thus we see that what is smallest in the embryo may become largest in the adult. At birth, the nostrils are large, with a high rim; but the eyes are covered beneath the skin, and the ears are represented by small elevations on the sides of the head, while the lips have a remarkable development and peculiar covering, which reminds us of the first embryonic traces of the duck-like bill of ornithorhynchus. The tongue has a peculiar papillated groove above, to fit the nipple, and three very large papillæ on its base. The larynx and epiglottis project so high into the broad pharynx that the milk swallowed passes in two currents, one on either side. A very large three-lobed thymus gland lies above the heart. Only a rudiment of this exists in the adult. The heart is large, and situated on the median line. Its position changes somewhat as it grows older. The lungs are equal in size. Curiously, the œsophagus enters the stomach near its pyloric end. A very large gland lies on the cardiac end of the stomach. Prof. Owen, speaking of the character of the stomach in marsupials, says: "The stomach is simple in the genera Didelphys, Myrmecobius, and Parameles, and likewise simple in Dasyurus and Phalangista; also in the kaola and wombat, but in these two animals it is provided with a glandular apparatus situated to the left of the cardiac orifice." This is so large in the young Didelphys, that it is curious it does not exist when the animal is fully developed. In the possession of this organ, the young opossum agrees with the old kaola and wombat, but the old opossum has developed a stage further, so that the organ becomes rudimentary, or disappears. The cæcum is relatively twice as large as in the adult. The optic lobes of the brain were relatively larger, and the cerebral lobes somewhat smaller than when full grown. When first born, the male and female are, externally, exactly alike; clitoris and penis are large external organs, just in front of the vent, and so much alike, that it is impossible to distinguish the female from the male by these parts, so markedly different at maturity. Even in the oldest specimens studied, the same similarity of size and form of these parts exists, but the female organ stands nearer to the margin of the vent. Some time after birth, the testes descend into a large scrotum, which has a peculiar position, being at some distance in front of the penis. This is the first external sexual difference, for, although the marsupium begins to appear about the same time, it is remarkable that the male at first has as good a pouch as the female. This is first seen as a cluster of very low papillæ on the abdomen, nearly surrounded by a slight ridge. Slowly this ridge rises higher, and the depression extends itself deeper and more laterally, while the outer edge becomes a fold of skin growing inward toward the median line, until, finally, only a narrow opening is left. The marsupium of the male never becomes fully developed, but gradually diminishes in size; still it was well marked in the largest specimens studied.

To the embryologist every one of these curious facts has great significance. We have seen how organs exactly alike in the beginning may differentiate before our eyes into parts altogether dissimilar, just as individual animals of a like kind may have their progeny gradually modified from generation to generation, until, finally, different races are produced from a common ancestry. The adult opossum has rather slender and delicate limbs and fingers, and a long, slender, pointed nose; hence it may naturally be wondered that her offspring, even at such an early period of development, should have the parts of the body of an opposite character, they being, as is shown in Fig. 3, wonderfully bulky and clumsy, more like those of the hippopotamus than any thing else. But, if we look to its possible ancestry, and find something similar, we can discover a tolerably satisfactory reason for this by regarding it as inherited. Going back to the Diluvial formation, we find the remains of huge fossil marsupials with similar coarse, bulky proportions. Such were the Diprotodon and Nototherium of New Holland. The skull of the former is three feet long, really surpassing that of the hippopotamus in clumsiness, while its body and limbs were built in the same bulky style, and it is probable that numerous smaller marsupials of the same pattern existed in those remote ages. The embryo opossums show resemblance to lower animals in the general shape of the body, in the early form of the brain, the peculiarities of the lips, the thymus gland, the glandular apparatus of the stomach, the early conditions of the reproductive and urinary organs, and the primitive condition of the mammary glands. Peculiar embryonic resemblances are found in the young of every animal of which the embryology is known, and these facts have no meaning at all to us unless they mean inheritance and descent.

## IDOL-WORSHIP AND FETICH-WORSHIP.[1]

BY HERBERT SPENCER.

I.

FACTS already named show how sacrifices to the man recently dead pass into sacrifices to his preserved body. We have seen that to the corpse of a Tahitian chief daily offerings were made on an altar by a priest; and the ancient Central Americans performed kindred rites before bodies dried by artificial heat. That, along with a developed system of embalming, this grew into mummy-worship, Peruvians and Egyptians have furnished proof. Here the thing to be observed is that, while believing the ghost of the dead man to have gone away, these peoples had confused notions, either that it

[1] From advance-sheets of the "Principles of Sociology."

was present in the mummy, or that the mummy was itself conscious. Among the Egyptians, this was clearly implied by the practice of sometimes placing their embalmed dead at table. The Peruvians, who by a parallel custom betrayed a like belief, also betrayed it in other ways. By some of them the dried corpse of a parent was carried round the fields that he might see the state of the crops. How the ancestor, thus recognized as present, was also recognized as exercising authority, we see in this story given by Santa Cruz. When his second sister refused to marry him, "Huayna Capac went with presents and offerings to the body of his father, praying him to give her for his wife, but the dead body gave no answer, while fearful signs appeared in the heavens."

The primitive idea that any property characterizing an aggregate inheres in all parts of it, implies a corollary from this belief. The soul, present in the body of the dead man preserved entire, is also present in preserved parts of his body. Hence the faith in relics. Ellis tells us that, in the Sandwich Islands, bones of the legs, arms, and sometimes the skulls, of kings and principal chiefs, are carried about by their descendants, under the belief that the spirits exercise guardianship over them. The Crees carry bones and hair of dead persons about for three years. The Caribs, and several Guiana tribes, have their cleaned bones "distributed among the relatives after death." The Tasmanians show "anxiety to possess themselves of a bone from the skull or the arms of their deceased relatives." The Andamanese "widows may be seen with the skulls of their deceased partners suspended from their necks."

This belief in the power of relics leads in some cases to direct worship of them. Erskine tells us that the natives of Lifu, Loyalty Islands, who "invoked the spirits of their departed chiefs," also "preserve relics of their dead, such as a finger-nail, a tooth, a tuft of hair, . . . and pay divine homage to it." Of the New Caledonians Turner says: "In cases of sickness, and other calamities, they present offerings of food to the skulls of the departed." Moreover, we have the evidence furnished by conversation with the relic. Lander says: "In the private fetich-hut of the King Adólee, at Badagry, the skull of that monarch's father is preserved in a clay vessel placed in the earth." He "gently rebukes it if his success does not happen to answer his expectations." Similarly, Catlin describes the Mandans as placing the skulls of their dead in a circle. Each wife knows the skull of her former husband or child—

"and there seldom passes a day that she does not visit it, with a dish of the best-cooked food. . . . There is scarcely an hour in a pleasant day, but more or less of these women may be seen sitting or lying by the skull of their child or husband—talking to it in the most pleasant and endearing language that they can use (as they were wont to do in former days), and seemingly getting an answer back."

Thus propitiation of the man just dead leads to propitiation of his preserved body or a preserved part of it; and the ghost is supposed to be present in the part as in the whole.

Any one asked to imagine a transition from worship of the preserved body, or a preserved part of it, to idol-worship, would probbly fail; but transitions, such as imagination does not suggest, actually occur.

The object worshiped is sometimes a figure of the deceased, made partly of his remains and partly of other substances. Landa says the Yucatanese

"cut off the heads of the ancient lords of Cocom, when they died, and, as if to cook them, cleared them from flesh; they then sawed off half of the top of the head, leaving the anterior part with the jawbones and teeth, and to these half-skulls they joined what they wanted in flesh with a certain cement, and made them as like as possible to those to whom they belonged; and they kept them along with the statues and the ashes. All were kept in the oratories of their houses beside their idols, and were greatly reverenced and assiduously cared for. On all their festivals they offered them food." . . . In other cases they "made for their fathers wooden statues," left "the occiput hollow," put in ashes of the burnt body, and attached "the skin of the occiput off the corpse."

The Mexicans had a different method of joining some of the deceased's substance with an effigy of him. When a dead lord had been burned, says Camargo, "they carefully collected the ashes, and, after having kneaded them with human blood, they made of them an image of the deceased, which was kept in memory of him." And from Camargo we also learn that images of the dead were worshiped.

A transitional combination partially unlike in kind occurs: sometimes the ashes are contained in a man-shaped receptacle of clay. Of the Yucatanese the writer above quoted states that—

"The bodies of lords and people of high position were burned. The ashes were put in large urns and temples erected over them. . . . In the case of great lords the ashes were placed in hollow clay statues."

And in yet other cases there is worship of the relics joined with the representative figure, not by inclusion but only by proximity. Thus the Mexicans, according to Gomara—

"closed the box [in which some hair and the teeth of the deceased king were present] and placed above it a wooden figure shaped and adorned like the deceased." Then they "made great offerings, and placed them where he was burnt, and before the box and figure."

Lastly may be named the practice of the Egyptians, who, as their frescoes show, often worshiped the mummy, not as exposed to view, but as inclosed in a case shaped and painted to represent the dead man.

From these examples of transition we may turn to those in which the funeral propitiations are made to a substituted image.

The Mexicans practised cremation: and, when men killed in battle were missing, they made figures of them, and after honoring these burned them and buried the ashes. Here are extracts from Clavigero and Torquemada:

"When any of the merchants died on their journey, . . . his relations . . . formed an imperfect statue of wood to represent the deceased, to which they paid all the funeral honors which they would have done to the real dead body."

"When some one died drowned or in any other way which excluded concremation and required burial, they made a likeness of him and put it on the altar of idols, together with a large offering of wine and bread."

In Africa kindred observances occur. While a deceased King of Congo is being embalmed, says Bastian, a wooden figure is set up in the palace to represent him, and is daily furnished with food and drink. Parkyns tells us that among the Abyssinians mourning takes place on the third day; and, the deceased having been buried on the day of his death, a representation of the corpse does duty instead. Of some Papuan-Islanders Earl states that, when the grave is filled with earth, they collect round an idol and offer provisions to it. Concerning certain Javans we learn from Raffles that after a death a feast is held, in which a man-shaped figure, supported round the body by the clothes of the deceased, plays an important part.

These practices look strange to us; but a stranger thing is that we have so soon forgotten the like practices of civilized nations. In Monstrelet's "Chronicles," book i., the burial of Charles VI. of France is described thus:

"Over the coffin was an image of the late king, bearing a rich crown of gold and diamonds, and holding two shields, one of gold, the other of silver; the hands had white gloves on, and the fingers were adorned with very precious rings. This image was dressed with cloth of gold," etc. . . . "In this state was he solemnly carried to the church of Notre-Dame."

This usage was observed in the case of princes also. Speaking of the father of the great Condé, Madame de Motteville says, "The effigy of this prince was attended (*servit*) for three days, as was customary:" forty days having been the original time during which food was supplied to such an effigy at the usual hours. Monstrelet describes a like figure used at the burial of Henry V. of England; and the effigies of many English monarchs, thus honored at their funerals, are said to have been preserved in Westminster Abbey till they decayed.

With these reminders before us, we ought to have no difficulty in understanding the primitive ideas respecting such representations. When we read that the Coast negroes in some districts "place certain earthen images on the graves;" that the Araucanians fixed over a tomb an upright log, "rudely carved to represent the human frame;"

that, after the deaths of New Zealand chiefs, wooden images, twenty to forty feet high, were erected as monuments—we cannot shut our eyes to the fact that the figure of the dead man is an incipient idol. Could we doubt, our doubt would end on finding the figure persistently worshiped. J. d'Acosta tells us of the Peruvians that—

"each king had, while living, . . . a stone figure representing himself, called Guanqui [huanque]—i. e., brother. This figure was to be worshiped like the Ynca himself, during his life as well as after his death."

So, too, according to Andagoya—

"When a chief died, his house and wives and servants remained as in his lifetime, and a statue of gold was made in the likeness of the chief, which was served as if it had been alive, and certain villages were set apart to provide it with clothing, and all other necessaries."

And, similarly, Cogolludo testifies that the Yucatanese "worshiped the idol of one who is said to have been one of their great captains."

That we may understand better the feelings with which a savage looks at a representative figure, let us recall the kindred feelings produced by representations among ourselves.

When a lover kisses the miniature of his mistress, he is obviously influenced by an association between the appearance and the reality. Even more strongly do such associations sometimes act. A young lady known to me confesses that she cannot bear to sleep in a room having portraits on the walls; and this repugnance is not unparalleled. In such cases, the knowledge that portraits consist of paint and canvas only, fails to expel the suggestion of something more. The vivid representation so strongly arouses the thought of a living personality, that this cannot be kept out of consciousness.

Now, suppose culture absent—suppose there exist no ideas of attributes, law, cause—no distinctions between natural and unnatural, possible and impossible. This associated consciousness of a living presence will then persist. No conflict with established knowledge arising, the unresisted suggestion will become a belief.

Beliefs thus produced in savages have been incidentally referred to. Here are some further examples of them. Kane states that the Chinooks think portraits supernatural, and look at them with the same ceremony as at a dead person. According to Bancroft, the Okanagans "have the same aversion that has been noted on the coast" to having their portraits taken. We learn from Catlin that the Mandans thought the life put into a picture was so much life taken from the original. He also says:

"They pronounced me the greatest *medicine-man* in the world; for they said I had made *living beings*—they said they could see their chiefs alive in two places—those that I had made were a *little* alive—they could see their eyes move."

Nor do more advanced races fail to supply kindred facts. Concerning the Malagasy, Ellis testifies that friends of the prince, on seeing a photograph of him, took off their hats to it and verbally saluted it.

That which holds of a pictorial representation holds of a carved or sculptured one—holds even more naturally; since the carved representation, being solid, approaches closer to the reality. Where the image is painted and has eyes inserted, this notion of participation in the vitality of the person imitated becomes, in the uncritical mind of the savage, very strong. Any one who remembers the horror a child shows on seeing an adult put on an ugly mask, even when the mask has been previously shown to it, may conceive the awe which a rude effigy excites in the primitive mind. The sculptured figure of the dead man arouses the thought of the actual dead man, which passes into a conviction that he is present.

And why should it not? If the other-self can leave the living body and reënter it; if the ghost can come back and animate afresh the dead body; if the embalmed Peruvian, presently to be resuscitated by his wandering double, was then to need his carefully-preserved hair and nails; if the soul of the Egyptian, after its transmigrations, occupying some thousands of years, was expected to infuse itself once more into his mummy—why should not a spirit go into an image? A living body differs more from a mummy in texture than a mummy does from wood.

That a savage does think an effigy is inhabited we have abundant proofs. Lander, describing the Yorubans, says a mother carries for some time a wooden figure of her lost child, and, when she eats, puts part of her food to its lips. The Samoiedes, according to Bastian, "feed the wooden images of the dead." The relatives of an Ostyak

"make a rude wooden image, representing, and in honor of, the deceased, which is set up in the yurt, and receives divine honors for a greater or less time, as the priest directs. . . . At every meal they set an offering of food before the image; and, should this represent a deceased husband, the widow embraces it from time to time. . . . This kind of worship of the dead lasts about three years, at the end of which time the image is buried."

Erman, who states this, adds the significant fact that the descendants of deceased priests preserve the images of their ancestors from generation to generation—

"and, by well-contrived oracles and other arts, they manage to procure offerings for these their family penates, as abundant as those laid on the altars of the universally-acknowledged gods. But that these latter also have an historical origin, that they were originally monuments of distinguished men, to which prescription and the interests of the Shamans gave by degrees an arbitrary meaning and importance, seems to me not liable to doubt."

These Ostyaks, indeed, show us unmistakably how worship of the dead man's effigy passes into worship of the divine idol; for the two are identical. At each meal, placing the dishes before the household god, they wait (i. e., *fast*) till "the idol, who eats invisibly, has had enough." Moreover, we are told by Bastian, that when a Samoiede goes on a journey, "his relatives direct the idol toward the place to which he has gone, in order that it may look after him." How among the more advanced peoples of these regions there persists the idea that the idol of the god, developed, as we have seen, from the effigy of the dead man, is the residence of a conscious being, is implied by the following statement of Erman respecting the Russians of Irkutsk:

"Whatever familiarities may be permitted between the sexes, the only scruple by which the young women are infallibly controlled is a superstitious dread of being alone with their lovers in the presence of the holy images. Conscientious difficulties of this kind, however, are frequently obviated by putting these witnesses behind a curtain."

Like beliefs are displayed by other races wholly unallied. Of the Sandwich-Islanders, Ellis tells us that, after a death in the family, the survivors worship "an image with which they imagine the spirit is in some way connected;" and also that "Oro, the great national idol, was generally supposed to give the responses to the priests." Concerning the Yucatanese, Fancourt, quoting Cogolludo, says that "when the Itzaex performed any feat of valor, their idols, whom they consulted, were wont to make a reply to them;" and, quoting Villagutierre, he describes the beating of an idol said to have predicted the arrival of the Spaniards, but who had deceived them respecting the result. Even more strikingly shown is this implication in the Quiché legend. Here is an extract from Bancroft:

"And they worshiped the gods that had become stone—Tohil, Avilix, and Hacavitz; and they offered them the blood of beasts, and of birds, and pierced their own ears and shoulders in honor of these gods, and collected the blood with a sponge, and pressed it out into a cup before them. . . . And these three gods, petrified, as we have told, could nevertheless resume a movable shape when they pleased; which, indeed, they often did."

Nor is it among inferior races only that conceptions of this kind are found. In his "Histoire des Musulmans d'Espagne," Dozy, describing the ideas and practices of the idolatrous Arabians, says:

"When Amrolcais set out to revenge the death of his father on the Beni-Asad, he stopped at the temple of the idol Dhou-'l Kholosa to make a consultation by means of the three arrows called command, prohibition, expectation. Having drawn prohibition, he recommenced drawing. But three times he drew prohibition. Thereupon he broke the arrows, and, throwing them into the idol's face, he shouted, 'Wretch, if the killed man had been thy father, thou wouldst not forbid revenging him!'"

# ON A PIECE OF LIMESTONE.[1]

By WILLIAM B. CARPENTER, LL.D., F.R.S.

IN selecting a subject for the lecture which, at the request of the council of the British Association, I undertook to give you during its present meeting, I have been guided by the desire to tell you something that would be new to you in regard to matters with which you are already familiar, and to connect this with the results of my own deep-sea researches, in which I might hope that my own local connection with Bristol would lead you to feel somewhat of a personal interest.

In the rocks that border the Avon on either side, the Bristolian has one of the most characteristic examples of limestone that can be anywhere found; and he has only to go as far as the deep gorge of Cheddar, in the Mendip hills, to find limestone cliffs yet more imposing in height than St. Vincent's rocks; or as far as Chepstow, to see, along the Wye to Tintern Abbey, a still more varied and picturesque display of the same great rock-formation. Its material is sometimes distinguished as the *mountain* limestone, on account of the rugged character it imparts to the districts in which it prevails; while it is now more commonly known as the *carboniferous* (coal-bearing), because it forms the basins or troughs in which the "coal-measures" lie. Now, if you look at a geological map of England, you will trace this limestone as a band lying obliquely northeast and southwest; beginning in Northumberland, passing through Durham and Yorkshire, through Derbyshire (where it forms the romantic scenery about Matlock), then through the midland counties (where, however, it is generally covered up by later formations), and then into Gloucestershire and South Wales, where its relation to the coal-basins is most distinctly marked. Speaking generally, this oblique band divides England into two great areas: one to the northwest, in which the strata that have been brought to the surface, by the crumpling action that has disturbed the crust of the earth during its cooling, are *older* than the carboniferous limestone; the other to the southeast, in which the strata are *newer*. You have not to go far from Bristol to see examples of both. As you pass down the Avon, you observe a succession of limestone-strata lying obliquely one beneath another; and at last you come to an end of these, and find that the next underlying rock is that Old Red Sandstone, of which the massive pier on the Somersetshire side of the suspension bridge is built. And Dundry Hill, which is everywhere so conspicuous, is formed at its lower part of Lias, and at its upper part of Oolite, two later formations which were not deposited until after the

[1] A Lecture given to the workingmen of Bristol, at the meeting of the British Association, August 28, 1875.

carboniferous limestone had been uplifted to something near its present position. By measuring the whole length of the succession of limestone-strata that presents itself along the gorge of the Avon, and making the requisite allowance for their slope, the geologist has no difficulty in determining their thickness; and he can say with certainty that, if these successive beds of limestone were piled horizontally upon one another, in the same manner as when they were first formed, their total thickness would exceed 2,000 feet.

Further, you must think of these strata, not only as they present themselves at the surface, but as underlying all our coal-fields, and as probably extending very far beneath the newer strata to the southeast of the dividing band I have just spoken of. Thus, if you look again at the geological map, and notice how the great South Wales coal-field is surrounded by the blue band that indicates the carboniferous limestone, you must think of this limestone as really continuous over the whole of the included area, since it is met with at all points in which the coal-pits are sunk deep enough to reach it. And so in the midland counties, where the map indicates New Red Sandstone and later formations as the surface-strata, these, on being bored through, are found to have coal beneath them; and if we continue the boring downward through the coal-measures, we everywhere come to the limestone-base of this great and important carboniferous series. How far this series extends beneath the newer deposits which form the land of the southeastern portion of England, no geologist can at present say with certainty. If it really underlies them, it must be at an enormous depth, as the results of the Sub-Wealden boring have clearly proved.

Although we are accustomed to speak of the coal-basins of Northumberland, Durham, Yorkshire, Staffordshire, Gloucestershire, Somersetshire, and South Wales, as distinct and separate, it is important to bear in mind that they were probably continuous when the coal-measures were first formed, the "basins" not having then taken shape. This shape was given them by the great disturbance of the older crust of the earth which marked the close of the Palæozoic period, and which brought up the carboniferous limestone into the ridges that now constitute the borders of the basins.

It is this upheaval which has given us access to a vast storehouse of a material of the greatest value to man. Every Bristolian knows the use of this limestone, alike for building and for the making of roads; and the demand for it in the midland counties, to which the Severn affords an easy water-carriage, hastens the already too rapid demolition of his beautiful cliffs. When "burned," i. e., reduced by heat to the condition of "quicklime," it becomes—in virtue of its peculiar power of combining with water—the basis of all mortars and cements. It is as indispensable to the iron-smelter as the coal by which his furnaces are heated, since without its presence he could not reduce the metal from its ores. It is of no less importance in our great chemical manufactures; such, for example, as that of alkali and bleaching-powder. And the agriculturist makes large use of lime in increasing the productiveness of many soils which would be otherwise comparatively barren.

Now, let us inquire by what agency, and under what circumstances, these vast limestone formations were produced.

You all know that, in particular beds of your Avonside rocks, fossils are met with in great abundance, so that any one who looks for them may find stones that seem almost made up of shells, corals, etc.; but in other beds, some of them of great thickness, scarcely any traces of fossils are found, the whole rock having a uniform sub-crystalline texture. Now, in regard to the first, it is easy to show that the fossils are not merely imbedded in the rock, as they are in a sandstone or a clay, but that the rock is really made up of them; for, when we cut thin slices of such specimens, and examine them with the microscope, we find that the "matrix," or uniting material by which the fossils are held together, is itself composed of minute fragments of the same organic forms, mingled, it may be, with entire specimens of minuter forms. But what are we to say of the massive beds of sub-crystalline stone, in which no trace of fossils is to be found? This question we shall be better able to answer, when we have taken a glance at the other limestones which present themselves in different parts of the great geological succession.

The oldest stratified rocks of which we have any knowledge are those which make up the great *Laurentian* formation, first investigated by the late Sir William Logan, the distinguished geologist who was employed by the Government of Canada to examine the geological structure of that country. This formation chiefly consists of quartz, hornblende, felspar, and other mineral constituents, without any admixture of lime; but near its base is a very remarkable stratum of "serpentine limestone," extending over hundreds of square miles, which has a distinctly organic structure. It is composed of a series of layers, usually very thin, of carbonate of lime alternating with serpentine (magnesian silicate); and the microscopic examination of the calcareous layers first made by Principal Dawson, of Montreal, and afterward extended by myself, has satisfied us that the calcareous layers form a composite fabric of shelly substance, having a regular chambered arrangement, and that the serpentine takes the place of the original animal which occupied these chambers and formed the shell. The animal resembled, in its extreme simplicity of structure, the minute "jelly-specks" by which the Globigerina-shells that cover the Atlantic sea-bed are even now being formed; and differed from it only as the animal of a large composite coral mass differs from that of a simple coral, in extending itself indefinitely by budding; so that a large continuous zoöphytic growth was produced, bearing a strong resemblance to a coral-reef, instead of the aggregate of minute and separate shells which formed the old Chalk, and which is even now continuing the like formation. I do not know any more remarkable result of microscopic inquiry, than the very distinct evidence it has afforded, in well-preserved specimens of this *Eozoön Canadense*, of a minutely tubular structure, which my own researches into the structure of the *Foraminifera* enable me to identify with certainty as belonging to that type. For we are thus carried back in geological time to a period so extremely remote, that (as Sir William Logan remarked) the oldest fossils previously known are modern in comparison. The investigations of Sir Roderick Murchison have shown that the equivalent of the Laurentian in this country is the "fundamental gneiss" of Scotland, which (as I was shown a few days ago by my friend Mr. Symonds, of Pendock) crops up in the Malvern Hills. Now, in Central Europe this fundamental gneiss has a thickness of 90,000 feet; and near its base Prof. Gümbel has recognized the equivalent of the Canadian *Eozoön*, which must have thus preceded the life of what has been called the "primordial zone," corresponding to our Cambrian rocks, by an interval of time so great that no geologist would venture to assign a limit to it.

The *Cambrian* series, consisting of the grits, sandstones, and slates, that form the mountains of North Wales, scarcely contain any limestone; and we may pass from this to the *Silurian*, or Mid-Wales, series in which we have the well-known Dudley limestone, as well as other less important seams. A slab of Dudley limestone usually shows an extraordinary variety of fossils, among which the most conspicuous are generally the beaded stems of Encrinites; the joints of these stems, when separated by the weathering of the rock, being known in the north as "St. Cuthbert's beads." The whole of this limestone is obviously made up of the corals, shells, crinoids, etc., which we find imbedded in it, and of a matrix formed by comminuted fragments of the like types. A much greater development of these calcareous beds presents itself in North America, the Trenton limestone occurring in the lower Silurians, and the Niagara limestone in the upper; and these rocks have obviously been formed by the same agency as the Dudley limestone.

Passing on now to the *Devonian* series, we find beds of limestone interposed among the sandstones, shales, and conglomerates, of which it is chiefly composed; and these, like the Silurian limestones, are made up of the fossilized remains of corals, shells, crinoids, etc., more or less resembling those of earlier age. It is on the Old Red Sandstone, which is here the uppermost member of the Devonian formation, that, as I have already pointed out, our Carboniferous series immediately rests; its lower beds being distinguished as "limestone shales," on account of the interposition of seams of shale (formed of a mixture of sand and clay) between the layers of limestone.

Postponing for the present the more detailed inquiry into the origin of our own Limestone, of which this general survey is the prelude, I pass on to the *Permian* formation, which rests upon the Carboniferous, and has been upheaved with it, having been deposited previously to the general disturbance that closed the Palæozoic (ancient life) period. Of this Permian formation there are few traces in our part of England; but it has a much greater development in the north, and to it belongs that remarkable bed of Magnesian limestone which comes to the surface in Northumberland and Durham. It is of this stone (selected on account of the durability it has shown in York Minster and other old buildings) that the Houses of Parliament are built. Now, although very few fossils are found in this rock, yet I believe that most geologists would agree that it was originally formed, like limestones generally, by the growth of corals, shells, etc., which separated the carbonate of lime from the sea-water they inhabited; its subsequent conversion into magnesian limestone having been probably effected by the infiltration of water in which magnesia was dissolved. In the Eozoic limestone of Canada, I have myself frequently met with veins of dolomite (magnesian limestone), which retain the general arrangement characteristic of the original shell, although its minute structure has been obliterated by this metamorphic action.

Passing on now to the Secondary or Mesozoic (middle life) series, we find that although the *Trias*, which is the oldest member of it, is represented in England by sandstones alone, there is an important bed of limestone in Germany called the Muschelkalk (shell-limestone), which is interposed between the lower and the upper New Red Sandstones. This bed derives its name from the fact that it is obviously formed by an aggregation of shells, mingled with other fossils, among which the beautiful Lily Encrinite is one of the most abundant. In the *Lias*, which overlies the New Red Sandstone, a considerable portion of lime is generally mingled with the clay deposits of which this formation is principally composed; and some of its beds, especially on the northeast of Yorkshire, are almost entirely calcareous. If you walk along the shore between Saltburn and Whitby, and examine the blocks which have fallen from the lias cliffs above, you will find them to be almost entirely made up of fossils; among which *Belemnites*—conical chambered shells, with solid calcareous "guards," which belonged to animals resembling cuttle-fishes—are specially abundant. And here, as elsewhere, the calcareous matrix in which the fossils are imbedded, though sub-crystalline in some parts, is obviously made up in others of fragments of shell, etc., ground down by the action of the sea in which the deposit was formed. The Lias abounds in the neighborhood of Bristol, and is exposed in many railway-cuttings. These, when in progress some forty years ago, yielded many valuable fossils, especially skeletons of the great Fish-Lizards, which you will see in the Museum of the Bristol Institution. In this neighborhood, also, you have a splendid illustration of the great *Oolitic* formation, which is almost entirely made up of calcareous deposits that can be clearly traced to an animal origin, although their condition is now very different. The Coral Rag of Oxfordshire is an old coral-reef that has undergone very little change, consisting of fossil corals, and of the shells, crinoids, etc., that lived on the reef. And the "freestones" of Bath and Portland are mainly composed of the fine sand which was formed by the wearing-down of similar reefs, of which the remains are found here and there. The name "oolite" or roe-stone, is given to the whole formation, on account of the resemblance in texture borne by some of its characteristic members to the roe of a fish; but this "oolitic" structure is not peculiar to the Oolitic formation, being found in other limestones, as I shall presently point out to you. A very curious example of the "metamorphic" action by which the texture of a calcareous rock may be so completely altered as to conceal its origin is afforded, by the fact that the beautiful Carrara marble, which is used for statuary, belongs to the Oolitic formation. If this metamorphism, the nature of which I shall presently explain, proceeds further, it will produce large crystals of calc-spar; and I remember that Mr. Baily, the sculptor of the beautiful statue of "Eve at the Fountain," which is in your Fine Arts Gallery, was greatly embarrassed by a vein of calc-spar that ran through the block from which he cut it, and had to let a patch of marble into Eve's back. The next great calcareous formation above the Oolite is the *Chalk*, the material of which is exactly the same as that of limestone, although its texture is so different. Our deep-sea researches have entirely confirmed the opinion which had been previously formed on the basis of microscopic research, that the whole of the enormous mass of Chalk now raised up into the cliffs and downs of the southern portion of England was formed on the bed of the ocean, by the agency of animals—chiefly the minute *Foraminifera*, which separate carbonate of lime from the sea-water as the material of their shells; just as successive generations of fresh-water mussels living in a lake form a bed of calcareous marl on its bottom by the decay of their shells, which sets free in a solid form the lime they have taken from the water that poured it into the lake in solution. We have brought up by the hundred-weight, from depths of three miles in the Atlantic, a white mud, which, when dried, exactly resembles chalk; and this, when examined with the microscope, is found to consist partly of perfect shells of minute *Globigerinæ*, of which many hundreds would only weigh a grain, and partly of what we call *Globigerina ooze*, which is obviously the product of the decay of former generations of similar shells.

In the *Tertiary* or Neozic (modern life) series, we find many limestone deposits of considerable importance, but none so vast as those to which I have previously drawn your attention. The most extensive is the "nummulitic limestone," which is one of the oldest members of the *Eocene* formation, the earliest of the tertiaries. We find this limestone forming a bed of considerable thickness on the flanks of the Pyrenees, and extending from the shores of the Atlantic along the south of France to the Alps, in some parts of which it shows a thickness of fifteen hundred feet, thence across to Asia Minor, Northern India, and probably to the Pacific shore; while another division of it ranges along Northern Africa, and is especially noteworthy in Egypt, where it rises into the hills that border the Nile for a long distance above Cairo, and furnishes the stone of which the Pyramids are built, and out of which the Sphinx is carved. This stone not merely contained *nummulites*, which are Foraminiferal shells much larger than Globigerinæ (sometimes attaining the size of a half-crown), but is entirely made up of them, and of the fragments of those which have been ground down by the action of the waves, as well as of other shells inhabiting the same sea; all cemented into a solid mass by the process I shall presently describe. Another limestone of more limited extent, belonging to the Eocene age, is found in the neighborhood of Paris, and has furnished the material of which that beautiful city is built. This is entirely made up of the minute Foraminiferal shells termed *Miliolæ*, from their resemblance in size to grains of millet, and is known as "miliolite limestone." So in Malta and in the neighborhood of Vienna, there are limestones entirely composed of shells, corals, and Foraminifera, which were formed in the *Miocene* or Middle Tertiary period. And we have on the coast of Suffolk the calcareous bed known as the "coralline crag," to which equivalents are found in various parts of Europe, that belongs to the *Pliocene* or Later Tertiary period. The material of this bed is chiefly contributed by the calcareous skeletons of composite animals that formerly ranked as zoöphytes, but are now distinguished as *Polyzoa*. Although individually extremely minute, in fact microscopic, they have a very complicated structure, allied to that of the lower Mollusks; and they extend themselves like trees by continuous budding, so that the fabrics they form often have a stony solidity. They abound in our own seas, and, as we shall presently find, they extend very far back in geological time.

Thus, then, we see that, in the case of the Secondary and Tertiary limestones, there can be no question of their production by the agency of animals, which separated carbonate of lime from its solution in sea-water, and formed it into corals, shells, etc., just as similar animals are doing at the present time. And we have in these calcareous deposits many instances of local "metamorphism," which show that the existence of a sub-crystalline, or even of a complete crystalline, arrangement in the particles of carbonate of lime is no proof that the materials of these deposits were not originally drawn from their solution by the agency which formed those whose organic origin is obvious. Thus in the neighborhood of the Giant's Causeway, where volcanic rocks have burst up through the chalk which forms a long succession of fine cliffs on the Antrim coast, this chalk has been so altered in texture as almost to resemble marble, all trace of its original nature being obliterated. Knowing, as we do, how much more extensive and potent must have been the agencies which were at work in metamorphosing the Palæozoic rocks, we have no difficulty in accounting for the fact that vast beds of our Carboniferous Limestone now show little or no trace of the organic texture which we believe them to have originally possessed. That you may better understand the nature of this metamorphosis, I shall now show you some of the chemical properties of carbonate of lime, which is the material of all calcareous rocks alike, whether showing the perfect crystalline form of calc-spar, the close minutely-crystalline arrangement of marble, the sub-crystalline texture of limestone, the "roe-stone" aggregation of oolite, or the fine powdery condition of chalk.

If we treat a piece of any one of these substances with dilute nitric or muriatic acid, an effervescence is immediately produced by the liberation of carbonic acid, while the lime is dissolved; and this gives a ready way of distinguishing a calcareous from any other rock. In "burning" limestone, on the other hand, the union of the carbonic acid and the lime is dissolved by heat; the carbonic acid is driven off, and the lime remains behind in the condition of "quicklime." This is very greedy (so to speak) of carbonic acid, and is always trying to get it back again. We can dissolve a small quantity of quicklime in water; and if we leave this with a large surface exposed to the air, it gradually recombines with the carbonic acid which it draws from the air; and, as the carbonate is nearly insoluble in water, it falls as a fine white powder, making the water turbid. We may do the same in a moment, by blowing through a pipe into a glass of lime-water, our breath containing a considerable quantity of carbonic acid; and we may then clear the liquid again, by a drop or two of nitric or muriatic acid. But, though insoluble in pure water, carbonate of lime is slightly soluble in water which is already charged with carbonic acid; and, as all rain-water brings down carbonic acid from the air, it is capable of taking up carbonate of lime from the soils and rocks through which it filters; and it thus happens that all springs and rivers, that rise in localities in which there is any kind of calcareous rock, become more or less charged with carbonate of lime kept in solution by an excess of carbonic acid. This is what gives the peculiar character to water which is known as "hardness;" and a water hard enough to curdle soap may be converted into a very "soft" water (as the late Prof. Clark, of Aberdeen, showed) by the simple addition of lime-water, which, by combining with the excess of carbonic acid, causes the precipitation of all the lime in solution in the form of insoluble carbonate, which gradually settles to the bottom, leaving the water clear. It is this solvent power of water charged with carbonic acid, which has been the great agent in the metamorphism of many calcareous rocks, whereby their texture has been entirely changed, while their composition remains unaltered; and it acts with augmented potency where heat and pressure concur to increase it. Of this we have an example in the action of hot springs highly charged with carbonic acid, such as we often find in volcanic localities; it is to such that the formation of the "travertine" limestone of Italy is due, the carbonate of lime being slowly deposited almost in the condition of marble, when the excess of carbonic acid is disengaged, and the water is dispersed in vapor, by free exposure to air. We have familiar examples of this, on a more limited scale, in the formation of the "stalactites" which hang from the roofs of caves in limestone rocks (as at Cheddar), and in the "stalagmitic" crust formed by their droppings on the floors.

Those who have had opportunities of observing the changes which have taken place in the condition of recent corals that have been upheaved by volcanic action above the level of the sea, in the "area of elevation" to which Mr. Darwin drew attention forty years ago, assure us that their texture is often so changed, that detached pieces of them could not be distinguished from pieces of sub-crystalline limestone. I well remember having first learned this from Mr. S. Stutchbury, who was the curator of the museum here when I was a youth, and who was the first to observe the ring of upraised coral which encircles the cone of the great volcano of Tahiti, and which belongs to the same type as that now forming reefs around the coast of that island. He told me that some specimens of it, which he had collected and brought home, were treated by his brother, a professed mineralogist, as specimens of carboniferous limestone. The formation of oolites, again, may be studied at the present time. When a bed of calcareous sand, formed by the wearing down of shells or corals, is raised above the sea-level, and is penetrated by rain-water charged with carbonic acid, this, dissolving the carbonate of lime of the surface-layer, deposits it again around the grains of the deeper layers, which it invests with concentric coats. Such oolites present themselves in various geological epochs, indicating the similarity of the past and present conditions. There are oolitic beds, for example, in the Clifton rocks; and we thus know that these must have been shore formations; while other beds seem to have been deep-sea deposits, resembling the Globigerina mud of the present Atlantic sea-bottom. For there is in Russia a very extensive bed of limestone belonging to the carboniferous series, which is as completely composed of *Fusulinæ* (an extinct type of foraminifers about the size of a sugar-plum) as the nummulitic limestone is of nummulites. In the clay-seams, again, which we sometimes find interposed between beds of pure limestone, numerous Foraminifera are found well preserved, of which some belong to types still living; and my friend Mr. H. B. Brady, of Newcastle, who has been lately making a microscopic study of the Carboniferous Foraminifera, has found their remains abundant in specimens of this limestone which do not show any indications of organic structure that are obvious to the naked eye. If the Globigerina-mud were to be subjected to the pressure of an enormous weight of rock deposited above it, and then to the heat and pressure which we know must have accompanied the great crumpling of the earth's crust that made the marked separation between the Palæozoic and the Secondary epochs, we may well believe that it would have been metamorphosed into a limestone closely resembling the least fossiliferous of the Avonside rocks; and we have no difficulty in accounting for the vast thickness of these beds, if we regard them as having been progressively formed on the bottom of a very deep ocean, through a long succession of ages.

That certain beds of the Avonside rocks are ancient Coral-Reefs, cannot be a matter of question; for we find them to be entirely made up of fossil corals, together with the fossilized shells and crinoids which such reefs would have supported. This was especially the case with what used to be called the "black rock" under the sea-wall, which has been nearly all quarried away since, when a boy, I brought home a piece of it as large as I could carry, wondering at such an accumulation of fossils, but without any such understanding of their import as that which I am endeavoring to give you. Every one has heard of the coral reefs and islands, which are popularly said to be "built up" in tropical seas by the agency of "insects," as bees build their waxen combs. And I suppose that every one of you is familiar with specimens of some kind of coral brought home by a seafaring friend, or has seen such in your museum. Now, the fact is, that all these corals are the production of animals resembling in essential points the common sea-anemone, but differing from it in depositing a stony skeleton in the fleshy substance which forms its base, and also in the radiating partitions which surround its stomach. We have on our own shores a small type of the coral-forming polyps, in the little *Caryophyllia*, which, when the animal is expanded, you would take to be a small sea-anemone, but which, when contracted, shrinks down into its stony cup. The *Fungia* of tropical seas is a much larger solitary polyp of the same kind; and you will often meet with its stony disk, four or five inches in diameter, with beautiful thin vertical plates radiating from the centre to the circumference, very much like the "gills" of the under-side of a mushroom (fungus), whence its name is derived. But all the more massive corals are the skeletons of *composite* animals; that is, of polyps which bud like plants, and thus grow to large dimensions. In some cases they form tree-like structures, in which you will find a multitude of polyp-cells, sometimes very small, each having its characteristic arrangement of radiating plates. But in the reef-building corals, the polyp-cells are packed closely together; and the older portion becomes so completely solidified by calcareous deposit that, when broken across, it looks like a stone. This is especially the case with the *Meandrina*, or brain-stone coral, so named from the resemblance which its furrowed surface bears to the convoluted surface of the brain; hemispherical masses of this coral are not unfrequently to be seen in museums having a diameter of from two to three feet; and in the upraised coral-cliffs of Bermuda they are reported to be five or six feet in diameter. The polyps lie in rows along the furrowed surface, and the active life of the composite mass does not extend far down; its stony interior being the product of its earlier life, as the heart-wood of a tree is the product of previous successions of leaf-buds. But it is no more correct to say that the polyps have built up the stony mass, than it would be to say that the leaves of a tree build up its woody stem, or that our own soft parts build up our bony skeleton. The hard parts are formed in each case by a process of *growth;* soft tissue being first produced as a part of the animal body, and this being subsequently solidified by mineral deposit, the material for which is absorbed by the animal from the sea-water in which it lives.

The admirable researches of Mr. Darwin have shown us that, although the reef-building corals seem unable to live and grow at depths greater than twenty fathoms (one hundred and twenty feet), yet that if their base gradually subsides, at a rate not greater than that of coral-growth, the reef or island will be kept up to the surface by such growth; so that, if we could bore down into it, we might find the coral-structure to have a depth of many hundreds or even thousands of feet. The recent soundings of the Challenger around the Bermuda islands, which are entirely composed of coral, indicate that they form the summit of a pillar rising from a depth of twelve thousand feet; and as we have no instance of a mountain having such a shape, it seems probable that the upper part of this pillar, at any rate, must have been formed of coral, which kept growing upward, in the manner indicated by Mr. Darwin, while the bottom was slowly subsiding. It is commonly supposed by geologists that the limestone beds of which I have been speaking are the result of the metamorphosis of ancient coral formations, which attained their great thickness by continuous growth at their living surface, as their base gradually subsided. But it appears to me that all we know of existing coral formations renders it unlikely that there should have been such a *continuity* of area in ancient coral formations, as would be required to account for the continuity in the area of our great beds of carboniferous limestone; and that this continuity is far better accounted for by supposing them to have been formed in the manner I previously indicated—by the foraminiferal life which recent researches have shown to be even now forming a calcareous deposit over vast areas of the ocean-bottom.

Thus, then, we should regard the beds which show distinct coral-structure as representing reefs or islands of limited extent in the

Palæozoic ocean; while the formation of those beds of vast area, in which few or no traces of animal life are found, may be fairly referred to the agency of minute forms, essentially similar to those of the Old Chalk and of its existing representative (Globigerina-mud), whose habitation is the deep sea.

No inconsiderable proportion of the calcareous material of some of the local beds seems to have been furnished by the stems and bodies of the *Crinoids* (lily-like animals), which abounded in the Palæozoic seas, and of which the representatives at the present time have been proved by recent deep-sea exploration to be much more numerous and widely diffused than was previously supposed. I remember to have seen these very conspicuous in polished sections of the old "black rock;" and certain beds in the limestone of Derbyshire, which are worked for marble chimney-pieces, seem almost entirely composed of their remains. The stems of the Crinoids of the Carboniferous period were not beaded like those of the Dudley (Silurian) limestone, but were cylindrical in form; they had, however, the same jointed structure and central canal; and you will thus readily recognize them when cut either longitudinally, transversely, or obliquely.

It has been further recently shown that *Polyzoa* essentially resembling those of our modern "coralline crag" existed at this epoch, and had a share in the formation of certain beds of the carboniferous limestone. There is a particular bed in St. Vincent's rocks, which has been found by Mr. Stoddart to be composed of fragments of their delicate calcareous fabrics, with Foraminifera, and other small forms of animal life; and he has appropriately named it the *microzoic* bed. And Prof. Young, of Glasgow, has been fortunate enough to find, in a clay-seam of the carboniferous limestone in his neighborhood, a collection of these fabrics preserved entire in the fullest perfection.

Thus we seem justified in the conclusion that the vast strata of carboniferous limestone, which in England alone must cover tens of thousands of square miles, and has a thickness of more than two thousand feet, had their sole origin in the continuous life of innumerable generations of humble animals, which, in times long past, did the work that is still being performed in the depths of our own seas by animals of similar types, which we may believe to be their lineal descendants. I have shown you how we are indebted to their agency for the abundant supplies they have provided of a material most useful—I may say indispensable—to us. Let us take care that, with our larger capacities and higher aims, we strive to promote the welfare of those who come after us, by doing well, each in his station, that which our powers and opportunities best fit us to accomplish.—*Author's advance-sheets.*

# STRANGE MENTAL FACULTIES IN DISEASE.

By HEZEKIAH BUTTERWORTH.

THERE are certain mental mysteries associated with peculiar states of disease, and especially with low, nervous diseases, which discover unexpected powers of mind, and which illustrate some of the conditions on which human life depends, and the laws that govern its continuance. Among these are certain enlargements of the perceptive faculties, and a singular power which the mind seems to possess of acting independently of its organs.

Our attention was recently called to the subject by the mental condition of a near relative, suffering from extreme nervous debility. "I am in constant fear of insanity," she said to me one day, "and I wish I could be moved to some retreat for the insane. I understand my condition perfectly: my reason does not seem to be impaired, but I can think of *two things at the same time.* This is an indication of mental unsoundness, and is a terror to me. I do not seem to have slept at all for the last six weeks. If I sleep, it must be in a succession of vivid dreams that destroy all impression of somnolence. Since I have been in this condition, I seem to have very vivid impressions of what happens to my children who are away from home, and I am often startled to learn that these impressions are correct. I seem to have also a certain power of anticipating what one is about to say, and to read the motives of others. I take no pleasure in this strange increase of mental power; it is all unnatural; I cannot live in this state long, and I often wish that I were dead."

The faculty of memory is one of the first to be obviously affected by disease. When disease for a time seems to suspend the action of this faculty, or visibly to diminish it, the result is not looked upon as phenomenal, for it is common and expected. But when disease increases the power of this faculty, a thing not uncommon, the patient is not unfrequently regarded as possessing more than human wisdom, and the case usually excites comment as one of great mystery. Dr. Steinbech mentions the case of a clergyman who, being summoned to administer the sacrament to an illiterate peasant, found the patient praying aloud in Greek and Hebrew. The case was deemed wellnigh miraculous. After the peasant's death, it was found that he was accustomed in youth to hear the parish minister pray in those languages, and it was inferred that he must have been repeating remembered words without understanding their meaning. Dr. Abercrombie relates the circumstances of a more remarkable case. A poor shepherd-girl was for a time accustomed to sleep in a room adjoining that occupied by an itinerant musician. The man was an artist by education, a lover of his profession, and often spent a large portion of the night in practising difficult compositions. The violin was his favorite instrument. At last the shepherd-girl fell ill, and was removed to a charitable institution. Here the attendants were amazed at hearing the most exquisite music in the night, in which were recognized finely-rendered passages from the best works of the old masters. The sounds were traced to the shepherd-girl's room, where the patient was found playing the violin in her sleep. Awake, she knew nothing of these things, and exhibited no capacity for music.

A late number of the London *Medico-Chirurgical Review*, in an article on apoplexy, speaks of vivid dreams as a common warning in the first and often unrecognized stages of insanity, heart-disease, and phthisis, and one that it would be well to better understand and heed. Vivid dreaming, which in some cases seems to be a mental illumination, and in others a prophecy of impending ill, precedes many diseases long before the victim is aware of his condition. These dreams sometimes take the forms of waking fancies, double consciousness, and what is called mystic memory. In February, 1829, when Sir Walter Scott was breaking himself down by severe and protracted literary labor, and was suffering the first invasion of ill health which ultimately ended in death, he wrote in his diary on the 17th, that, on the preceding day, at dinner, although in company with two or three old friends, he was strongly haunted by a "sense of preëxistence," a confused idea that nothing that passed was said for the first time; that the same topics had been discussed, and that the same persons had expressed the same opinions before. "There was," he writes, "a vile sense of a want of reality in all that I did or said." Goethe relates that, as he was once in an uneasy and unhealthy state of mind, riding along a foot-path toward Drusenheim, he saw himself on horseback coming toward himself; and similar stories are told of other highly-imaginative persons whose mental balance has been disturbed by over-anxiety or incipient illness.

The states of physical prostration known as *coma somnolentum* and *coma vigil* exhibit, in their largest extent, the poetic capacities of the mind. The impressions, dreams, and illusions, in these conditions, are such as no healthy mind could possibly conceive. The patient seems to live in a charmed world, amid spectral beings and airy people, changing lights, luminous heights, and appalling shadows; in short, no glowing epic or work of the painter's art seems so much as to touch upon such richness of imagery. Mrs. Hemans on her deathbed said that no pen could describe or imagination conceive the visions that passed before her mind, and made her waking hours more delightful than those spent in repose.

Rev. William Tennent, of Freehold, New Jersey, was an overworked student, and was supposed to be far gone in consumption. In a protracted illness he apparently died, and the preparations were made for his funeral. Not only were his friends deceived in his case, which was one of coma, but he himself was doubly illusioned, for he both thought that he was dead and that his spirit had entered paradise. His soul, as he thought, was borne aloft, to celestial altitudes, and was enraptured with visions of the Deity and angelic hosts. He seemed to dwell in an enchanted region of limitless light and inconceivable splendor. At last an angel came to him and told him that he must go back. Darkness, like an overawing shadow, shut out the celestial glories, and, full of sudden horror, he uttered a deep groan. This dismal utterance was heard by those around him, and prevented him from being buried alive, after all the preparations had been made for the removal of the body.

In certain forms of physical prostration, the mind seems to the patient to be capable of unusual freedom; to be in and out of the body at the same time, to be able to make impressions at a distance, and to have a knowledge of itself and of events transpiring around it quite beyond the usual range of the faculties. In analyzing these seeming powers, it is impossible to separate the imaginary from what may be real, and to determine the exact limit of mental action. Plutarch relates that a certain profligate and profane man, named Thespesius, fell from a great height and was taken up apparently dead. He remained in a state of seeming insensibility for three days, but on the day appointed for the funeral unexpectedly revived, and from this time a remarkable change was observed in his moral conduct and character. On inquiry being made as to the cause of the sudden reformation, he said that, in his state of apparent insensibility, he had been made so clearly to see the relation of mind to matter as to be convinced of the future existence of the soul. After his injury he had supposed himself to be dead, and his spirit to be separated from the body. He had seemed to float in an abysm of light, and to be surrounded by spirits transcendently bright and glorious. One of the latter at last announced to him that he must return to the flesh again, when he suddenly seemed to reappear on earth, as a being from another world. In 1733, Johann Schwerzeger, after a long illness, fell into a comatose state, from which he recovered. He said that he had seen as in a vision *his whole life pass before him*, even events which, before his sickness, he seemed to have quite forgotten. He further stated that he thought he was about to enter a state of rest and happiness, when he was recalled to the world; that he was sorry to have come back, but that he should remain here but two days. His death fulfilled the prediction.

But perhaps the most remarkable of all phenomena of this nature is a certain power a few patients have seemed to possess of "withdrawing from sensation," of becoming at will insensible to pain, and of producing a resemblance of death. Colonel Townsend, an Englishman, who died at the end of the last century, had in his last sickness the extraordinary power of apparently dying and returning to life again. "I found his pulse sink gradually," wrote Dr. Cheyne, his medical attendant, "so that I could not feel it by the most exact or nice touch. Dr. Raymond could not detect the least motion of the heart, nor Dr. Skrine the least soil of the breath upon the bright mirror held to his mouth. We began to fear that he was actually dead. He then began to breathe softly." The colonel tried this experiment a number of times during his illness, and was able to render himself insensible at will.

Dr. Brown-Séquard, in a course of lectures before the Boston-Lowell Institute, last winter, illustrated many like remarkable powers of mind in mental and physical disease, by cases which had come under his own observation. From such cases it would seem that the mind is largely dependent on physical conditions for the exercise of its faculties, and that its strength and most remarkable powers, as well as its apparent weakness, are often most clearly shown and recognized by some inequality of action in periods of disturbed and greatly-impaired health.

## PROGRESSION AND RETROGRESSION.

By Prof. W. D. GUNNING.

WE walk along a rocky beach when the tide is out. Twice every twenty-four hours this narrow zone is sea and twice it is land. Its tenants are, as itself, a sort of dividing zone between land and sea. The Algæ in the tide-pools will remind you of Confervæ in the ponds. The littorinæ on the rocks will remind you of snails. The shapeless, gelatinous clumps adhering to rocks or wharf-posts will remind you of garden slugs, or naked snails. We will give our attention first to these soft and shapeless clumps.

They will call up no image in the mind until the sea returns, or until you detach one of them, and drop it into a glass of sea-water. You have a Dendronotus, or a Doris, or an Eolis, or an Aplysia.

Out of the shapeless clump comes a form like that of the slug; but the slug in our captive is soon disguised, for along its back, from end to end, rises a fringe of pinkish papillæ. We have an Eolis. What does Eolis do with these papillæ? The last generation of naturalists said, "He breathes with them."

The last generation was too sparing of the knife. We cut through Eolis's back till we reach the stomach, which we find to be a mere expansion of the intestinal tube. This tube extends lengthwise through the body and lies near the *dorsal*, not the ventral side. It branches, and the branches branch again, and run up into the papillæ which stand out like quills on an angry porcupine. The papillæ are supplementary stomachs.

Eolis has no liver. With so much stomach it can carry on the process of digestion without the aid of that organ, so troublesome to man and beast. A row of hepatic cells extending part way along the intestine represents the rudiment of a liver, or its vestige.

Where are the lungs? Nowhere—or, rather, everywhere. No part is specialized and set apart for aërating the blood. In the vital economy of this sea-slug, there is but little division of labor. The surface is soft tissue, covered with vibrating cilia, and currents of water, set in motion by the cilia, flow around the tissue and yield oxygen to its blood.

Perhaps the gelatinous knob you detached was not an Eolis. If your knife reaches a stomach which is not arborescent, you may have a Doris. The dorsal papillæ of Doris are genuine lungs, but they breathe for only part of the body. They aërate only the blood which goes to the liver, an organ which appears now, not as a row of bile-cells, but as a well-defined gland. The foot shares the labor of the lungs, they breathing for the liver, it for the rest of the body.

Fig. 1.—Doris lacina.

In Eolis the quill-like diverticula of the stomach are placed in rows; in Doris the leaf-like, moss-like, or flower-like branchiæ are gathered into clusters (Fig. 1). Our first woodcut represents a Doris (*Doris lacina*), with two horn-like antennæ on the head; and on the back, at the other extremity, a tuft of crimson leaves finely reticulated and deeply lobed. The second cut represents a Doris (*Doris plumulata*), with frond-like antennæ and a lung resembling tufts of delicate sea-weed wrought into an eight-rayed star. Another Doris wears its lung like a brilliant flower, another like a begemmed tiara. Doris can draw his lungs into his body or throw them out at pleasure (Fig. 2).

Dendronotus may be known, as its name implies, by its branching, tree-like gills. If we leave the rocks and wharf-posts, and examine the laminaria (oar-weed), or ulva (sea-lettuce), we may find another member of this family. Aplysia is known to fishermen under the name of "sea-hare." A hump on its back calls up the image of a camel rather than that of a hare. If you make a dissection you will find that an idea has been borrowed from the camel's stomach as well as hump. Aplysia has a *row* of stomachs, and, what is strange, the teeth are not inserted in the mouth, but in one of the stomachs. In Aplysia, the liver is better defined than in Doris, and the leaf-like gills aërate blood for the whole body.

The classification of these naked mollusks will be as obvious now to the reader as to the observer.

In Eolis no liver, but a few bile-cells representing its rudiment, or vestige; no lung, every part of the surface respiring for itself; no well-differentiated stomach, but an arborescent intestinal tube.

Fig. 2.—Doris plumulata.

In Doris (sea-lemon), a liver; respiratory organs in the guise of crown, or star, or leaf, or tufts of sea-weed, organs which serve the liver only; a stomach.

In Aplysia (sea-hare), a better liver, respiratory organs in the form of leaves, organs which serve the whole body; many stomachs.

Eolis stands lowest, Aplysia highest. The series is suggestive of the history of organs, if not of species. It invites special attention to the lung.

In all marine animals except Cetacea, either the entire outer surface absorbs oxygen and exhales carbonic acid, or part of this surface has been differentiated for the function of respiration. In all mammals, and birds, and mature reptiles, part of an *inner* tissue has been differentiated and set apart for the function of respiration. External respiratory organs rise from the skin. Internal respiratory organs rise from the skin of the throat. Internal respiratory organs exist in the fish as a rudiment. External respiratory organs appear in embryotic mammals as vestiges.

The inner lung begins as a little hollow bud on the throat. This bud pushes out another and another, and so on till by continuous budding it becomes a tree-like growth, interlaced with blood-vessels. Let such a bud start from the outer surface, on the back. It will become, according to the mode of secondary budding, a little tree, or leaf, or flower of blood-vessels and vascular tissue—such a lung as adorns the back of Doris.

The history of the inner lung is indicated by fishes and amphibians. The history of the outer lung is indicated in these naked mollusks.

Eolis, which shows us the beginning of a liver, or perhaps the last stage of its reduction, seems to be prehistoric as to the gill. One part of the surface absorbs oxygen as well as another. If we leave the beach and the Eolids for mid-ocean and the Pteropods, we shall find the first shadowing forth of a gill. In the Pteropod one part of the skin is a little more vascular than the rest, and on this part the blood is more freely oxidized. Now "respiratory activity," as Spencer has shown, "aids in the development of respiratory appendages." A larger and larger surface is exposed to the water, and this larger surface, developed partly by Natural Selection, and partly by respiratory activity itself, is attained in multitudinous branchings of the mimic tree, and deep sinuosities of the mimic leaf.

But in Doris, which represents a great advance in gill development over a Pteropod, the gill is still imperfect, and as a respiratory organ it is supplemented by the creeping disk. In Aplysia the gill is carried up to perfection and aërates all the blood.

In the evolution of an organ we have hints as to the evolution of a species.

No interest can attach to such low forms of life as the Eolids unless they teach something of the methods of Nature in originating species. Readers of The Popular Science Monthly will not give their attention to mere description or anecdote. Facts they know do not pass into science until fertilized by ideas. We shall return to Eolis and its family through a study of forms which the eye, not aided by the knife, would report as far removed from them.

A mollusk is a soft, fleshy, sac-like body, with a mantle (pallium) extending from the back in two folds, right and left, around the sides. In the Bryozoan (moss-animal), whose reticulated coral incrusts many shells and sea-weeds, the molluscan type reaches down almost to the polyp. The Bryozoan has a cylindrical body with a tentacular crown. Structurally it is a mollusk, morphologically a polyp. It would seem to be a case in the organic world analogous to that in the inorganic, in which a small portion of a mineral, in crystallizing, forces a large portion of a foreign mineral into its own crystalline form and masks the structure under the shape.

The mantle performs important functions, and it will guide us along a series of transformations. Suppose that the two folds cohere along their edges. The mantle would then become a kind of sac, inclosing the body. If we call it a *tunic*, we might say that the animal is wrapped in its tunic, and this cohering of the tunic-folds would bring us to the order of *Tunicata*.

If we put the dredge down fathoms deep into the sea, it may bring from the bottom a Clavelina, most beautiful of Tunicates. In shape it is a pitcher without handle, an inch high, tapering down to a slender base, which springs from a creeping gelatinous thread. The mantle is transparent as crystal, and through it you may see, as if suspended in the cavity of the body, what seems the frilled edge of a ribbon of snow-white lace. This is Clavelina's lung. A little sac, seen through the transparent mantle and body walls, contracting and expanding with a slow and measured beat, is Clavelina's heart.

Another cloaked mollusk is Cynthia. It adheres to rocks or pebbles under a few fathoms of ocean, and has something of the form and color of a blood-peach. It is known to watermen under the name of "sea-peach." Its mantle is tough and leathery.[1]

Another and a more interesting member of the cloaked family is the Salpa. In the structure of the heart it marks an advance on Clavelina. Instead of a single pulsating sac, we find an auricle and a ventricle, veins and arteries. But, Nature having advanced from a single to a double heart, it would seem that she did not yet know how to use the improvement. In the Salpa we find the heart incessantly changing its auricle into a ventricle, its ventricle into an auricle, veins into arteries, arteries into veins.

The Salpæ swim freely in the open sea and occur singly, or united in long chains or rings. They are phosphorescent, and a chain of united Salpæ appears like a writhing, fiery serpent gliding over the waves. The Pyrosomes, which are free Salpæ, congregate in vast shoals, and in their phosphorescence glare like pillars of fire, green, unearthly, elfish.

Let the edges of the mantle unite along part of their surface, but remain open at the ends. The animal now will not be completely tunicated. It will be inclosed in a kind of funnel. If, now, such a mantle be drawn out into a siphon to conduct a current of water to the gills, it would be of use to the animal in aiding respiration. The edges of the mantle having united in this way, a siphon-bearing mollusk, like the cockle or solen, would be simply a question of time. Natural Selection would bring it about.

Let the edges of the mantle not unite at all, we shall have a mollusk something like the oyster.

Remove the shell, and an oyster lies before you in irregular, ragged outline. An opening at the sharper end, which lies near the beak of the shell, is the mouth. Around the mouth are four leaf-like bodies, which hang in pairs. The heart is an advance on that of Salpa, not in structure but in behavior. It has settled down into regular work, the auricle always an auricle, and the ventricle always a ventricle. The liver is a decided advance on that of Eolis, although not yet a well-defined gland. The mantle is a fringed, veil-like membrane,

[1] It is known that the mantle of many tunicate mollusks is *non-azotized* matter. Azote is another name for nitrogen, and in various proportions it is found in animal tissues. This is a distinguishing feature between animal (azotized) and vegetal (non-azotized) matter. *Chemically* the plant meets the animal on the back of a tunicate mollusk.

whose folds are not united along their edges. Near the mouth, on the ventral side, is a portion of the surface a little tougher than the rest. This toughened surface on the oyster we shall find as significant as we found the softened vascular patch on the surface of the Pteropod.

The leaf-like bodies which surround the mouth appear as silent members. In some form or other they are present in all mollusks, and in the order of Cephalopods they reach the maximum of development, and appear as long, flexible limbs. In this order—represented by the Octopus—the molluscan type reaches the highest expression. Early in the history of life, the type had unfolded and found expression in Cephalopods of great bulk and of many species. The Cephalopods have long been a waning dynasty (Fig. 3).

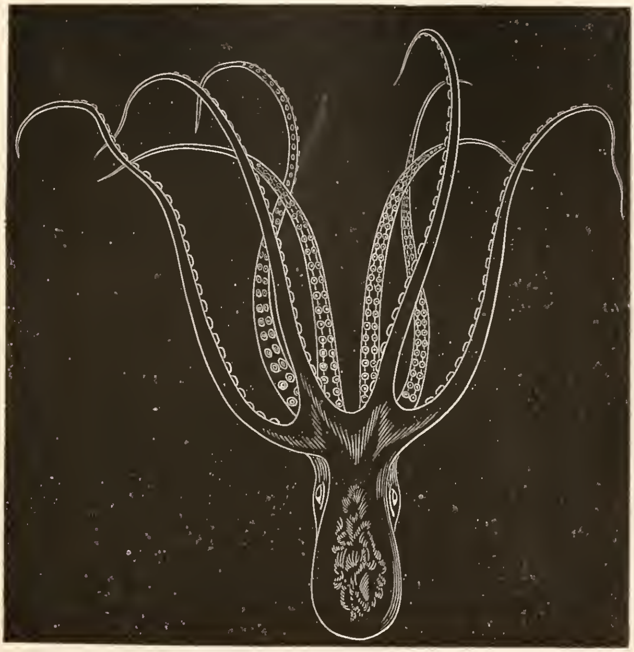


FIG. 3.—OCTOPUS FULVUS.

As we have met the palpi—rudimental in the oyster—in other guise in oyster's distant relatives, so we will find that toughened portion, so faintly pronounced in the oyster, expressed with greater distinctness in oysters' nearer relatives. In the mussel this toughened surface supports a bundle of fibres, which protrudes from the shell and adheres to a rock or wharf-post. In the cockle we find this same portion prolonged into a finger-like organ, which performs the office of locomotion. It is called a foot. In the teredo this "foot" has reached the maximum of development, as the palpi in Octopus. But for the rudimental palpi, we might look on the oyster as a degraded cockle or mussel. But for the toughened surface representing the cockle's foot, we might regard the oyster as a lapsed form of some ancient Cephalopod.

The mantle secretes the shell, and in all bivalves it lies through its whole extent against the shell. Now, in all mollusks, the axis of the body is at first straight, and the body is bisymmetrical. If growth were arrested at an early stage, all mollusks would look alike, and, if the embryotic mantle were to secrete a shell, all these arrested growths would appear as miniature bivalves. They would be symmetrical. But circumstances determine shapes. The mollusk which, in maturity as well as infancy, lives in the open sea, will be exposed to like conditions on either side, and will retain its bilateral symmetry. A mollusk which lies on the sea-bottom will be exposed to unlike conditions, one side being buried in mud and the other bathed in water. As a shrub which grows against a wall loses its symmetry and becomes one-sided, so a young oyster, as soon as it leaves off its roving ways, and fixes its abode on the sea-mud, must begin to develop unsymmetrically. One side and one valve of the shell outgrow the other side and valve. In the Gryphæa, an ancient species of oyster, this over-development of one side is carried further, and, while the right valve is small and flat, the left is deep and partially rolled up. In the Gasteropods, except Chiton, this one-sidedness is carried still further. One side outgrows the other so much that the body takes a spiral form, and one valve, secreted by one fold of the mantle, appears as a spiral shell, while the other valve, secreted by the aborted fold of the mantle, appears as an operculum—a little shelly disk known under the name of "eye-stone." In the snail this one-sided development is carried to the highest pitch of asymmetry. Overgrowth of the right side forces it into a spiral, and the right valve twists around with the body it incloses, while the left valve, which, in the marine Gasteropod, we had found reduced to an operculum, is here completely eliminated.

From the cloaked clavelina to the oyster, we were led, step by step, along successive modifications of the mantle. From the oyster to the snail we have passed, step by step, along successive stages of one-sided over-development. The facts have shown that a bivalve mollusk could not have descended from a univalve. As all mollusks in early life have the axis of the body straight, and the parts symmetrically arranged on either side, we may infer that bilateral symmetry characterized the remote ancestors of the molluscan type. Now, while a mollusk is bisymmetrical or nearly so, if the mantle secretes a shell it must be in in two parts, or, as in Chiton, in many parts. The snail is the last term of our series, and its successive stages of growth should indicate the path along which Nature has moved in the evolution of the unsymmetrical Gasteropod from a symmetrical, oyster-like bivalve (Fig. 4).

Lereboullet has made out the embryology of Limneus, a fresh-water snail. We need not follow him into details. It will be enough for our purpose to note that from a "mulberry mass"—the egg after segmentation of the yelk—there comes a sort of hemispherical cup. The mouth of the cup changes from a circle to a long slit, and the edges of the slit unite except at one point. The embryo has now taken on the molluscan type. The aperture along the line of the slit is the opening to the sac, the mouth to the coming snail. The line along which the approximated sides of the cup have united is in the trend of a plane which divides the body into right and left sides, equal

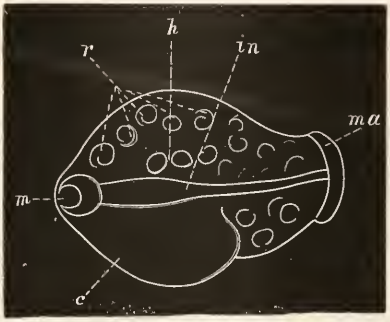



Fig. 4.—Symmetry. Embryotic Snail: *m*, mouth; *ma*, mantle; *c*, creeping disk; *in*, intestine; *h*, heart (auricle and ventricle in line with the intestinal tube); *r*, remnants of yolk-cell.

and similar. The mantle has begun to form, and as a sort of cap it covers the part of the body opposite the mouth. The intestine begins in a little depression under the mantle and in line with the mouth and stomach. This depression is elongated, becomes a tube, and opens into the stomach. A few days later, traces of a heart appear as two pulsating, globular sacs, placed end to end (Fig. 5).

If development were arrested at this stage, our snail would be bisymmetrical, and, if it had a shell, the shell would be in two equal valves, right and left. But development goes on, and now every step is a departure from right and left symmetry. First, the intestine gets a twist. Other organs are quick to follow. Even the heart moves askance. The two chambers which, a while before, were placed end to end in line with the axis of the body, begin to change position. The receiving chamber moves obliquely to the right and downward, the distributing chamber to the left and upward. The right fold of the mantle spreads rapidly; the left, not at all. The right side of the body grows rapidly; the left remains almost stationary. The right valve of the shell grows rapidly, and twists over with the inclosed body; the left is completely aborted. Now, it is a very significant fact that the only parts which do not share this one-sided overgrowth are the head and creeping disk; and these are the parts which, not being covered by the mantle, do not become incased in the shell. Exposed to the water or the air equally on both sides, they retain their bilateral symmetry.

From a sac-like body, moving freely through the water, and thus exposed equally on both sides to the same environment, and therefore bisymmetrical, we may suppose that all mollusks have been derived. If such a free-moving body became fixed, unless as a stemmed Ascidian, its parts would be differently conditioned as to environment, and the side more favored would outgrow the other. As the first part of the snail's body to bend out of line with the axis is the intestinal canal, we infer that this bend occurred far back in the snail's ancestry. It occurs in the oyster. As the last organ to share the general twist resulting from unequal growth of the sides is the heart, we infer that displacement of this organ occurred later down in the history of the type. It does not occur in the oyster.

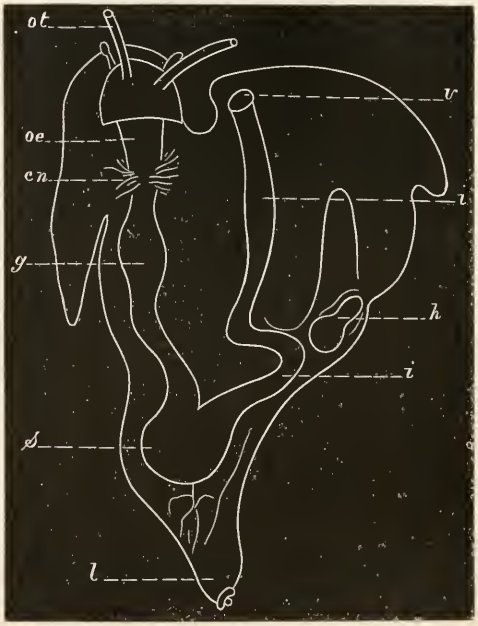



Fig. 5.—Asymmetry. Adult Snail: *op*, optic tentacle; *oe*, œsophagus; *cn*, cephalic ganglion; *g*, gizzard; *s*, stomach: *l*, liver; *i*, intestine (bent out of line with the axis of the body); *h*, heart (auricle and ventricle not in line with axis or intestinal tube); *v*, vent.

The first step toward a spiral-shelled gasteropod was taken in the first mollusk whose environment on one side was mud or rock, and on the other water. Difference of environment was the first factor in this series of evolutions. Only this would induce one-sidedness, and acting through long periods it might induce excessive one-sidedness. It might carry an oyster as far along in asymmetrical growth as the partially rolled-up oyster called Gryphæa. When asymmetry came to be of advantage to the animal, Natural Selection began and carried it to greater excess, with the aid of other factors—for Nature is too rich to be limited to one or two efficient causes—carried it to the order of Gasteropods.

In this order we find Eolis, and Doris, and Aplysia. From them our studies have ranged over kindred, near and remote. From their kindred we return, prepared by what we have found to interpret them. In form, these animals do not depart from bilateral symmetry, as from their habits they should not. Each side is exposed in the same way to the same environing element. But the alimentary canal is bent out of line with the axis of the body. The reproductive system is still more askance. It is altogether one-sided. Very suggestive facts. We find one-sided growth without the conditions which induce it. These conditions must have pertained to an ancestor. The bend in the alimentary canal and the displacement of the reproductive organs have been inherited from an ancestor so conditioned in the environment as to produce overgrowth of one side. But the alimentary canal does not bend out of line so much as in the shell-bearing Gasteropods; and in Eolis—in which the last vestige of a shell has disappeared—the canal has become straight. Another suggestive fact. We find in these naked mollusks heredity and abbreviated heredity.[1] Aplysia and Doris inherit the ancestral twist. In Eolis the heritage is cut off.

From symmetry to asymmetry, from a bivalve to a univalve, Nature has moved, closing a cycle of evolution in the snail; from asymmetry back to symmetry, from a shell-bearer to a non-shell-bearer, she is moving in the sea-slugs. In this retrogression, Aplysia has shared the least. It retains the largest shell-vestige; it has the most perfect liver; its gills cover the mantle. Eolis has been carried back the farthest. In this retrogressive movement we may find the *rationale* of Aplysia's many stomachs, and Eolis's branching stomach and hepatic cells. In the snail, perhaps in all Gasteropods, the alimentary

[1] To account for the facts of heredity, Darwin has formulated a theory called *Pangenesis.* To account for the facts of heredity and *abbreviated* heredity Dr. Elsberg has proposed a theory which he calls "*the Conservation of the Organic Molecule.*" The biologist must be allowed as much "scientific use of the imagination" as the physicist. If the one must have his atoms and molecules, the other must have his physiological units, his plastic molecules, his "*plastidules.*" Let us imagine the first pair of any race, say the human race. A child of the Adam and Eve would be derived wholly from its parents, and, if the plastidules which passed into the embryo were derived equally from each parent, one-half of the Adam would be represented in the child. Now, if some of these organic molecules were to remain latent in the body of the offspring, and pass unchanged into the offspring of the next generation, a smaller portion of the Adam would be repeated in the grandchild. We are to suppose that each plastidule carries so much of the parent, potentially, into the child. At each successive generation less and less of the Adamic plastidules would appear, and less and less of the Adam. We should have a fractional series with unity for numerator, and an ever-increasing number for denominator. At last we should reach a term whose denominator would be infinitely large. It would express the complete elimination of the Adamic plastidules. Now, so long as any plastidules of an ancestor of any degree of remoteness remain, so long will the man or the animal inherit something from that ancestor; so long will atavism occur. When all plastidules of such ancestor are cut off, we have *abbreviated* heredity.

canal develops *isolately*, a section here and another there. Now, a stomach is simply an expanded portion of the canal. Let the tract of the canal be laid in isolated openings, let these openings be elongated, each, into a tube, and let the original openings be marked as pouches along this continuous tube, and we have Aplysia's row of stomachs. It is after the pattern of the digestive tube of an embryotic Gasteropod.

In Eolis the branching alimentary canal lies along the dorsal side, not the ventral. In getting itself straight, it seems to have got itself as near the dorsal papillæ as possible. Now, these papillæ, for a long time mistaken for lungs, for a long time, perhaps, were lungs. We have found that in Doris the gills are connected only with the digestive system, and we may suppose that in some ancestral form of Eolis papilliform gills were connected with this system in the same way, that is, through the liver. Only a slight departure from the normal development would transfer the connection of a gill-bud from one part of the digestive system to another, from the liver to the stomach. If, then, it would be for the advantage of the animal to have more stomach, we can see how, by Natural Selection, all the gill-buds or papillæ would, in the end, cease to respire for the liver and become diverticula of the stomach. What would become of the liver? Losing its lung, it would suffer degradation. It would abort, lapse into a few hepatic cells, and become a mere vestige.

The naked Tunicates are intelligible as initial terms of a molluscan series. The naked Gasteropods are intelligible as final terms of a descending series, as impoverished heirs of an ancient house.

We have chosen for our study these slugs of the sea to develop a phase of evolution not generally understood. Evolution does not imply an unbroken course of progression. It does not imply a tendency in every thing to become something else and better. It is determined by many factors, inner and outer, and, as Spencer has shown, "the coöperation of inner and outer factors works changes until an equilibrium is reached between the organism and its environment."

On the deep-sea bottom the environing actions remain constant age after age, and we find that in the abyssal world a number of species have remained constant since the Cretaceous epoch. On the surface of the sea and on the beach, the conditions of life have not been constant, and surface and littoral species have been more subject to change. The air is more fickle than the sea. It is now warm and now cold; now moist and now dry; now in motion and now at rest: and the aërial fauna must oppose to these outer factors a corresponding adjustment of inner factors. The fauna of this element we should find the most unstable, and so we do. The only insect known to have come down to our times from times so remote as the Cretaceous, unchanged or changed but little, is the tiger-beetle of our sea and lake shores, and the uplands of Colorado. Moreover, an insect at rest is not conditioned as an insect in the air. Let it forsake little by little its aërial life, and rest longer and longer on other bodies. In time it becomes a parasite. The structure it had acquired while in the air becomes useless. The environment being more stable, the opposing actions within are reduced, and the organism lapses into a simpler form. In the insect world we should find the largest number of retrograded species, and so we do. Fleas, bugs, the dream of which sends a shudder through our sleep, creepers in the hair, burrowers in the flesh, form a descending series, each order carrying with it, in the form of vestiges, reminiscences of a higher state when, as winged insects, its ancestors lived in the open air.

Retrogression of this kind has affected higher orders. An amphibious mammal, taking less to the land and more to the water, would lapse in time into a simpler form. The studies of Prof. Wilder on the embryotic dugong seem to show that dugongs and manatees have descended by retrogression from some ancient hippopotamoid mammal.

Retrogression, whose *rationale* is not found in our studies on the Eolids, has affected still higher orders. If the elephants of our day are descendants of the mastodons and mammoths which, in Pleistocene days, possessed North America and Europe, as the investigations of Gaudry wellnigh demonstrate; if the living tigers and lions have descended from species whose remains abound in ancient caves, as is probable; if the "grizzly" of the Rocky Mountains is a modified form of the great cave-bear, once so common in Europe, as naturalists believe; if the anthropoid apes of Africa and tropical Asia are survivals from a race which spread beyond the tropics and ranked somewhat nearer to man, as the *Mesopithecus* of Greece and *Dryopithecus* of France testify out of Miocene strata, the proboscidians, carnivores, and primates have all suffered retrogression, and, at the advent of man, life having reached its zenith, *animal* life began a downward curve. If, in the main, the higher has followed the lower, within this cycle of progression the struggle for life would involve another cycle of retrogression. As the savage in presence of civilization often sinks to lower savagery, so a species, outstripped in the race of life, and left hopelessly behind, degenerates, and finally dies.

And as the two cycles, progression and retrogression, are involved in the life-history of the earth, so the two movements may go on simultaneously in the same species. Man himself is such a species. His brain, and its servant, the hand, have attained the utmost development. His digestive system and his foot have been modified but little from a primitive type. Progression above in that which is most distinctively human may involve retrogression below in that which is distinctively animal.

# GEOGRAPHY AND EVOLUTION.[1]

By Lieutenant-General R. STRACHEY, F. R. S.

IN accordance with the practice followed for some years past by the presidents of the sections of the British Association, I propose, before proceeding with our ordinary business, to offer for your consideration some observations relative to the branch of knowledge with which this section is more specially concerned.

My predecessors in this chair have, in their opening addresses, viewed geography in many various lights. Some have drawn attention to recent geographical discoveries of interest, or to the gradual progress of geographical knowledge over the earth generally, or in particular regions. Others have spoken of the value of geographical knowledge in the ordinary affairs of men, or in some of the special branches of those affairs, and of the means of extending such knowledge. Other addresses, again, have dwelt on the practical influence produced by the geographical features and conditions of the various parts of the earth on the past history and present state of the several sections of the human race, the formation of kingdoms, the growth of industry and commerce, and the spread of civilization.

The judicious character of that part of our organization which leads to yearly changes among those who preside over our meetings, and does not attempt authoritatively to prescribe the direction of our discussions, will no doubt be generally recognized. It has the obvious advantage, among others, of insuring that none of the multifarious claims to attention of the several branches of science shall be made unduly prominent, and of giving opportunity for viewing the subjects which from time to time come before the Association in fresh aspects by various minds.

Following, then, a somewhat different path from those who have gone before me in treating of geography, I propose to speak of the physical causes which have impressed on our planet the present outlines and forms of its surface, have brought about its present conditions of climate, and have led to the development and distribution of the living beings found upon it.

In selecting this subject for my opening remarks, I have been not a little influenced by a consideration of the present state of geographical knowledge, and of the probable future of geographical investigation. It is plain that the field for mere topographical exploration is already greatly limited, and that it is continually becoming more restricted. Although no doubt much remains to be done in obtaining detailed maps of large tracts of the earth's surface, yet there is

[1] Address of the President of Section E, at the Bristol Meeting of the British Association.

but comparatively a very small area with the essential features of which we are not now fairly well acquainted. Day by day our maps become more complete, and with our greatly-improved means of communication the knowledge of distant countries is constantly enlarged and more widely diffused. Somewhat in the same proportion the demands for more exact information become more pressing. The necessary consequence is an increased tendency to give to geographical investigations a more strictly scientific direction. In proof of this I may instance the fact that the two British naval expeditions now being carried on, that of the Challenger and that of the arctic seas, have been organized almost entirely for general scientific research, and comparatively little for topographical discovery. Narratives of travels, which not many years ago might have been accepted as valuable contributions to our then less perfect knowledge, would now perhaps be regarded as superficial and insufficient. In short, the standard of knowledge of travelers and writers on geography must be raised to meet the increased requirements of the time.

Other influences are at work tending to the same result. The great advance made in all branches of natural science limits more and more closely the facilities for original research, and draws the observer of Nature into more and more special studies, while it renders the acquisition by any individual of the highest standard of knowledge in more than one or two special subjects comparatively difficult and rare. At the same time the mutual interdependence of all natural phenomena daily becomes more apparent; and it is of ever-increasing importance that there shall be some among the cultivators of natural knowledge who specially direct their attention to the general relations existing among all the forces and phenomena of Nature. In some important branches of such subjects, it is only through study of the local physical conditions of various parts of the earth's surface and the complicated phenomena to which they give rise that sound conclusions can be established; and this study constitutes physical or scientific geography. It is very necessary to bear in mind that a large portion of the phenomena dealt with by the sciences of observation relates to the earth as a whole in contradistinction to the substances of which it is formed, and can only be correctly appreciated in connection with the terrestrial or geographical conditions of the place where they occur. On the one hand, therefore, while the proper prosecution of the study of physical geography requires a sound knowledge of the researches and conclusions of students in the special branches of science, on the other, success is not attainable in the special branches without suitable apprehension of geographical facts. For these reasons it appears to me that the general progress of science will involve the study of geography in a more scientific spirit, and with a clearer conception of its true function, which is that of obtaining accurate notions of the manner in which the forces of Nature have brought about the varied conditions characterizing the surface of the planet which we inhabit.

In its broadest sense science is organized knowledge, and its methods consist of the observation and classification of the phenomena of which we become conscious through our senses, and the investigation of the causes of which these are the effects. The first step in geography, as in all other sciences, is the observation and description of the phenomena with which it is concerned; the next is to classify and compare this empirical collection of facts, and to investigate their antecedent causes. It is in the first branch of the study that most progress has been made, and to it indeed the notion of geography is still popularly limited. The other branch is commonly spoken of as physical geography, but it is more correctly the science of geography.

The progress of geography has thus advanced from first rough ideas of relative distance between neighboring places, to correct views of the earth's form, precise determinations of position, and accurate delineations of the surface. The first impressions of the differences observed between distant countries were at length corrected by the perception of similarities no less real. The characteristics of the great regions of polar cold and equatorial heat, of the sea and land, of the mountains and plains, were appreciated; and the local variations of season and climate, of wind and rain, were more or less fully ascertained. Later, the distribution of plants and animals, their occurrence in groups of peculiar structure in various regions, and the circumstances under which such groups vary from place to place, gave rise to fresh conceptions. Along with these facts were observed the peculiarities of the races of men—their physical form, languages, customs, and history—exhibiting on the one hand striking differences in different countries, but on the other often connected by a strong stamp of similarity over large areas.

By the gradual accumulation and classification of such knowledge the scientific conception of geographical unity and continuity was at length formed, and the conclusion established that while each different part of the earth's surface has its special characteristics, all animate and inanimate Nature constitutes one general system, and that the particular features of each region are due to the operation of universal laws acting under varying local conditions. It is upon such a conception that is now brought to bear the doctrine, very generally accepted by the naturalists of our own country, that each successive phase of the earth's history, for an indefinite period of time, has been derived from that which preceded it, under the operation of the forces of Nature as we now find them; and that, so far as observation justifies the adoption of any conclusions on such subjects, no change has ever taken place in those forces, or in the properties of matter. This doctrine is commonly spoken of as the doctrine of evolution, and it is to its application to geography that I wish to direct your attention.

I desire here to remark that, in what I am about to say, I altogether leave on one side all questions relating to the origin of matter, and of the so-called forces of Nature which give rise to the properties of matter. In the present state of knowledge such subjects are, I conceive, beyond the legitimate field of physical science, which is limited to discussions directly arising on facts within the reach of observation, or on reasonings based on such facts. It is a necessary condition of the progress of knowledge that the line between what properly is or is not within the reach of human intelligence is ill defined, and that opinions will vary as to where it should be drawn: for it is the avowed and successful aim of science to keep this line constantly shifting by pushing it forward; many of the efforts made to do this are no doubt founded in error, but all are deserving of respect that are undertaken honestly.

The conception of evolution is essentially that of a passage to the state of things which observation shows us to exist now, from some preceding state of things. Applied to geography, that is to say to the present condition of the earth as a whole, it leads up to the conclusion that the existing outlines of sea and land have been caused by modifications of preëxisting oceans and continents, brought about by the operation of forces which are still in action, and which have acted from the most remote past of which we can conceive; that all the successive forms of the surface—the depressions occupied by the waters, and the elevations constituting mountain-chains—are due to these same forces; that these have been set up, first, by the secular loss of heat which accompanied the original cooling of the globe; and second, by the annual and daily gain or loss of heat received from the sun acting on the matter of which the earth and its atmosphere are composed; that all variations of climate are dependent on differences in the condition of the surface; that the distribution of life on the earth, and the vast varieties of its forms, are consequences of contemporaneous or antecedent changes of the forms of the surface and climate; and thus that our planet as we now find it is the result of modifications gradually brought about in its successive stages, by the necessary action of the matter out of which it has been formed, under the influence of the matter which is external to it.

I shall state briefly the grounds on which these conclusions are based.

So far as concerns the inorganic fabric of the earth, that view of its past history which is based on the principle of the persistence of all the forces of Nature may be said to be now universally adopted. This teaches that the almost infinite variety of natural phenomena arises from new combinations of old forms of matter, under the action of new combinations of old forms of force. Its recognition has, however, been comparatively recent, and is in a great measure due to the teachings of that eminent geologist, the late Sir Charles Lyell, whom we have lost during the past year.

When we look back by the help of geological science to the more remote past, through the epochs immediately preceding our own, we find evidence of marine animals—which lived, were reproduced, and died—possessed of organs proving that they were under the influence of the heat and light of the sun; of seas whose waves rose before the winds, breaking down cliffs, and forming beaches of bowlders and pebbles; of tides and currents spreading out banks of sand and mud, on which are left the impress of the ripple of the water, of drops of rain, and of the tracks of animals; and all these appearances are precisely similar to those we observe at the present day as the result of forces which we see actually in operation. Every successive stage, as we recede in the past history of the earth, teaches the same lesson. The forces which are now at work, whether in degrading the surface by the action of seas, rivers, or frosts, and in transporting its fragments into the sea, or in reconstituting the land by raising beds laid out in the depth of the ocean, are traced by similar effects as having continued in action from the earliest times.

Thus pushing back our inquiries we at last reach the point where the apparent cessation of terrestrial conditions such as now exist requires us to consider the relation in which our planet stands to other bodies in celestial space; and, vast though the gulf be that separates us from these, science has been able to bridge it. By means of spectroscopic analysis it has been established that the constituent elements of the sun and other heavenly bodies are substantially the same as those of the earth. The examination of the meteorites which have fallen on the earth from the interplanetary spaces shows that they also contain nothing foreign to the constituents of the earth. The inference seems legitimate, corroborated as it is by the manifest physical connection between the sun and the planetary bodies circulating around it, that the whole solar system is formed of the same descriptions of matter, and subject to the same general physical laws. These conclusions further support the supposition that the earth and other planets have been formed by the aggregation of matter once diffused in space around the sun; that the first consequence of this aggregation was to develop intense heat in the consolidating masses; that the heat thus generated in the terrestrial sphere was subsequently lost by radiation; and that the surface cooled and became a solid crust, leaving a central nucleus of much higher temperature within. The earth's surface appears now to have reached a temperature which is virtually fixed, and on which the gain of heat from the sun is, on the whole, just compensated by the loss by radiation into surrounding space.

Such a conception of the earliest stage of the earth's existence is commonly accepted, as in accordance with observed facts. It leads to the conclusion that the hollows on the surface of the globe occupied by the ocean, and the great areas of dry land, were original irregularities of form caused by unequal contraction; and that the mountains were corrugations, often accompanied by ruptures, caused by the strains developed in the external crust by the force of central attraction exerted during cooling, and were not due to forces directly acting upward generated in the interior by gases or otherwise. It has recently been very ably argued by Mr. Mallet that the phenomena of volcanic heat are likewise consequences of extreme pressures in the external crust, set up in a similar manner, and are not derived from the central heated nucleus.

There may be some difficulty in conceiving how forces can have been thus developed sufficient to have produced the gigantic changes which have occurred in the distribution of land and water over immense areas, and in the elevation of the bottoms of former seas so that they now form the summits of the highest mountains, and to have effected such changes within the very latest geological epoch. These difficulties in great measure arise from not employing correct standards of space and time in relation to the phenomena. Vast though the greatest heights of our mountains and depths of our seas may be, and enormous though the masses which have been put into motion, when viewed according to a human standard, they are insignificant in relation to the globe as a whole. Such heights and depths (about six miles) on a sphere of ten feet in diameter would be represented on a true scale by elevations and depressions of less than the tenth part of an inch, and the average elevation of the whole of the dry land (about one thousand feet) above the main level of the surface would hardly amount to the thickness of an ordinary sheet of paper. The forces developed by the changes of the temperature of the earth as a whole must be proportionate to its dimensions; and the results of their action on the surface in causing elevations, contortions, or disruptions of the strata, cannot be commensurable with those produced by forces having the intensities, or by strains in bodies of the dimensions, with which our ordinary experience is conversant.

The difficulty in respect to the vast extent of past time is perhaps less great, the conception being one with which most persons are now more or less familiar. But I would remind you that, great though the changes in human affairs have been since the most remote epochs of which we have records in monuments or history, there is nothing to indicate that within this period has occurred any appreciable modification of the main outlines of land and sea, or of the condition of climate, or of the general characters of living creatures; and that the distance that separates us from those days is as nothing when compared with the remoteness of past geological ages. No useful approach has yet been made to a numerical estimate of the duration even of that portion of geological time which is nearest to us; and we can say little more than that the earth's past history extends over hundreds of thousands or millions of years.

The solid nucleus of the earth with its atmosphere, as we now find them, may thus be regarded as exhibiting the residual phenomena which have resulted on its attaining a condition of practical equilibrium, the more active process of aggregation having ceased, and the combination of its elements into the various solid, liquid, or gaseous matters found on or near the surface having been completed. During its passage to its present state many wonderful changes must have taken place, including the condensation of the ocean, which must have long continued in a state of ebullition, or bordering on it, surrounded by an atmosphere densely charged with watery vapor. Apart from the movements in its solid crust caused by the general cooling and contraction of the earth, the higher temperature due to its earlier condition hardly enters directly into any of the considerations that arise in connection with its present climate, or with the changes during past time which are of most interest to us; for the conditions of climate and temperature at present, as well as in the period during which the existence of life is indicated by the presence of fossil remains, and which have affected the production and distribution of organized beings, are dependent on other causes, to a consideration of which I now proceed.

The natural phenomena relating to the atmosphere are often extremely complicated and difficult of explanation; and meteorology is the least advanced of the branches of physical science. But sufficient is known to indicate, without possible doubt, that the primary causes of the great series of phenomena, included under the general term climate, are the action and reaction of the mechanical and chemical forces set in operation by the sun's heat, varied from time to time and from place to place, by the influence of the position of the earth in its orbit, of its revolution on its axis, of geographical position, elevation above the sea-level, and condition of the surface, and by the great mobility of the atmosphere and the ocean.

The intimate connection between climate and local geographical conditions is everywhere apparent; nothing is more striking than the great differences between neighboring places where the effective local conditions are not alike, which often far surpass the contrasts attending the widest separation possible on the globe. Three or four miles of vertical height produce effects almost equal to those of transfer from the equator to the poles. The distribution of the great seas and continents gives rise to periodical winds—the trades and monsoons—which maintain their general characteristics over wide areas, but present almost infinite local modifications, whether of season, direction, or force. The direction of the coasts and their greater or less continuity greatly influence the flow of the currents of the ocean; and these, with the periodical winds, tend on the one hand to equalize the temperature of the whole surface of the earth, and on the other to cause surprising variations within a limited area. Ranges of mountains, and their position in relation to the periodical or rain-bearing winds, are of primary importance in controlling the movements of the lower strata of the atmosphere, in which, owing to the laws of elastic gases, the great mass of the air and watery vapor are concentrated. By their presence they may either constitute a barrier across which no rain can pass, or determine the fall of torrents of rain around them. Their absence or their unfavorable position, by removing the causes of condensation, may lead to the neighboring tracts becoming rainless deserts.

The difficulties that arise, in accounting for the phenomena of climate on the earth as it now is, are naturally increased when the attempt is made to explain what is shown by geological evidence to have happened in past ages. The disposition has not been wanting to get over these last difficulties by invoking supposed changes in the sources of terrestrial heat, or in the conditions under which heat has been received by the earth, for which there is no justification in fact, in a manner similar to that in which violent departures from the observed course of Nature have been assumed to account for some of the analogous mechanical difficulties.

Among the most perplexing of such climatal problems are those involved in the former extension of glacial action of various sorts over areas which could hardly have been subject to it under existing terrestrial and solar conditions; and in the discovery, conversely, of indications of far higher temperatures at certain places than seems compatible with their high latitudes; and in the alternations of such extreme conditions. The true solution of these questions has apparently been found in the recognition of the disturbing effects of the varying eccentricity of the earth's orbit, which, though inappreciable in the comparatively few years to which the affairs of men are limited, become of great importance in the vastly increased period brought into consideration when dealing with the history of the earth. The changes of eccentricity of the orbit are not of a nature to cause appreciable differences in the mean temperature either of the earth generally or of the two hemispheres; but they may, when combined with changes of the direction of the earth's axis caused by the precession of the equinoxes and nutation, lead to exaggeration of the extremes of heat and cold, or to their diminution; and this would appear to supply the means of explaining the observed facts, though doubtless the detailed application of the conception will long continue to give rise to discussions. Mr. Croll, in his book entitled "Climate and Time," has recently brought together with much research all that can now be said on this subject; and the general correctness of that part of his conclusions which refers to the periodical occurrence of epochs of greatly-increased winter cold and summer heat in one hemisphere, combined with a more equable climate in the other, appears to me to be fully established.

These are the considerations which are held to prove that the inorganic structure of the globe through all its successive stages—the earth beneath our feet, with its varied surface of land and sea, mountain and plain, and with its atmosphere which distributes heat and moisture over that surface—has been evolved as the necessary result of the original aggregation of matter at some extremely remote period, and of the subsequent modification of that matter in condition and form under the exclusive operation of invariable physical forces.

From these investigations we carry on the inquiry to the living creatures found upon the earth: what are their relations one to another, and what to the inorganic world with which they are associated?

This inquiry, first directed to the present time, and thence carried backward as far as possible into the past, proves that there is one general system of life, vegetable and animal, which is coextensive with the earth as it now is, and as it has been in all the successive stages of which we obtain a knowledge by geological research. The phenomena of life, as thus ascertained, are included in the organization of living creatures, and their distribution in time and place. The common bond that subsists between all vegetables and animals is testified by the identity of the ultimate elements of which they are composed. These elements are carbon, oxygen, hydrogen, and nitrogen, with a few others in comparatively small quantities; the whole of the materials of all living things being found among those that compose the inorganic portion of the earth.

The close relation existing between the least specialized animals and plants, and between these and organic matter not having life, and even with inorganic matter, is indicated by the difficulty that arises in determining the nature of the distinctions between them. Among the more highly-developed members of the two great branches of living creatures, the well-known similarities of structure observed in the various groups indicate a connection between proximate forms which was long seen to be akin to that derived through descent from a common ancestor by ordinary generation.

The facts of distribution show that certain forms are associated in certain areas, and that as we pass from one such area to another the forms of life change also. The general assemblages of living creatures in neighboring countries easily accessible to one another, and having similar climates, resemble one another; and much in the same way, as the distance between areas increases, or their mutual accessibility diminishes, or the conditions of climate differ, the likeness of the forms within them becomes continually less apparent.

The plants and animals existing at any time in any locality tend constantly to diffuse themselves around that local centre, this tendency being controlled by the conditions of climate, etc., of the surrounding area, so that under certain unfavorable conditions diffusion ceases.

The possibilities of life are further seen to be everywhere directly influenced by all external conditions, such as those of climate, including temperature, humidity, and wind; of the length of the seasons and days and nights; of the character of the surface, whether it be land or water; and whether it be covered by vegetation or otherwise; of the nature of the soil; of the presence of other living creatures, and many more. The abundance of forms of life in different areas (as distinguished from number of individuals) is also found to vary greatly, and to be related to the accessibility of such areas to immigration from without; to the existence, within or near the areas, of localities offering considerable variations of the conditions that chiefly affect life; and to the local climate and conditions being compatible with such immigration.

For the explanation of these and other phenomena of organization and distribution, the only direct evidence that observation can supply is that derived from the mode of propagation of creatures now living; and no other mode is known than that which takes place by ordinary generation, through descent from parent to offspring.

It was left for the genius of Darwin to point out how the course of Nature, as it now acts in the reproduction of living creatures, is sufficient for the interpretation of what had previously been incomprehensible in these matters. He showed how propagation by descent operates subject to the occurrence of certain small variations in the offspring, and that the preservation of some of these varieties to the exclusion of others follows as a necessary consequence when the external conditions are more suitable to the preserved forms than to those lost. The operation of these causes he called Natural Selection. Prolonged over a great extent of time, it supplies the long-sought key to the complex system of forms either now living on the earth, or the remains of which are found in the fossil state, and explains the relations among them, and the manner in which their distribution has taken place in time and space.

Thus we are brought to the conclusion that the directing forces which have been efficient in developing the existing forms of life from those which went before them are those same successive external conditions including both the forms of land and sea, and the character of the climate, which have already been shown to arise from the gradual modification of the material fabric of the globe as it slowly attained to its present state. In each succeeding epoch, and in each separate locality, the forms preserved and handed on to the future were determined by the general conditions of surface at the time and place; and the aggregate of successive sets of conditions over the whole earth's surface has determined the entire series of forms which have existed in the past, and have survived till now.

As we recede from the present into the past, it necessarily follows, as a consequence of the ultimate failure of all evidence as to the conditions of the past, that positive testimony of the conformity of the facts with the principle of evolution gradually diminishes, and at length ceases. In the same way positive evidence of the continuity of action of all the physical forces of Nature eventually fails. But inasmuch as the evidence, so far as it can be procured, supports the belief in this continuity of action, and as we have no experience of the contrary being possible, the only justifiable conclusion is, that the production of life must have been going on as we now know it, without any intermission, from the time of its first appearance on the earth.

These considerations manifestly afford no sort of clew to the origin of life. They only serve to take us back to a very remote epoch, when the living creatures differed greatly in detail from those of the present time, but had such resemblances to them as to justify the conclusion that the essence of life then was the same as now; and through that epoch into an unknown anterior period, during which the possibility of life, as we understand it, began, and from which has emerged, in a way that we cannot comprehend, matter with its properties, bound together by what we call the elementary physical forces. There seems to be no foundation in any observed fact for suggesting that the wonderful property which we call life appertains to the combinations of elementary substances in association with which it is exclusively found, otherwise than as all other properties appertain to the particular forms or combinations of matter with which they are associated. It is no more possible to say how originated or operates the tendency of some sorts of matter to take the form of vapors, or fluids, or solid bodies, in all their various shapes, or for the various sorts of matter to attract one another or combine, than it is to explain the origin in certain forms of matter of the property we call life, or the mode of its action. For the present, at least, we must be content to accept such facts as the foundation of positive knowledge, and from them to rise to the apprehension of the means by which Nature has reached its present state, and is advancing into an unknown future.

These conceptions of the relations of animal and vegetable forms to the earth in its successive stages lead to views of the significance of type (i. e., the general system of structure running through various groups of organized beings) very different from those under which it was held to be an indication of some occult power directing the successive appearance of living creatures on the earth. In the light of evolution, type is nothing more than the direction given to the actual development of life by the forces that controlled the course of the successive generations leading from the past to the present. There is no indication of any adherent or prearranged disposition toward the development of life in any particular direction. It would rather appear that the actual face of Nature is the result of a succession of apparently trivial incidents, which by some very slight alteration of local circumstances might often, it would seem, have been turned in a different direction. Some otherwise unimportant difference in the constitution or sequence of the substrata at any locality might have determined the elevation of mountains where a hollow filled by the sea was actually formed, and thereby the whole of the climatal and other conditions of a large area would have been changed, and an entirely different impulse given to the development of life locally, which might have impressed a new character on the whole face of Nature.

But further, all that we see or know to have existed upon the earth has been controlled to its most minute details by the original constitution of the matter which was drawn together to form our planet. The actual character of all inorganic substances, as of all living creatures, is only consistent with the actual constitution and proportions of the various substances of which the earth is composed. Other proportions than the actual ones in the constituents of the atmosphere would have required an entirely different organization in all air-breathing animals, and probably in all plants. With any considerable difference in the quantity of water either in the sea or distributed as vapor, vast changes in the constitution of living creatures must have been involved. Without oxygen, hydrogen, nitrogen, or carbon, what we term life would have been impossible. But such speculations need not be extended.

The substances of which the earth is now composed are identical with those of which it has always been made up; so far as is known it has lost nothing and has gained nothing, except what has been added in extremely minute quantities by the fall of meteorites. All that is or ever has been upon the earth is part of the earth, has sprung from the earth, is sustained by the earth, and returns to the earth; taking back thither what it withdrew, making good the materials on which life depends, without which it would cease, and which are destined again to enter into new forms, and contribute to the ever-onward flow of the great current of existence.

The progress of knowledge has removed all doubt as to the relation in which the human race stands to this great stream of life. It is now established that man existed on the earth at a period vastly anterior to any of which we have records in history or otherwise. He was the contemporary of many extinct mammalia at a time when the outlines of land and sea, and the conditions of climate over large parts of the earth, were wholly different from what they now are, and our race has been advancing toward its present condition during a series of ages for the extent of which ordinary conceptions of time afford no suitable measure. These facts have, in recent years, given a different direction to opinion as to the manner in which the great groups of mankind have become distributed over the areas where they are now found; and difficulties once considered insuperable become soluble when regarded in connection with those great alterations of the outlines of land and sea which are shown to have been going on up to the very latest geographical periods. The ancient monuments of Egypt, which take us back perhaps seven thousand years from the present time, indicate that when they were erected the neighboring countries were in a condition of civilization not very greatly different from that which existed when they fell under the dominion of the Romans or Mohammedans hardly fifteen hundred years ago; and the progress of the population toward that condition can hardly be accounted for otherwise than by prolonged gradual transformations, going back to times so far distant as to require a geological rather than an historical standard of reckoning.

Man, in short, takes his place with the rest of the animate world, in the advancing front of which he occupies so conspicuous a position. Yet for this position he is indebted not to any exclusive powers of his own, but to the wonderful compelling forces of Nature which have lifted him, entirely without his knowledge, and almost without his participation, so far above the animals of whom he is still one, though the only one able to see or consider what he is.

For the social habits essential to his progress, which he possessed even in his most primitive state, man is without question dependent on his ancestors, as he is for his form and other physical peculiarities. In his advance to civilization he was insensibly forced, by the pressure of external circumstances, through the more savage condition, in which his life was that of the hunter, first to pastoral and then to agricultural occupations. The requirements of a population gradually increasing in numbers could only be met by a supply of food more regular and more abundant than could be provided by the chase. But the possibility of the change from the hunter to the shepherd or herdsman rested on the antecedent existence of animals suited to supply man with food, having gregarious habits, and fitted for domestication, such as sheep, goats, and horned cattle; for their support the social grasses were a necessary preliminary, and for the growth of these in sufficient abundance and naturally suitable for pasture was required. A further evasion of man's growing difficulty in obtaining sufficient food was secured by aid of the cereal grasses, which supplied the means by which agriculture, the outcome of pastoral life, became the chief occupation of more civilized generations. Lastly, when these increased facilities for providing food were in turn overtaken by the growth of the population, new power to cope with the recurring difficulty was gained through the cultivation of mechanical arts and of thought, for which the needful leisure was for the first time obtained when the earliest steps of civilization had removed the necessity for unremitting search after the means of supporting existence. Then was broken down the chief barrier in the way of progress, and man was carried forward to the condition in which he now is.

It is impossible not to recognize that the growth of civilization, by aid of its instruments, pastoral and agricultural industry, was the result of the unconscious adoption of defenses supplied by what was exterior to man, rather than of any truly intelligent steps taken with forethought to attain it; and in these respects man, in his struggle for existence, has not differed from the humbler animals or from plants. Neither can the marvelous ultimate growth of his knowledge, and his acquisition of the power of applying to his use all that lies without him, be viewed as differing in any thing but form or degree from the earlier steps in his advance. The needful protection against the foes of his constantly-increasing race—the legions of hunger and disease, infinite in number, ever changing their mode of attack or springing up in new shapes—could only be attained by some fresh adaptation of his organization to his wants, and this has taken the form of that development of intellect which has placed all other creatures at his feet and all the powers of Nature in his hand.

The picture that I have thus attempted to draw presents to us our earth carrying with it, or receiving from the sun or other external bodies, as it travels through celestial space, all the materials and all the forces by help of which are fashioned whatever we see upon it. We may liken it to a great complex living organism, having an inert substratum of inorganic matter on which are formed many separate organized centres of life, but all bound up together by a common law of existence, each individual part depending on those around it, and on the past condition of the whole. Science is the study of the relations of the several parts of this organism one to another, and of the parts to the whole. It is the task of the geographer to bring together from all places on the earth's surface the materials from which shall be deduced the scientific conception of Nature. Geography supplies the rough blocks wherewith to build up that grand structure toward the completion of which science is striving. The traveler, who is the journeyman of science, collects from all quarters of the earth observations of fact, to be submitted to the research of the student, and to provide the necessary means of verifying the inductions obtained by study or the hypotheses suggested by it. If, therefore, travelers are to fulfill the duties put upon them by the division of scientific labor, they must maintain their knowledge of the several branches of science at such a standard as will enable them thoroughly to apprehend what are the present requirements of science, and the classes of fact on which fresh observation must be brought to bear to secure its advance. Nor does this involve any impracticable course of study. Such knowledge as will fit a traveler for usefully participating in the progress of science is now placed within the reach of every one. The lustre of that energy and self-devotion which characterize the better class of explorers will not be dimmed by joining to it an amount of scientific training which will enable them to bring away from distant regions enlarged conceptions of other matters besides mere distance and direction. How great is the value to science of the observations of travelers endowed with a share of scientific instruction is testified by the labors of many living naturalists. In our days this is especially true; and I appeal to all who desire to promote the progress of geographical science as explorers, to prepare themselves for doing so efficiently, while they yet possess the vigor and physical powers that so much conduce to success in such pursuits.

## DIAMOND-CUTTING.[1]

By Dr. A. C. HAMLIN.

THE process of diamond-cutting is a very simple matter to those acquainted with the nature of the gem. To cut the facets, two stones are cemented on two sticks, and rubbed against each other until a facet is cut; then the position of one of the stones is changed, and another flat surface is cut. The process is thus continued until the gem is faceted all over. After the facets are cut, and a definite form given to the stone, the diamond is placed in the hands of the polisher, who fastens it in solder, and then holds it against a small steel disk revolving horizontally with a speed of 1,500 to 3,000 times a minute. This disk is moistened with oil mixed with diamond-powder, and one facet is polished at a time. Diamond-cutting proper is a rapid operation, but the polishing is slow and tedious. One cutter can generally furnish sufficient work for four or five polishers.

There are a number of forms adopted by the lapidaries for these gems, but the two principal ones are the brilliant and the rose. The former pattern, first practised in Europe in the seventeenth century, is by far the best adapted for calling forth the powers of the gem. The other form is of unknown antiquity, and has long been in use among the Hindoos. It affords the largest beams of light for the weight, but it lacks greatly in colored reflections when compared with the brilliant.

For the perfection of the rainbow-play of hues, it is essential that the facets of the superior and inferior parts of the stone should correspond in exact proportions, and stand at fixed distances, so as to multiply the reflections and refractions, and produce the colors of the

[1] From a work on "The Diamond," in the press of D. Appleton & Co.

prismatic spectrum. All limpid and white gems must be cut according to this rule, but with colored stones the case is different, for here perfection of color is to be attained, and brilliancy is a secondary consideration. Hence, a fine ruby or sapphire may be decidedly thin, and yet be a gem of great beauty and value.

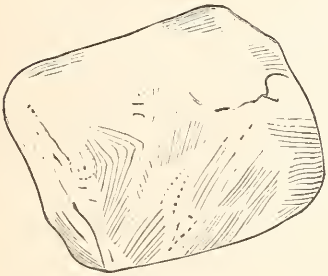


FIG. 1.—STEWART DIAMOND. Rough South African Crystal, weight, 288⅜ carats.

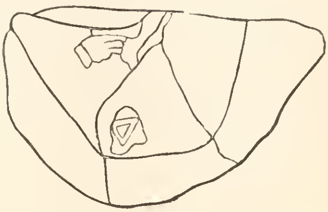


FIG. 2.—STAR OF THE SOUTH. Rough weight, 254½ carats.

The process of rifting diamonds by splitting them in their cleavage-planes was known long ago to the Hindoos, but was forgotten to modern lapidaries till revived by Wollaston not many years ago. By this means masses of the crystal may be removed to escape a flaw or remove a spot. Some diamonds of the spheroidal form are deficient

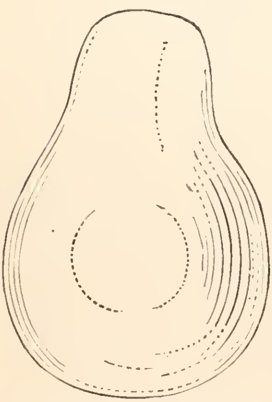


FIG. 3.—MATTAM DIAMOND, Borneo. Rough weight, 367 carats.

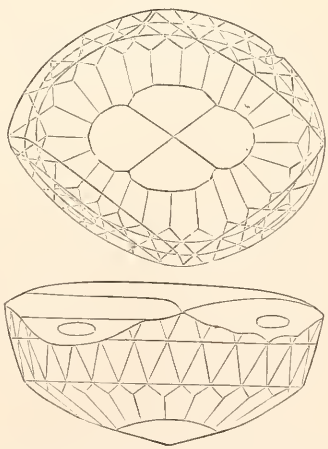


FIG. 4.—THE KOH-I-NOOR BEFORE RECUTTING.

in cleavage-planes, and are quite impracticable for cutting; others have a concentric arrangement of the planes of cleavage, as though crystallization radiated from the centre, and it is very difficult to polish them. The Hindoos avail themselves of the natural cleavage of the gem, and form table diamonds by adroitly striking along one of the planes with a sharp-edged tool, thereby separating the layers, as slate is rifted by the miner. This operation, which appears so simple, really requires considerable skill, and much of that acquired instinct or tact which is best exhibited by our Western Indians, who chip, with marvelous rapidity and certainty, a glass-bottle into symmetrical arrow-heads.

The workman at a glance ascertains the direction of the laminæ, and with another diamond cuts a notch at the point where he would begin operations. In this notch he places the edge of his blunt steel knife, and, by tapping the back of it with a light iron rod, he splits the diamond with perfect ease. In reducing the natural diamond to a regular form, much of its substance is lost, and sometimes as much as one-half the weight of the stone. The amount of loss, however, de-

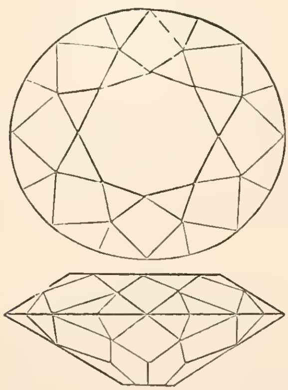


FIG. 5.—THE KOH-I-NOOR AFTER RECUTTING. Weight, 102½ carats.

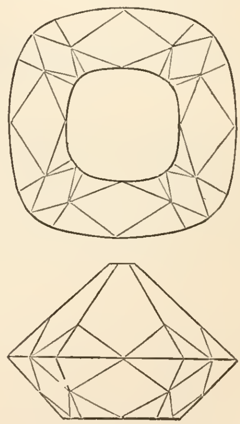


FIG. 6.—THE REGENT. Weight, 136 carats.

pends greatly on the natural form of the crystal. Perfect octahedrons lose but one-fifth of their weight when fashioned into brilliants, but rhombohedrons lose over one-third on taking the same form. The following figures will give some notion of the loss:

| | | |
|---|---|---|
| The Mogul weighed in the rough........................ | $780\frac{1}{2}$ | carats. |
| Reduced in cutting to.................................. | $279\frac{9}{16}$ | " |
| The Regent weighed 410 carats; reduced to ............ | $136\frac{14}{16}$ | " |
| The Koh-i-noor weighed $186\frac{1}{2}$ carats; reduced to......... | $102\frac{1}{2}$ | " |
| The Star of the South weighed $254\frac{1}{2}$ carats; reduced to .. | $124\frac{4}{16}$ | " |

The process of cutting diamonds of large size is always attended with risk, and is necessarily a costly operation. The Regent cost for cutting $25,000, and occupied two years' time. The Star of the South occupied only ninety days, and the Koh-i-noor only thirty-eight working-days. This great feat in diamond-cutting was performed by the ablest of the Dutch lapidaries, with the aid of steam-power. The cost of cutting is said to have been $40,000—reduced, however, to some extent by the sale of the fragments.

The process of diamond-cutting has within a few years been established in the United States. Mr. Henry D. Morse, a jeweler of Boston, conceived the idea of constructing a machine for cutting and polishing the gem. While engaged in perfecting his appliances,

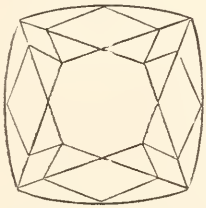


Fig. 7.—Proper Size of Brilliant Diamond, 100 carats, according to Jeffries's Scale.

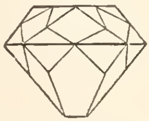


Fig. 8.—Form of the Brilliant-Cut.

chance threw in his way an itinerant vender of porcelain, who had once been employed as a workman in the diamond *ateliers* of Amsterdam. The sight of the rough gems and the apparatus recalled to the mind of the Jew the scenes of his youth, and awakened a desire to resume his former occupation, and he offered to do the work of a diamond-cutter. But, as the process was carefully considered, it was discovered that the Jew could only cut the facets of the diamond, and the art of the subsequent polishing he did not understand. It seemed strange that an artisan who possessed the rare ability to tell at a glance how large a gem the stone would cut, how to avoid internal imperfections, and how to take advantage of the cleavage-planes, could not polish the facets after he had cut them. But such was the fact, for the two processes of cutting and polishing are widely different, and require separate instruction. However, the deficiency was soon supplied by an acquaintance who was induced to leave Holland and act as polisher in the American diamond adventure. The establishment was now complete, but the business was at first confined to recutting and repolishing gems that had been damaged by long use or accident. The inventive genius of Mr. Morse made several important changes in the machinery required by the lapidary, and displaced the rude and cumbersome apparatus of the old system. At first but two or three men were employed, but, after the discovery of the South African diamond-mines, the rough gems soon furnished abundant material, and now several men and boys are constantly employed, with the aid of steam-power.

In consequence of the success of the South African diamonds, and the abundant supply of the stones, another *atelier* has been established in New York, under the direction of Mr. J. Hermann. A large amount of capital is said to be invested in this adventure, and employment is given to forty or more workmen, all Israelites, with the aid of steam-power. The establishment already boasts of having cut a fine crystal from South Africa, weighing eighty carats.

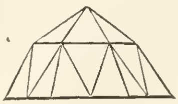


Fig. 9.—Form of the Rose-Cut.

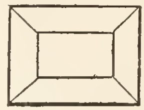


Fig. 10.—Form of the Table-Cut.

The process of cutting the diamond is divided by the Jews into several distinct branches, and workmen are educated to perform one part but not another. Thus the cleaving, the cutting, and the polishing, have special operators, who become expert in performing well the parts assigned to them, without attempting the others. This course has undoubtedly produced skillful workmen, but we see no reason why all the parts may not be perfectly acquired by an intelligent mechanic. The art of cleavage, however, requires tact, and ought to include some knowledge of mineralogy. For the particulars of the art of diamond-cutting, we will refer our readers to the interesting works of Jeffries, Mawe, and Barbot; still we briefly mention here some of the forms adopted for the diamond, and how they are produced.

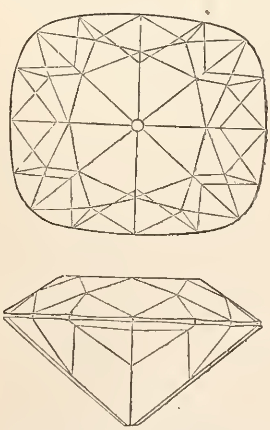


Fig. 11.—The Star of the South. Weight, $124\frac{1}{4}$ carats.

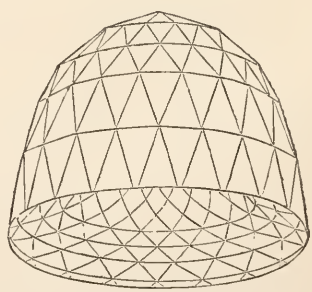


Fig. 12.—The Great Mogul. Weight, $279\frac{9}{16}$ carats.

The table and the rose patterns were the first regular forms adopted by the lapidaries. The first was simply the top of the stone ground flat, with a corresponding flat bottom of less area, with its four upper and lower sides parallel to each other. As the light passed through the stone without much refraction, the beauty of the mineral was not developed by this pattern. It has been stated that the rose-shape was invented in Paris, under the auspices of Cardinal Mazarin; but Tavernier describes the diamonds of Aurungzebe as being of the rose-cut. Therefore, we must give a more ancient date to the pattern than Mazarin's day. The form of the rose-cut is simply that of a hemisphere, covered with small facets. Its flattened base is therefore admirably adapted for incrustation-work, and the foil on which it is usually set serves as a reflector for the entering rays of light. The rose-pattern has several names, indicating the number of facets. If it has but twelve or less facets, it is called an Antwerp rose; if but eighteen or twenty, it is a semi-Holland; and a Holland rose, if it bears twenty-four facets. At the present time these gems are not in much demand, unless for incrustation-work, for which they are superior, both in effect and in adaptability to the surface of the object to be ornamented.

The form which appears to exhibit the splendors of the gem to the best advantage, is that known as the brilliant, and is rightly named from its effects. It was discovered in Italy, in the latter part of the seventeenth century, by Peruzzi, of Venice, which city was then one of the chief gem-marts of the world. The conclusions which led to the adoption of this shape were derived from experiments upon colored stones. This form of the brilliant is that of the ancient deep

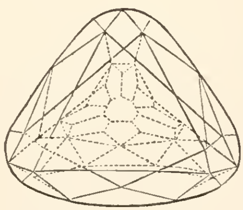


Fig. 13.—The Nassack. Weight, 78¾ carats.

table modified by receiving thirty-two facets above and twenty-four below its girdle. The great relative depth of the gem, aided by the numerous facets of the sides, appears to increase the natural refractive power of the stone by confining, as it were, the rays of light inside of it.

Another pattern, called the *brilliolette*, shows the beautiful qualities of the gem to great advantage. It is formed like two rose-diamonds joined together at the base; or may be flattened and elongated like an almond, and faceted all over with small facets. This is the form of the Saney, and should have been given to the Koh-i-noor and the Star of the South. The Austrian yellow diamond is of this pattern, and was probably cut in India. And it is thought that the famous twelve Mazarin diamonds were also cut after this pattern. The star-pattern, which was invented by Cane, is but little used at the present time.

# READING AS AN INTELLECTUAL PROCESS.

By E. O. VAILE.

LANGUAGE possesses a double imperfection. It is incomplete as an expression, as a product, as a symbol; it is imperfect, also, as a cause, as an excitant. It is inadequate both to perfect expression and to perfect impression. It fails to receive fully all that the mind would put upon it, neither does it faithfully deliver all which it fairly received. The soul, struggle as it will, cannot embody itself in form. Expression cannot equal conception. Language suffers this imperfection in common with every plastic art. To the great master how feeble must have seemed his glorious "Ninth Symphony" as an expression of that heavenly harmony which must have filled his soul! What forms and colors, beyond the powers of matter to present, must have possessed the spirit which produced "The Last Judgment!" So with the great masters of literature. To how little of what they must have felt and thought have they been able to give a "local habitation and a name!" And then, even at our best, what a feeble hold do we lay upon what they have bequeathed!

Now, this full interpretation and appreciation of an author, the perfect work of the apparatus which should take the impression, constitute reading of the highest order. In such reading perception becomes intuition, divination. It is not baffled by the inherent weakness of language, but feels that "more is meant than meets the ear."

Of course, reading of this kind assumes, to a large extent, equality of mental stature in author and reader. Indeed, it is quite true that, from a book, as from any work of art, we receive that only which is a reflex of ourselves, the counterpart of what we are. Words and sentences do not receive their interpretation from the writer alone. The reader himself becomes an unconscious author, loading the vehicle according to his own calibre and character. It is even a question to what extent great authors "have built better than they knew," so ingenious and profound have been their commentators. Lowell says: "Goethe wrote his 'Faust' in its earliest form without a thought of the deeper meaning which the exposition of an age of criticism was to find in it; without foremeaning it he had impersonated in Mephistopheles the genius of his century." Some one has said: "No man is the wiser for his books until he is above them." Milton expresses the same in "Paradise Regained," b. iv., line 322:

"... Who reads
Incessantly, and to his reading brings not
A spirit and judgment equal or superior,
(And what he brings what need he elsewhere seek?)
Uncertain and unsettled still remains,

> Deep versed in books, and shallow in himself,
> Crude or intoxicate, collecting toys,
> And trifles for choice matters, worth a sponge;
> As children gathering pebbles on the shore."

Notwithstanding their seeming inconsistency, these sentiments certainly contain a large portion of truth. It would be interesting to have the great poet's answer to his own parenthetical question. His devotion to books and his acquaintance with all literature and learning are a striking comment upon his query. Every *reader* must realize that the nearer his own intellectual grasp and sympathy coincide with his author's, the more nutriment he receives. Carlyle says, "We are all poets when we *read* a poem well."

In this reading well there is another element of very great importance, and exceedingly rare among ordinary people, not to speak of children. It is closely allied to the preceding. It is expressed in the phrase, "Reading between the lines." It is the perception of what is implied, as well as what is explicitly stated. It is the discovery, not of meanings purposely or carelessly hidden, but of thoughts which, in the highest symmetry and completeness, must have accompanied the one expressed. This power is needed in the proper reading of all good authors; but it is called forth most largely by our twin philosophers, Bacon and Shakespeare.

But there are elements more fundamental than these; so fundamental, in fact, that the thought seems seldom to occur to us that there can be any weakness in regard to them. The first of these, probably, is the knowledge of the meaning of words. How we obtain this knowledge is not so simple a question as it may seem.

We have a complete understanding of a term, when in our mind the association is so perfect between the arbitrary sign and the thing signified that the sign spontaneously suggests the thing. It is undoubtedly true that the first words addressed to a child are interpreted to him, and the idea fixed in his mind by the language of action and of circumstance which accompanies them. It is precisely the process by which a dog or a monkey is taught to perform its antics. The idea is associated directly with the phrase which strikes the ear, without a suspicion that there are any components, any words. The child's attention is engaged with complete propositions, and not with individual words; he grasps the whole, not realizing that there are parts. He hears you say, "Take care," "Come to mamma;" your actions and the circumstances associate the full thought with the proposition.

A process quite similar to this is employed by us largely through life. We get, and can get, the meaning of words to a great extent from their connections only. "Words are living things," says President Porter, "only when they are parts of the sentence. They cannot be fully understood except as seen in their connection." The power to appreciate these connections, to feel their force, is a valuable acquisition, and one in which our youth are sadly deficient. It is a power, for want of which no amount of use of the dictionary will compensate; it is most requisite where the dictionary is not thought of, and should not be, in cases where common words are used with modified or figurative meanings. The intellect is not so robust under our modern methods, as when every boy ciphered for himself, and overcame his difficulties as best he could. The power to grasp another's thought seems to have deteriorated with the other faculties. Now every thing has to be explained. The ability to see through good English without the aid of commentary, tone and inflection, seems to be a lost art in our schools. Recently a large class in one of the best high-schools in the country showed itself to be entirely unable to comprehend such sentences as these: "Words are the counters of wise men; the coin of fools." "Worth makes the man; the want of it the fellow." In such cases nothing will avail but the perfect appreciation of the words from their connections. I would not encourage the habit of "jumping at the idea," but I would encourage the habit of digging it out by main strength. There is such a thing as wrestling with a thought until it seems to unfold itself to our comprehension: and he is not worth much as a reader who does not know by experience what it is to grapple with a passage, and to hold on to it until light breaks from within it. Our education tends to shield us entirely from such contests. We are taught to hasten to the quarto oracle. When it fails to respond, we give up in despair. We do not learn the use of native strength; too much assistance has shorn us of our locks.

Although there is this important duty to be performed quite independent of the dictionary, it by no means lessens the value of that book. Because it is the custom to dilute thoughts until their vigor is gone, and to explain text-books until no thought is required to comprehend them, it does not follow that explanation is never of use. The old adage is simply to be recalled: "A place for every thing, and every thing in its place." There is a place for explanations and for definitions; but there is a larger place for active thought, for strong, unaided wrestling with the printed page, for a keen appreciation of the connections of words.

There is no guarantee of thorough scholarship and character so sure as the proper use and appreciation of the dictionary. It is an infallible omen as to the future of any boy or girl. The right habit is acquired only painfully and slowly. It represents a most high and valuable degree of self-discipline, as well as of intellectual activity. Much more can be, and should be, done for it in our upper schools than is accomplished. Any course of training is defective from which pupils pass without that appreciation for the dictionary and that interest in it which they feel for a worthy teacher, full of knowledge, always accessible, and ever in the best humor.

Asking questions is not necessarily a good thing. There must be reflection and an active use of the senses accompanying every inquiry of any value to the querist. And so it is in looking for definitions. To do this impulsively, and to be satisfied with synonyms, is not effective work. The element of thought and of association is wanting. Meanings thus acquired do not become a permanent acquisition: whereas thorough effort seldom allows the necessity of referring to a definition a second time.

The power to read well is also in proportion to the development of the power of association. This is a faculty in which we differ very greatly, and yet it is largely a matter of education. To one person a statement in physics will stand unsupported, until common facts are brought to his notice, while to another instances in support will flock unbidden from the household or the wayside. To some minds, passages in one author will spontaneously suggest passages in another; while other minds will fail to perceive the relation until accident or design brings it directly to their notice. It is true that memory is a large factor in this matter; but, independent of this, there is a readiness of association which may be acquired, and which is very essential. It is a quickness to levy on our own observation and experience when another's ideas are presented. Bacon advises, "Read to weigh and consider." When we do this, association is the most prominent faculty at work. In fact, according to our strength in this faculty we will weigh and consider. An author's sentiment will be flanked, as it were, on both sides, by phenomena from our experience to support or attack him. The degree of this faculty distinguishes the strong from the weak; the teacher from the learner; culture from crudeness. It means digestion, assimilation. It is in this faculty that genuine learning differs from mere memorizing; thorough acquisition from cramming. It vivifies knowledge; it is almost wisdom. This faculty is quite subject to cultivation, and no acquisition will so well repay the labor expended upon it. The attention is not given to it in our education which should be. To childhood and youth the different subjects of study stand as unrelated wholes. There is no interchange of thoughts and associations between different branches. An idea occurring in one subject does not bring up a closely-related idea in another subject. Pupils are not taught nor led to connect their knowledges. It is so by the force of circumstances. Every class-room has its own presiding genius which fellowships with no other. Every specialist tends to reproduce himself. Furthermore, there is a feeble association between what is learned from books and what is learned from practice. Life in the school-room and life out of it are separate existences. In the popular notion, book-learning is a sort of mystery, a peculiar power quite distinct from the common-sense and common experience of every-day life. The "connection of the physical sciences" has become a familiar idea. When shall we realize that there is a connection between all sciences and all knowledge, and that one truth really becomes ours only in proportion as it is surrounded and illuminated by other truths already ours? But, in spite of all untoward circumstances, the power of association in reading can be, and should be, trained carefully.

The power to read well depends, likewise, upon our power of perception, of mental perception; upon the readiness with which we discover the relation between ideas. The degree of this faculty, more than any other one thing, constitutes the difference between dull and sharp minds. Also, it seems to be, more than any other faculty, a native endowment. However, training will show here as plainly as elsewhere. Persons blindfolded have described the contents of rooms, the position of doors, windows, etc., with such accuracy that the credulous have attributed to them a superhuman power; whereas, their whole secret lay in the development of their perceptive faculties. Circumstances unnoticed by others gave them information and the power of inference. The same difference may be observed among readers. One person at a single reading will grasp the thought precisely as it was expressed; for another, even time and study are not sufficient to impress all the modifications and the exact form of the idea. Our Federal Constitution affords a good opportunity to test this power of perception in reading. "No person except a natural-born citizen, or a citizen of the United States at the time of the adoption of this Constitution, shall be eligible to the office of President; neither shall any person be eligible to that office who shall not have attained to the age of thirty-five years, and been fourteen years a resident within the United States." Upon once perusing this, a fair reader would instantly recognize the difference between the two classes of citizens spoken of, and also *consciously* notice that in the last line it is not "citizen," but "resident," and he will distinctly perceive the difference in the meaning of these words. But this is just what a vast number of those who ought to be good readers will not do. They will not perceive these distinctions until study or comment brings them to their attention. I say a good reader will *consciously* perceive these differences; he will think of them as he goes along: for many persons will retain in a physical chamber of the mind, as it were, an echo of the words, and repeat them *verbatim*, but these distinct ideas will not penetrate their consciousness. Submit to the average readers of Byron this line upon the Gladiator:

"... His manly brow
Consents to death, but conquers agony,"

and judge of the quickness and clearness of their perception.

A large part of the function of this faculty consists in the perception of analogies. Such is its chief office for the student of literature The feeling of likeness in one way or another is the foundation of all similes and metaphors, which make up so large a part of language. Here perception largely depends upon the power of reflection. Weakness often comes from neglect, or inability to hold the mind steadily to the thought. If you would be convinced of the general feebleness of perception of analogies and of their appreciation, experiment with a simple and beautiful couplet like this from Goldsmith:

> "To husband out life's taper at its close,
> And keep the flame from wasting by repose."

Or, this most perfect metaphor from Grattan on the failure of the Irish Government:

> "I sat by its cradle, I followed its hearse."

It is true that this power depends very largely upon maturity of mind and amount of experience. But it is the vigorous exercise of observation and perception, and not length of days, which gives maturity and experience.

Another faculty, and the foundation of all, upon which good reading depends, is the power of attention. Upon it directly depend the powers of association, of perception, and of memory. It is said that Sir Isaac Newton attributed his discoveries entirely to his habit of complete concentration of mind, and not to any superior quality of mind.

It is not a rare experience to most persons to find that they have read a passage, and yet that they are entirely unconscious of its contents. The physical man seems to have done its part perfectly; but the mind was employed upon other errands. Years are wasted before many of us discover that most of our ordinary reading is performed with not more than one-half of the mind, without real mental activity. There are persons who have been hard of hearing all their lives without realizing it, simply because experience has not given them an idea of a power more acute than their own. It is somewhat so in the matter of attention. It is rather a discovery to us when we first realize what may be accomplished by concentration of force; when we feel that attention is not passivity, but energy. It is a fortunate day for us when this awakening comes, and we begin the earnest endeavor to hold our mind to its work as though it were a truant school-boy.

We are told that we must appeal to curiosity to arouse this attention; that we must always read and study with interest. Good counsel, so far as it goes. But mere curiosity is quite inadequate to the great work of education. It may lead through "Nicholas Nickleby," but it rarely carries us through algebra or geometry. Something more reliable than a mere impulse is needed to make a strong mind. Back of all must stand a strong will, with the ability and disposition to use it. M. Marcel well says, "The great secret of education lies in exciting and directing the will." In later mental acquirements we realize the omnipotence of will. It is the want of this prime element which makes our attention so weak in the period of immaturity. In childhood, attention is a direct product of curiosity. As we grow older, curiosity is sated, and becomes weak as a motor. Nothing takes its place until we discover that attention is under the control of the will, and until, by perseverance, we acquire the power of thus controlling it. It is only then that we make rapid conquests, and that genuine mental discipline shows itself. There is no reason why it should be so late in life before this force becomes a substitute, as it were, for curiosity. From want of this mastery of the will over attention, the great majority of our youth close their school-life without realizing of what they are really capable.

Instead of aiding to impart this power, ordinary school-work does positively the reverse. Humdrum repetition is made a substitute for attention. By dint of drilling and memorizing, recitations are prepared, but without concentration of thought. Our children simply mark time; they do not advance. They know of no means of acquisition but "study," in the school-room sense. To them it is not quality of effort, but quantity. They can appreciate exertion only in the bulk. They know little of intensity of labor, or of its rewards. To them simple reading means a very feeble, unsatisfactory hold upon the matter read. With the mind only thus half awake, comprehension of the author is very feeble; and, as a consequence, we find substantial, profitable reading a dull exercise to many who, by their training, as we think, ought to find pleasure in it.

It is to be observed that just in proportion to the intensity of our mental action in grappling the thought, just to that extent does the language vanish from our view, and the thought only remain. The mind is not conscious of having seen words, but only of having perceived ideas. Any one must realize, upon reflection, that, when studying with a purpose of verbal reproduction, there is a diversion of effort from the thought. Ordinary memorizing, instead of aiding, is the direct enemy of thought. As we are impressed by the peculiarities of language, the vigor of the sentiment loses. The best reader, so far as seeing the author's mind is concerned, is the poorest proof-reader in regard to mere typographical errors—attention to the vehicle is so much withdrawn from the content. Hence, that study or reading is not entirely worthless which fails to give us the power to reproduce. The power of expression generally lags behind the power of thought. The slightest observation of a child will convince that he often thinks and feels what he cannot declare. Unquestionably there may be good ground for the remark, "I know, but cannot tell." He is to be pitied who, even in mature years, never finds his soul pregnant with a thought, while he feels that the words adequate to convey it are wanting. There may be mental perception without the power to reflect it. This is a dangerous fact with which to allow children to become impressed, because of the universal proneness to find refuge behind it from that wholesome effort at expression so essential to growth, and the clear apprehension of thought. For, without doubt, an idea is more firmly grasped and retained, and becomes negotiable only, by its clear enunciation. Generally speaking, "what we know, but cannot tell," is held by a very uncertain tenure. Thus, while the pupil should be urged to make his title good by the clear expression of his thought, he should realize that the most perfect reading fails to perceive the language consciously, or to retain it, leaving the thought disembodied, as it were, until the exigencies of communication require us to clothe it.

In connection with this matter of attention, the primary school affords abundant opportunity for remark. For instance, the habit of miscalling words. From what does it arise? Supposing the thought and language to be easily within the child's comprehension, it arises in this way: His attention has been exclusively occupied with individual words, in his struggle to master them He has failed to grasp the thought, or so much of the thought as he might have grasped up to the point of difficulty. Now, when circumstances bring the impulse to articulate a certain word, he is entirely unable to perceive whether or not the word coheres with what he has already uttered. In fact, he does not think, and cannot think, in regard to the sentiment of the sentence. His mind labors to recognize the words in their individual capacity only, and not at all in their connections. If he actually grasped the thought, although he might announce a word other than the one printed, still it would be impossible for him to announce a word which in the connection would be totally irrelevant or absurd. Now, in such a case, what is the teacher to do? To tell the child the word? To practically erase all the rest of the sentence, and to impress that individual form upon his mind? By no manner of means. This, however, is the universal practice; and from this practice partly results the abominable failure of our schools to teach our children to read fully and truly. It is the teacher's duty to get the child's mind on to the thought; to repeat the sentence, or to have it repeated, up to the point of difficulty, and to lead him by his own intellect to suggest a word, or the word, which will harmonize with the previous words. Indeed, he may not pronounce the word before his eyes, but, with any proper training, he will be far from suggesting a vocable which will present a solecism to his infantile perception. It is impossible to conceive of learning to read without miscalling words; but it is possible to conceive of a child's learning to read without pronouncing a word, among all his blunders, which his own powers are able to see is entirely absurd in the connection. Could that much be achieved, a great good would be done for us in after-life. One-half of the want of perception and attention which we now exhibit would be corrected.

Later in school-life teachers encounter this thing as a difficulty.

In "easy reading," children do not call the words printed, but others partly synonymous, or at least consistent. How is this to be looked at? It is a very trifling fault, so far as the real intellectual part of reading goes; the part we need in life, and which of all things should be taught. This fault, as it is called, is a good omen. You do not find the sluggards and the blockheads guilty of it. They continue the infantile fault first spoken of. This substitution of equivalent terms for those printed is done, and can be done, only by the bright, the active, the thoughtful. Observation will prove that this is invariably so. This fault teachers can well afford not only to tolerate, but to encourage. It indicates the presence of the only thing that is wanted—the clear grasping of the thought. It arises only because the pupil so fully comprehends that he is able by anticipation to supply a word for the author, if not *the* word. Such mistakes are worthy of remark, and, for the purpose of actually learning to read, there cannot be a better recitation than one made up entirely of such errors. Twenty reading-lessons devoted to this paraphrasing, and kindred work, to one of the ordinary kind of lessons, would work a wonderful change in the mental status of our children.

It is true, in the abstract, that words are the signs of ideas; but it is not true that the utterance of words by children is a sign that they possess the idea. We are taught in childhood upon the assumption that every sentence pronounced leaves its distinct and proper counterpart in our mind. None can know so well as teachers how far this is from being true; and how much more reliable as an indication of full mental perception, tone, inflection, emphasis, feature are, than the recital of the words. There is no fact which so loudly calls for the consideration of teachers as this—that the reading or reciting of words is a very uncertain sign that the idea is lodged in the child's mind. There is need for a new exercise and method in the teaching of reading; an exercise for teaching pure mental reading; a means of instruction in which things more reliable than words shall be taken as proof that the idea is grasped; a test of the accuracy of mental perception in which such unreliable evidence shall not be heard. There are devices which partly answer this purpose, but they cannot be described here.

If the real object to be aimed at in teaching reading were apprehended, there would be more use made of maxims, forms, riddles, etc. Every philosophic teacher must perceive their utility. They are of value only as a means of discipline; but there is nothing which so easily and strongly stimulates concentration of thought. They afford an opportunity to judge infallibly whether or not the learner clearly perceives. He is a rare child, indeed, who can read a pun, or any joke, to himself, and whose countenance will not promptly reveal to the slightest observation whether or not he "sees it." This cannot be said of ordinary sentences.

Furthermore, when wit does strike, it strikes with such effect, that the child himself cannot fail to discover whether he is hit or not; he cannot help but feel that he does or does not comprehend the idea. He may not be conscious that he does not clearly get an ordinary thought; but he can hardly remain so in regard to an epigram like this, upon a conceited person. He will either "see it," or know that he does not "see it:"

"The best speculation the market holds forth
To any enlightened lover of pelf,
Is to buy Tommy up at the price he is worth,
And sell him at that he puts on himself."

Or in regard to any of Lord Bacon's apothegms like this one. Dionysius gave no ear to the earnest suit of the philosopher Aristippus until the latter fell at the tyrant's feet. A by-stander afterward said to Aristippus, "You a philosopher, and to be so base as to throw yourself at the tyrant's feet to get a suit?" Aristippus answered, "The fault is not mine, but the fault is in Dionysius, who carries his ears in his feet."

What will so bring thought to a focus, and so develop the comprehension of words from their connections as a riddle like this from Dean Swift, and which Mr. Garvey, in his "Manual of Human Culture," mentions as an illustration upon this point:

"From heaven I fell, though from earth I begin;
No lady alive can show such a skin.
I'm bright as an angel, and light as a feather,
But heavy and dark when you squeeze me together.
Though candor and truth in my aspect I bear,
Yet many poor creatures I help to ensnare.
Though so much of heaven appears in my make,
The foulest impressions I easily take.
My parent and I produce one another,
The mother the daughter, and the daughter the mother."

Of course, such material, of which the active teacher will find abundance, must be used judiciously. The purpose must be to develop, not simply to entertain. Such specimens must be carefully adapted to the capacity of the class. Time must be given, and encouragement to "weigh and consider." Every contrast, comparison, and lurking sense, must be hunted out. No exercise in science or classics can equal this as a sharpener of the wits (to say nothing of wit). The child is made to realize what real comprehension is. He becomes familiar with the sensation which accompanies a clear perception, and is more sensitive to its absence when dealing with more ordinary thoughts. It is in this way that the study of Shakespeare, now being introduced into our high-schools, is going to do more for good common-sense in the comprehension and use of language, than all the grammar taught in a century. It must be observed that a valuable part of the study of Shakespeare is of the same nature as this of which I have been treating. The study of the poet is largely a process of simply unfreighting words; an exercise in obtaining impressions from language under unfavorable circumstances, but with every thing to stimulate and reward the effort. We cannot find him lowered to the comprehension of young minds, as we can this scattered wit and wisdom, or he would be a perfect substitute for it.

It is pertinent to ask how we know, how we become certain, that we correctly conceive the idea of a word or a sentence. The only answer which can be given is, that our judgment seems to rely upon the general symmetry of the whole thought, a harmony of parts, a connection through and through which satisfies the mind that it is right. The judgment may err here as well as elsewhere. The accuracy of this mental perception depends wholly upon the general power and activity of the reader. The great thing is, that the reader should obtain a clear, consistent, and reasonable idea, taking into consideration all the circumstances and connections.

But there is a thing which education can invariably secure, and that is a ready consciousness that we do or do not obtain a clear, coherent idea from what we read. It would be unreasonable to demand that education should give us the power to understand all that we read; but it is perfectly reasonable to demand that it should give us the power to discriminate quickly between what we understand and what we do not understand; that it should develop that kind of attention which notifies us at once when we fail to get or comprehend clearly an author's thought. The failure here is one of the saddest features connected with the subject of reading, and, indeed, with the whole matter of common-school education. From the lowest grades to the highest our children read, learn, and recite passages, without comprehending them, and, what is far worse, without realizing their want of comprehension. Any close observer and questioner can satisfy himself of this by a short visit to the school of his own district. This is an unpardonable weakness in the methods of instruction. It is a shame, and there can be no defense for it. From every thing that he reads or learns, the child can, and should get, not necessarily a correct idea, but an idea intelligible and coherent according to his powers; or else he should be perfectly conscious that he gets no such idea.

It has become chronic with college presidents, professors, and examiners generally, to complain of the inability of our youth to speak and write the language. If these wise men were as wise as they ought to be, they would discover that they have not yet reached the fundamental evil. They must probe deeper if they would reach the bottom. The foundation of the trouble lies in the want of ability, or rather in the want of the habit of understanding language fully.

In spite of all our systematic education, there is a fearful lack of accurate comprehension of good English; and this ever underlies the defect of expression. Of all the young men of whom the complaint is so justly made, I do not believe there is one to be found who has the faculties well developed which are necessary to a good reader. The primary fault is not to be found in the instruction in composition, but in the instruction in reading, and this last includes every subject in which the pupil has a book to use. Show me a person who is a good reader in the real sense of the term, one who has a strong power of attention, quick perception, active association, and other requisites to a fair mental reader, and I will show you a person who will not come far short of reasonable demands in his composition. The one follows the other naturally and invariably. This statement will be fully supported by any class after six months of faithful study of the English classics.

Of this want of comprehension there are several sources which are unwittingly fostered:

1. While children, we are compelled to study and read over and over again the same lessons. The mastery of words is made the end and the only end, in the view of both teacher and pupil, instead of remaining to each as a means only, a subordinate matter. Curiosity, at that age the natural governor of attention, is destroyed; and nine-tenths of our task-reading is performed with an indifference and weakness of thought which do not deserve the name of reading. This will continue so until the reading-matter put into our schools is greatly increased in variety and amount. Rarely, and only at long intervals, should a lesson be read more than once. The habit of seeming to read, of performing the physical part, while the mental faculties lie as dead, is easily formed. But it should be resisted. The problem before the primary teacher is this: To keep firmly fixed in the child's mind that the chief thing is the idea, while at the same time he is duly impressed with forms and words. Not only must the tongue utter, but the spirit must *see* what we read.

2. Also, in childhood we are allowed or required to read what we do not understand. A common illustration of one form of this evil occurred recently in the closing exercises of a first-class normal school. The pupil-teacher was to exhibit her power by means of a lesson in writing to a large class of bright boys about seven years of age. She had placed upon the black-board, as her copy, those four familiar lines—

> "Work while you work,
> Play while you play," etc.

The writing was certainly most admirable; but the inquiries of the lady-principal revealed the fact that the children had not the least conception of the first two lines. Most, indeed, seemed not to have thought any thing about the meaning. This is a sample, taken, however, from normal training, of the vast number of ways in which as children we are permitted or required to handle words without associating any meaning with them. The same may be seen in the thoughtless singing of our Sabbath-schools. Thus words become the only things which we think of; and we lose the feelings which accompany clear comprehension, or the want of comprehension. Accustomed to a dull tool, we lose the consciousness that it is dull. But let us rarely have a dull one in our hands, and how intolerable it seems to work with it! Blunt our keen perceptions upon things which we do not or cannot penetrate, and we become insensible to the fact that our instrument is dull, and fails to perform its proper work. It is better, by all means, that the child should attach wrong ideas to all he reads, than that he should form the habit of reading without attaching any ideas. Let any friend of education look upon the stolidity of the average product of our schools, which comes from this mechanical, absolutely thoughtless reading, and he cannot but feel that we are producing a large amount of artificial stupidity. I do not say that pupils should *never* be required to read or learn what they do not comprehend; but I do say that such should never be the requisition so long as they are in danger of falling into the habit of which I speak, nor until they have the habit of reading with the distinct realization that they do comprehend or that they do not.

3. I have said that the power of expression is possible only after a proper development of the capacity to receive impressions. The power and the habit of conveying thought will follow as a consequence of, and in proportion to, the power and the habit of receiving thought. This plainly indicates the plan which should be adopted by any rational system of primary instruction in reading. As a matter of fact, however, the universal practice of teachers is in direct opposition to this principle. It is assumed on all hands that the practice of reading can have no other object than to impart elocutionary skill; to cultivate the power of oral expression. The great question which governs the method in this branch is not, Do we understand others? but, How to make others understand us. It is taken for granted that distinctness of articulation, correctness of inflection, etc., surely indicate the presence of the thought within. Pupils are drilled almost daily in reading from the time they are six until they are sixteen, and yet they cannot read. They pass over that which to them is intelligible and that which is not intelligible alike, without the least discrimination. Words, words merely, are their only currency. Professors of elocution, and teachers of reading, do not impart the power we need. They teach us an accomplishment, but neglect our necessity. They make oral reading a high and important end, while it is simply a means, and should so be used. Our children are taught as though a large portion of their existence were to be spent in reading aloud; whereas, probably not one-fiftieth of all the reading done by people in ordinary circumstances is of that kind. For most of us, it is our intellectual busi-

ness in life to understand, to receive, to unload, as it were, that which others have put aboard. At least ability in this line is what we need infinitely more than the mere art of conveying thought. The number is comparatively small of those who are called upon to create, to body forth the soul either as orators or writers. The truth is, within the proper and legitimate sphere of school-reading, the cultivation of the organs of speech should be strictly subordinate to the great end of acquiring and retaining thoughts. The voice and ear have just that kind of work to do, and no other, which is performed by the gauge upon the steam-boiler, viz., to afford a means of judging of the condition of things within—the one of the pressure of steam, the other of the clearness and coherence of ideas. The paramount object in learning to read is to acquire the power of obtaining from the printed page, and by means of the eye only, ideas clearly and quickly. This should be the foremost thing with every teacher. Tone, emphasis, inflection, and general expression are, or should be, only the test-marks to indicate to the teacher whether or not the thought as presented by the printed words is fairly lodged in the mind of the learner. This perfectly subsidiary character of oral reading and the actual comprehension of the thought are almost entirely lost sight of. The subject is taught as a fine art, an art of expression only, the same as music, instead of the art of soul-perceptions, the art of seeing and feeling ideas and sentiments.

Such are some of the faculties which need attention in making good readers, and some existing faults which need correction.

## THE DEEPER HARMONIES OF SCIENCE AND RELIGION.[1]

### IV.

AT the outset I drew a distinction between theology and religion. Theology I considered to be the intellectual or scientific knowledge of God, religion the imaginative or sympathetic knowledge of him. After examining, then, to what extent theology is modified by the omission of the supernatural source of knowledge, after showing that it is in no way destroyed, since it has always been of the essence of theology to inquire what is the relation of the universe to human ideals—and this inquiry remains legitimate, necessary, and all-important, whether we appeal to natural or supernatural evidence—I pass on to consider the modification produced by the same omission in religion. With what *feelings* should we regard God contemplated only in Nature?

It will be evident, from what was said at the close of the last chapter, that the common impressions about the worship of Nature are

[1] From a series of papers, in *Macmillan's Magazine*, on "Natural Religion."

quite mistaken. It is vaguely imagined that the worship of Nature is neither more nor less than classical paganism, and that to adopt it would be to revive the "golden years" Shelley sings of, to substitute a *Madre Natura* for the Christian Church, and Pan or Apollo for Christ. This is a misconception of precisely the same sort as that which regards Nature as pitiless and inhuman. Let us always remember that Nature, as we are using that most ambiguous of words, is opposed simply to the supernatural. Sometimes, as I pointed out, it is opposed to man. When paganism is said to be a worship of Nature, the word is used in a third sense, and one somewhat indeterminate. It is opposed rather to civilization. Paganism did not confine itself to the worship of inanimate Nature. It deified, to be sure, the sun and moon, the sky, the morning and evening star, and all the principal phenomena of inanimate Nature. But it worshiped also certain deities who were supposed to preside over human life, powers of birth, marriage, and death, protectors of tribes and cities, powers of war and commerce, powers of the human mind. When we call it Nature-worship, therefore, we are not using the word Nature simply as opposed to man. But it so happened, we may say quite accidentally, that in its worship of the phenomena of man paganism paused abruptly. The worshiping disposition in the ancient nations decayed as society advanced; they ceased to increase their Pantheon as human phenomena became known to them. The consequence is, that the deities that have to do with human life in paganism concern only what is most elementary and primitive in human life. To people in the tribal stage paganism would have seemed to embrace the whole of humanity as well as inanimate Nature. But when nations had left that stage far behind them, when they had devised complicated politics, and invented arts and sciences, paganism still remained in its old condition. It did not progress, and in the last ages of the ancient world the traditional religions reflected the image of a much simpler time. This in reality deprived them of all influence except with the rural population, but at the same time it gave them a charm to all those who were influenced by that reaction against civilization and progress which is always going on. The same charm is felt by us when we look back upon paganism. When we see statues of Pan or Faunus, when we read Homer, we feel the fascination of *naïveté* and simplicity. And to express what we feel we fall back upon the unfortunate and overworked word Nature. We say these old pagans worshiped Nature, meaning apparently to say that their thoughts and feelings had not been much modified by the influence of thinkers, inventors, systematizers, that in fact their minds were in a childlike state, and had the freshness and joyousness of childhood.

Evidently Nature here is not in any way opposed to the supernatural. The supernatural could not enter into any creed more than it entered into the creeds of these so-called worshipers of Nature.

And, if the supernatural were omitted from our present creeds, the residuum would not be classical paganism. It would be something like what paganism would have been if religious feeling had not been weakened by the growing complication of human life. Had men's minds continued as religious in the age of Aristotle as they were in the days of Homer, it is not difficult to see how paganism would have developed. The great product of civilization is the development in men's minds of the feeling of justice, duty, and self-sacrifice. These new feelings, then, would have embodied themselves in new deities, or new conceptions of old ones. Paganism in developing would have become moral, and so would have lost all the charm which the moderns, tired of morality, find in it. And in doing so it would not necessarily have given more weight to the supernatural, and might easily have given less. Notions of duty and morality have no necessary connection with the supernatural. The worship of God in Nature, therefore, the worship of the Being revealed to us by science, would not be a religion without morality, because, however science may repudiate the supernatural, it cannot repudiate the law of duty. To human beings that have reached a certain social stage, duty is a thing quite as real as the sun and stars, and exciting much deeper feelings. In the sense in which we are using the word, duty is a part of Nature. The worship of Nature, therefore, would be no paganism. It would not be mere animal happiness or æsthetic enjoyment of beauty. It would be far more like Christianity. It would be mainly concerned with questions of right and wrong; it would be in almost as much danger as Christianity of running into excesses of introspection and asceticism.

But, now that we are on our guard against this misconception, let us go somewhat further back to inquire what the religion of God in Nature will be. The word religion is commonly and conveniently appropriated to the feelings with which we regard God. But those feelings—love, awe, admiration, which together make up religion—are felt in various combinations for human beings, and even for inanimate objects. It is not exclusively but only *par excellence* that religion is directed toward God. When feelings of admiration are very strong, they find vent in some act; when they are strong and at the same time serious and permanent, they express themselves in recurring acts, and hence arise ritual and liturgy, and whatever the multitude identifies with religion. But, without ritual, religion may exist in its elementary state, and this elementary state of religion is what may be described as *habitual and permanent admiration.*

Religious feeling readily connects itself with the supernatural—"Gern wohnt er unter Feen, Talismanen"[1]—but, at the same time, religious feeling can restrain itself, and sometimes even deliberately chooses to restrain itself from all associations of the kind. According-

[1] Loves to dwell amid fairies and talismans.

ingly, whatever the principal object of religious feeling in a particular case may be, of that object there springs up a natural religion and also a supernatural religion. There have been two classes of religions which have been conspicuous by their difference in the history of mankind. On the one hand, there have been the religions which have found their objects of worship principally in the sensible world, in physical phenomena, and in man considered as a physical phenomenon. On the other hand, there are the religions which contemplate more what is intellectual and moral. The best example of the former class is classical paganism, which, as I pointed out, was arrested in its development at the moment when it began to embrace the moral world; to the other class belong Judaism and Christianity. Now, both these forms of religion may be found connected with the supernatural and also unconnected with it. Classical paganism itself was a supernatural religion. The feelings excited in the Greek by the sight of a tree or a fountain did not end where they began, in admiration, delight, and love; they passed on into miracle. The natural phenomenon was transformed into a marvelous quasi-human being. But the same feelings aroused in the mind of Wordsworth produced a new religion of Nature not less real or intense than that of the ancients, but unconnected with the supernatural. He worships trees and fountains and flowers for themselves and as they are; if his imagination at times plays with them, he does not mistake the play for earnest. The daisy, after all, is a *flower*, and it is as a flower that he likes best to worship it. "Let good men feel the soul of Nature and see things as they are." In like manner moral religion has taken two forms. Judaism and Christianity are to a certain extent supernatural religions, but rationalistic forms of both have sprung up in which it has been attempted to preserve the religious principle which is at the bottom of them, discarding the supernatural element with which it is mixed. The worship of humanity, which has been springing up in Europe since the middle of the last century, is in a like manner a religion of moral qualities divorced from the supernatural.

If religion really accepts the supernatural even when its object is only isolated physical phenomena or human beings, how much more so when its object is God, whether God be regarded as the Cause of the universe or as the universe itself considered as a unity! Our experience of a limited physical phenomenon may be some measure of its powers; the antecedent improbability of its transcending in a particular case the limit which our experience had led us to put upon our conception of it may be very great. But who can place any limits to Nature or to the universe? We may indeed require rigid proof of whatever transcends our experience, but it is not only Orientals who say that "with God all things are possible;" the most scientific men are the most willing to admit that our experience is no measure of Nature, and that it is mere ignorance to pronounce *a priori* any thing to be impossible. Accordingly, those religions which have had for their object the unity of the universe, or what we call, *par excellence*, God, as distinguished from gods many and lords many, have generally been most lavish of miracle. They have delighted to believe in whatever is most improbable, because by doing so they seemed to show how strongly they realized the greatness of their Divinity. *Credo quia impossibile* is a paradox specially belonging to the religion of God. But, on the other hand, there is nothing in this religion that requires the miraculous. Those who realize the infinity and eternity of Nature most, and who are most prepared to admit that nothing is impossible, may quite well believe at the same time that the laws of Nature are invariable, and may be as skeptical as the most narrow-minded slaves of experience about particular stories of miracle that come before them. Indeed, there is perceptible, both in Judaism and Christianity, along with the fullest and readiest belief in miracle, a certain contempt for those who attach much importance to such occasional exceptions to general law. Prophets and apostles and Christ himself believe one and all that God can and does, at his pleasure, suspend ordinary laws; they believe this as a matter of course, and with a kind of wonder that any one can doubt it; but they hold it rather as a matter of course than as a matter of much importance—though they may hold a particular suspension of law to be very important for the light it throws on the Divine will; and it is evident that the God of their worship is rather the God who habitually maintains his laws than the God who occasionally suspends them. As therefore we found that the physical religion which in paganism existed along with a belief in the supernatural appeared elsewhere divorced from it, and that the Christian religion of humanity reappeared in modern religions divorced from miracle, so we may expect to find somewhere a purely natural religion of God.

I have before asserted that modern science, however contemptuously it may reject the supernatural, has nevertheless both a theology and a God. It has a God because it believes in an Infinite and Eternal Being; it has a theology because it believes in the urgent necessity of obeying his laws and in the happiness that comes from doing so. Is it not equally true that it has or may have a religion? If religion be made of love, awe and admiration, is not Nature a proper object of these as well as of scientific study?

It will be said that the religion of God thus understood is intelligible enough, but has no character of its own by which it may be differenced from the physical and moral religions described above. When we admire a flower we are worshiping Nature, but this is paganism stripped of the supernatural, or Wordsworthianism. When we admire justice or self-sacrifice in any human being, we are again, after the explanation given above, worshiping Nature, but this is Christianity stripped of the supernatural, or the modern religion of humanity. Now, what third kind of religion can there be unless we introduce a third or supernatural order of beings? I answer that the natural religion of God, though closely connected with both of these religions, is nevertheless clearly distinct from them. Its material is certainly the same; it contemplates the same phenomena and no others, but it contemplates them in a different spirit and for a different purpose. The object which excites its admiration may be, as in the former case, a tree, a flower, the sky, or the sea, but the admiration, when aroused, goes beyond the object which aroused it, and fixes upon a great unity, more or less strongly realized, in which all things cohere. It is thus that the view which the man of science takes of any natural object differs from that taken by an uneducated man. The admiration of the latter is, as it were, pagan. It ends in the particular form and color before it. It sees nothing in the object but the object itself. But the eye of science passes entirely beyond the object and sees the law that works in it; instead of the individual it sees the kind, and beyond the kind it sees higher unities in endless scale. What it admires is also in a sense Nature, but it is not Nature as a collective name for natural things, but Nature as the unity of natural things, or, in other words, God. Similar, with feelings less distinct but probably stronger, is the contemplation of Nature in ancient Hebrew poetry, which, when it surveys the great phenomena of the world, instead of considering each by itself in succession, instinctively collects them under a transcendent unity. Instead of saying, "How spacious the floor of ocean, how stately the march of the clouds across heaven, how winged the flight of the wind!" the Hebrew poet says, "*Who* layeth the beams of his chambers in the waters, *who* maketh the clouds his chariot, and walketh upon the wings of the wind."

We see, then, that human admiration, when it organizes itself in religion, may take three forms and not two only. Not only may it fix itself almost exclusively upon sensible phenomena and become paganism, or turn away from the sensible world to contemplate moral qualities as in Christianity, but also it may fix itself not upon the phenomena themselves, but upon a unity of them. The simplest form of this religion of unity is, I suppose, Mohammedanism, which not only contemplates a unity of the world, but takes scarcely any interest in the phenomena themselves, the unity of which it contemplates. Lost in the idea of the greatness of God, it loses its interest in the visible evidences of his greatness; but in most cases this religion of unity is combined with one or both of the other religions. The unity worshiped is not an abstract unity, but a unity either of the physical or of the moral world, or of both. In paganism the physical world is not worshiped simply for itself, but a feeble attempt is made to establish some unity among its phenomena by setting up a supreme Jove over the multitude of deities. In the moral religions the tendency to unity is still stronger, so much so that it may seem wrong to class, as we have done, Judaism and Christianity among religions of humanity rather than religions of God. They are, in fact, both at once, and the former at least is primarily a religion of God, and only secondarily a religion of humanity. It is because the worship of humanity in them, rather than the worship of Deity, determines their specific character, because they conceive Deity itself as a transcendent humanity, or as united with humanity; it is not because Deity plays a less, but because humanity plays a *more* prominent part in them, that I have chosen to name them rather from humanity than from Deity.

When, therefore, modern systematizers, in endeavoring to organize a religion which should exclude the supernatural, have extracted out of Christianity a religion of humanity, and have rejected as obsolete whatever in it had relation to Deity, they have not been wrong in taking what they have taken, though wrong in leaving what they have left. Deity is found in other religions besides Christianity, and in some religions, e. g., in Islamism, is not a whit less prominent than in Christianity; what is characteristic of the Christian system is its worship of humanity. How great a mistake, nevertheless, is made when it is supposed that Deity ought to be removed out of our religious systems, or that the rejection of supernaturalism in any way involves the dethronement of Deity or the transference to any other object of the unique devotion due to him, I shall show immediately; but what I have said about those inferior forms of religion which have not God for their object suggests another observation before we pass to consider the religion of God.

## SKETCH OF PRINCIPAL DAWSON.

JOHN WILLIAM DAWSON was born at Pictou, Nova Scotia, in 1820. He received his early academic training in the College of Pictou. Here, in addition to the regular course of study, he investigated with great success the natural history of his native province, thus early manifesting a taste for original scientific inquiry.

Having finished his course at Pictou, he entered the University of Edinburgh. After a winter's study he returned to Nova Scotia, and devoted himself with ardor to geological research. He was the companion of Sir Charles Lyell during his tour in Nova Scotia, in 1842.

In the autumn of 1846 he returned to the University of Edinburgh, his special objects of study being now practical chemistry and other subjects, of which he had found the necessity in the original work in which he was engaged.

In 1850 he was appointed Superintendent of Education for Nova Scotia. This office he held for three years, and rendered valuable service to that province at a time of special interest in the history of its schools and educational institutions. He also took an active part in the establishment of a normal school in Nova Scotia, and in the regulation of the affairs of the University of New Brunswick, as a member of the commission appointed by Sir Edmund Head for the purpose.

In 1855 he was called to the position which he still holds, that of Principal and Professor of Natural History in McGill College and University, an institution which, situated in Montreal, the commercial capital of Canada, draws its students from all parts of the Dominion. The university has prospered under his wise and liberal management beyond the most sanguine expectations of its friends and promoters.

The raising of McGill College to its present position would have been work enough in itself for these years, but in addition to this Dr. Dawson has had under his care the Protestant Normal School. From his position there he has had a great deal to do with the moulding and controlling of the school system of the country. After many years' faithful work, he withdrew (in 1870) from this office.

His special work in connection with the university and the normal school took up much of that time which would have otherwise have been devoted to original investigations in his favorite science.

A review of his more important scientific labors will show us how much may be done even in the midst of engrossing educational occupations. As early as 1830 Dr. Dawson began to make collections of the fossil plants of the Nova Scotia coal formation. In 1841 he contributed to the Wernerian Society of Edinburgh his first scientific paper, on the species of field-mice found in Nova Scotia. In 1843 he communicated a paper on the rocks of Eastern Nova Scotia to the Geological Society of London; this was followed in 1844 by a paper on the newer coal formation. In 1845, besides exploring and reporting on the iron-mines of Londonderry, Nova Scotia, he published a paper on the coal fossils of that province.

During the winter of 1846–'47, while studying in Edinburgh, he contributed to the Royal Society of that city papers on the "Formation of Gypsum," and on the "Bowlder Formation," and an article to Jameson's *Edinburgh Philosophical Journal*, on the "Renewal of Forests destroyed by Fire." The facts embodied in the last were subsequently employed by him in combating the exaggerated periods of time assigned to such changes by European geologists.

From 1847 to 1849 we find him, with the same never-flagging zeal, pursuing his geological researches, and giving the results to the world in frequent papers. The most important of these are: 1. "On the Triassic Red Sandstones of Nova Scotia and Prince Edward Island;" 2. "On the Coloring Matters of Red Sandstones;" 3. "On Erect Calamites found near Pictou;" 4. "On the Metamorphic Rocks of Nova Scotia." He also published his "Handbook of the Geography and Natural History of Nova Scotia," and delivered courses of lectures on natural history and geology in the Pictou Academy, and in Dalhousie College, Halifax, and reported to the Nova Scotia Government on the coal-fields of Southern Cape Breton.

In 1852, in company with Sir Charles Lyell, he made a reëxamination of the Joggins section, and visited the remarkable deposit of Albertite at Hillsborough, New Brunswick. A paper soon appeared on the Joggins section, giving a more full exposition than any previous one of the structure and mode of formation of a coal-field. The Albert Mine was also made the subject of a paper. In the further study of the Joggins section, microscopic examinations were made of coal from all its beds, as well as of coal from other sources, the results being published in papers on the "Structures in Coal," and on the "Mode of Accumulation of Coal."

It was during the visit to the Joggins, just referred to, that the remains of *Dendrerpeton Acadianum* and *Pupa vetusta* were found. With the exception of *Baphetes planiceps*, which Dr. Dawson had discovered the year previous at Pictou, but not described, *Dendrerpeton Acadianum* was the first reptile found in the coal formation of America, while *Pupa vetusta* was the first known Palæozoic land-snail. These discoveries were followed by the finding and describing of several other reptiles, and of the first carboniferous millipede (*Xylobius sigillariæ*). About this time, also, a second report on the Acadia mines was prepared, and an elaborate series of assays of coal made for the General Mining Association.

In 1855 he published the first edition of his "Acadian Geology." In 1856, though now trammeled by the arduous duties incumbent upon the principal of a university, he still continued his geological work in his native province, and prepared a description of the Silurian and Devonian rocks. During the same summer he visited Lake Superior, and wrote a paper and report on the copper-regions of Mamainse and Georgian Bay.

In the two following years he made a number of contributions to the *Canadian Naturalist* and the *Journal of the Geological Society*, and commenced the study of the Post-pliocene deposits of Canada. In 1859 his "Archaia," or studies of creation in Genesis, appeared, a work showing not only a thorough knowledge of natural history, but also considerable familiarity with the Hebrew language.

In 1860 Dr. Dawson issued a supplementary chapter to his "Acadian Geology." He also continued his work in fossil botany, and in the Post-pliocene, publishing several papers on these subjects, as well as desultory researches on such subjects as the "Flora of Mount Washington," "Indian Antiquities at Montreal," "Marine Animals of the St. Lawrence," "Earthquakes in Canada," "Classification of Animals," etc.

In 1863 he issued his "Air-Breathers of the Coal Formation," a complete account of the fossil reptiles and other land animals of the coal of Nova Scotia. This publication was followed, in 1864, by a "Handbook of Scientific Agriculture." It was in 1864, moreover, that Dr. Dawson made what may be considered as one of the most important of his scientific discoveries—that of *Eozoon Canadense.* Previous to this the rocks of the Laurentian age were looked upon as devoid of animal remains, and called "Azoic."

In 1865 Dr. Dawson, at the meeting of the British Association at Birmingham, gave illustrations of his researches on the "Succession of Palæozoic Floras," the "Post-pliocene of Canada," and the "Structure of Eozoon."

While in England, in 1870, Dr. Dawson lectured at the Royal Institution. He also read a paper on the "Affinities of Coal Plants" before the Geological Society, and one on the "Devonian Flora" before the Royal Society. The same year his "Handbook of Canadian Zoölogy" appeared, being followed in 1871 by a "Report on the Silurian and Devonian Flora of Canada," and a "Report on the Geological Structure of Prince Edward Island." His studies of the Devonian plants were begun as early as 1858, and Gaspé, St. John's, and Perry in Maine, were twice visited in order to collect material to aid in their pursuance.

His "Notes on the Post-pliocene of Canada" were published in 1873. From them we learn that the number of known species of Post-pliocene fossils had been raised principally by his labors from about thirty to over two hundred. We also find that Dr. Dawson is still what he has always been, a stanch opponent to the theory of general land glaciation. "The Story of the Earth and Man," issued last year, was a republication of papers published in the *Leisure Hour* in 1871 and 1872. A report on the "Fossil Flora of the Lower Carboniferous Coal Measures of Canada," and communications to the British Geological Society on the probable Permian age of beds overlying the coal-measures of Nova Scotia, and also occurring in Prince Edward Island, and on recent facts as to the mode of occurrence of Eozoon in the Laurentian rocks, are still more recent labors. A course of six lectures delivered in New York in the winter of 1874–'75 has been largely circulated both in America and England, under the title "Science and the Bible;" and last fall there appeared in London and New York a popular illustrated *résumé* of the facts relating to Eozoon and other ancient fossils, entitled "The Dawn of Life." At the Detroit meeting of the American Association, Prof. Dawson, as Vice-President of Section B, delivered an address in which he vigorously combated the doctrine of evolution.

Dr. Dawson was elected a Fellow of the Geological Society of London in 1854, and of the Royal Society in 1862. He is a Master of Arts of Edinburgh, and Doctor of Laws of McGill; and is an honorary or corresponding member of many of the scientific societies on both sides of the Atlantic.

# EDITOR'S TABLE.

### *THE NATION ON "GERMAN DARWINISM."*

SOME months ago a correspondent asked the *Nation* what were the best books to read on the theory of evolution. It replied, and seized the occasion to draw a contrast unfavorable to Herbert Spencer, whose books on that subject, it took pains to say, it did *not* recommend. In a more recent review of two books under the title of "German Darwinism," the same writer came forward and reaffirmed the positions of the former article, amplified the discussion, and continued to refer to Mr. Spencer in terms of contemptuous disparagement. More recently, in a eulogistic sketch of the character of the late Chauncey Wright, of Cambridge, the *Nation* recognizes him as the "great mind" of the town, and informs us that he was the author of the article on "German Darwinism." This was no news to many. A few years ago it was quietly given out from Cambridge that the pretensions of Mr. Spencer were to be once for all disposed of by Chauncey Wright, who would do the work in the *North American Review*. The onslaught was made, but, from divers indications, both at home and abroad, it seems to have failed of its intended effect. But Mr. Wright appears to have regarded it as his permanent function to put down this philosopher, and accordingly the last literary act of his life was another attempt to demolish him. It looks almost like a Cambridge fashion for its great men to die in their antipathies. The article on "German Darwinism," from its misleading character and its appearance in the *Nation*, was entitled to an answer; but this is still more necessary, now that its authorship is announced in connection with very high claims put forth for the author. It is still further provocative of reply, as, upon careful perusal, it will be found to throw very little light indeed upon "German Darwinism;" that topic being used mainly as a convenient means of reviving and repointing the writer's old charges against Spencer. We have no desire to pursue this topic; but, as long as such charges are conspicuously and authoritatively made, they must be answered.

Referring first to the most trivial, it is insinuated that the system of Mr. Spencer has a footing with "English-thinking readers" only; while in fact various of his works are translated into Italian, German, Hungarian, Dutch, Russian, and French, and nearly all of them into the latter languages. Several of the translations, moreover, have been made by eminent philosophical scholars, and it is fairly to be presumed that their continued reproduction in foreign countries is due to a demand for them.

In noticing Schmidt's German work on "Darwinism and Descent," the writer makes a point against Mr. Spencer by stating that he is nowhere named in it. Gegenbaur had done the same thing in his great work on "Comparative Anatomy," and he was reproached by Prof. Rolleston in the *Academy* for giving no account of Spencer's "Biology," which made his work defective. There are various reasons why the Germans have been slow to recognize Mr. Spencer's ideas. They are embodied in a "system of philosophy," and by philosophy the Germans understand only speculations like those of Kant, Hegel, and Schelling. They have no conception of a philosophy organized out of science, and their biologists do not dream of finding the development of species scientifically dealt with in a philosophical system. Understanding philosophy as the Germans do, and being wedded to their *a priori* system, they have habitually sneered at "English philosophy," and therefore pay little attention to its new books. Again, they are greatly given to titles of all orders, political, social, scientific. Every man is jealous of his distinctions—they glory in their "jewels five words long," as they have been called. Hence they think nothing of a man without scientific titles, and it is beyond their imagination that any one should refuse them. Mr. Spencer was, therefore, without due passports to German consideration. But against the fact that Schmidt has ignored him, we may put the fact that the translation of "First Principles" into German was made at the instigation of Darwin's chief German disciple, Haeckel, and was made by his assistant, Dr. Vetter.

Mr. Darwin is made out to be untheological by an exquisite bit of logic. It is true that he appeals to supernaturalism for the starting-point of his doctrine, and gives exactly the same account of it that theology has always offered, speaking of "life with its several powers having been originally breathed by the Creator into a few forms, or into one." But Mr. Darwin's science is saved by the charitable imputation that he used these words in a sort of Pickwickian or poetical sense, and was willing to conciliate the theologians by "a slight difference of style" in referring to the origin of life. But when to an extensive series of expository works, treating of the course of Nature by rigorous scientific method, Mr. Spencer prefixes an essay of a hundred and odd pages, to clear away religious difficulties and protect himself from the imputation of materialism, which was sure to be made against his scientific labors, there is neither kindly feeling to see the propriety of such a course, nor even a sense of justice to recognize the fact; but the whole system is declared to be theological in origin and character, because, forsooth, the author put theology aside at the outset of his undertaking.

We here touch upon the main source of misunderstanding of Mr. Spencer's system. The preliminary part which treats of religion is necessarily metaphysical. But Mr. Spencer does not regard religion as an illusion, nor metaphysics as necessarily futile. He holds that the order of the universe is not without its cause, although the nature of that cause is a mystery past finding out, and from the very nature of intelligence must forever transcend the human understanding. The infinite source of things is usually called God, and there are many who hold that man can have a knowledge of God as of other things; Mr. Spencer declines to use the current term; and, to mark his own sense of humility toward that infinite cause or power of which all phenomena are manifestations, he prefers employing the term The Unknowable. What is represented by it is not a negation or a nothing, but the most exalted object of religious feeling, though beyond the grasp and analysis of intellect. Having defined his ground in this preliminary dissertation, and shown that science deals with the phenomenal, while religion relates to that which transcends the phenomenal, so that there can be no radical or fundamental conflict between them, he then proceeds to his great work of organizing the highest and most certain knowledge attainable of the phenomenal universe into a system of philosophy. That system must be judged intrinsically, or on its own merits, as a coherent and consistent body of demonstrable and verifiable truth; yet his critics, from unscrupulous motives—resenting his assumption in undertaking so immense a task, or from incapacity—getting swamped among the factors of a great discussion, have a habit of representing him as basing his philosophical system on metaphysical speculations regarding the Unknowable, and as the author of an unknowable philosophy. The article on "German Darwinism" rings many changes on this gross misrepresentation.

The writer says that evolution is regarded by Darwin "as a theorem of natural history," while Mr. Spencer treats of evolution "as a philosophical thesis deductively, and as a part of a system of metaphysics;" and furthermore, "a system like Mr. Spencer's is obliged to stand on such positions," namely, "undemonstrated beliefs." Again, he says, "Evolution is, with Mr. Spencer, not a theorem of inductive science, but a necessary truth deduced from axioms." These statements—is it not almost needless to say it?—are altogether groundless. Mr. Spencer's system never could have taken the hold of the cultivated scientific mind of half a dozen nations in the present age, which it confessedly has, if the above characterization of it were true. Speaking of an important research of Mr. Spencer, the President of the Royal Society of London, when addressing the British Association, said: "I need dwell no further on it here than to quote it as an example of what may be done by an acute observer and experimentalist, versed in physics and chemistry, but above all thoroughly instructed in scientific methods." Testimony like this, that Mr. Spencer, whatever may be his shortcomings, is a master of scientific methods, might be accumulated to any extent. Is it probable or conceivable that a man so thoroughly equipped for their use should repudiate the sound and solid methods of science, and fly off into baseless speculation when dealing with the most comprehensive and important scientific problem of our time? The thing is absurd unless it is proved, and the author of "German Darwinism" stops with mere dogmatic assertion.

We aver, on the other hand, that the scope of Mr. Spencer's great argument for evolution is only equaled by the fidelity and completeness of his adherence throughout to the established canons of scientific inquiry, and his reputation as a master of true logical method is beyond doubt mainly due to his practical application of it in the construction of his system. In "First Principles" the law of evolution is placed upon the most comprehensive inductive basis; and, if we go back to the earlier enunciation of his views, we find the law propounded with no reference whatever to metaphysical speculations. The original form of the conception and the order of its development are seen in the essay on "Progress, its Law and Cause." There is here not a word of metaphysics, not a word implying the endeavor to derive the phenomena from the persistence of force, not a shadow of foundation for the alleged theologico-metaphysical origin of the doctrine. The first part of the essay is devoted entirely to establishing the induction, from all orders of phenomena, that every thing progresses in heterogeneity; and then, the induction having been established as universal, the second part of the essay is an inquiry into the dynamical law which determines it in all cases. This second part sets out thus: "And now from this uniformity of procedure may we not infer some fundamental necessity whence it results? May we not rationally seek for some all-pervading process of things? Does not the universality of the *law* imply a universal *cause?*" And then the course of the argument is, first, to show that the cause alleged, the multiplication of effects, affords a deductive interpretation of the induction previously established. Are we to be told that this is an illegitimate scientific procedure?

The author of "German Darwinism" pronounces Spencer unscientific and unbaconian, because he employs the deductive or *a priori* method. But is not that the method in which science finds its completion? Did it weaken the induction made by Mr. Spencer, to show that the facts are deducible from a general law in the redistributions of matter and motion? Was the induction made by Kepler respecting the laws of planetary motion weakened when Newton proved those laws to be deducible from the law of gravitation? If so, then truths are scientific only so long as they remain empirical generalizations, and become unscientific when they are reduced to the form of rational generalizations. In pursuance of this view we may say that, so long as the geometrical truth, that the square of the hypothenuse of a right-angled triangle is equal to the squares of the other two sides, is recognized as experimentally true, it constitutes a part of real science, but that it becomes metaphysical and worthless when it is shown to follow inevitably from necessary axioms and postulates. The strictures of the author of "German Darwinism," leveled at Spencer as an *a priori* thinker, thus spend their force against completeness of scientific method. The reproach cast upon him could have had no possible ground, if in elucidating the law of evolution Mr. Spencer had left it in the form of a generalization based upon all orders of phenomena—astronomical, geological, biological, psychological, and sociological—that is, if he had left the work half done. But when the law is explained, or when the universal course of transformation is shown to result from certain universal laws of physical action—laws which are themselves inductively established before they are deductively applied—then Mr. Spencer is to be discredited as a mere speculating metaphysician. It is now admitted as a principle—a universal principle—that force can neither come out of nothing nor disappear into nothing. It is "conserved," say some physicists; it "persists," says Mr. Spencer, and its persistence is an ultimate truth. The laws of physical action which result in evolution, undeniable as they severally are, are shown by Mr. Spencer to be all corollaries from this ultimate truth. They are established by induction, they are explained and verified by proving that they are consequences of a universal principle; therefore Mr. Spencer is metaphysical and unscientific.

The *Nation* declares that "there is nothing in Spencer's writing relating to what is really honored by men of science (namely, the scientific explanation of the origin of species) that is not to be credited either to Lamarck or Darwin." Lamarck is to be credited with the sagacious perception, and the courageous avowal, in opposition to Cuvier and the whole science of his time, of the doctrine of the variability of species, and the thinness of the partition between species and varieties. He saw many facts that led him to deny the Cuverian dogma of the fixity of species, and he had a strong conviction that their variation was in some way connected with surrounding conditions. That is, Lamarck has the great merit of having perceived the nature of the biological problem that was yet to be solved, but he can hardly be said to have entered upon its solution. Mr. Darwin is to be credited with the sagacious working out of one of the conditions of that problem, namely, the influence of natural selection in giving rise to the diversities of species. But the achievements of both Lamarck and Darwin only bring us to the threshold of the great general question of which they form a part. If their positions are held to be valid, they simply open the door to a new and immense scientific investigation which has for its object to determine the conditions, processes, and causes of evolution. That natural selection is not evolution, but only one of its elements, and that Mr. Darwin has never engaged in the investigation of evolution in its general principles as Science is bound to consider it, we have shown again and again in these pages. Mr. Spencer, therefore, undertook no illegitimate or superfluous task in devoting many years to evolutionary researches. If the work of Darwin and other biologists was not futile, the larger inquiry was imminent and lay straight in the path of progressive science. Mr. Spencer undertook it, and the language of the *Nation* implies that in his contributions to it there is nothing that is really honored by men of science. To this dictum we give a flat contradiction, and, if space allowed, we could weary our readers with the copious evidence that eminent men of science honor the work of Spencer by accepting his results as guides to their own investigations. Let one illustration suffice: Mr. Alfred Russel Wallace, one of the independent discoverers of the principle of natural selection, in his address as President of the Anthropological Society of London, in 1872, referred to a view propounded by Mr. Spencer on biological evolution as "one of the most ingenious and remarkable theories ever put forth on a question of natural history." Nor did he stop with turning a mere compliment. He went on to say: "More than six years ago Mr. Herbert Spencer published, in his 'Principles of Biology,' a view of the nature and origin of the Annulose type of animals, which goes to the very root of the whole question; and, if this view is a sound one, it must so materially affect the interpretation of all embryological and anatomical facts bearing on this great subject, that those who work in ignorance of it can hardly hope to arrive at true results. I propose, therefore, to lay before you a brief sketch of Mr. Spencer's theory, with the hope of calling attention to it and inducing some of you to take up what seems to me a most promising line of research." Of course there are plenty of scientific men who do not honor what Mr. Spencer has done and care little for what anybody has done outside of his own narrow specialties. Human nature works in scientific men, it must be confessed, much as it does in other people, and they often exhibit petty jealousies toward each other that are a scandal to the scientific character. That from timidity, prejudice, and lack of interest in general ideas, many of them should decline to honor a broad and independent thinker like Spencer, is not surprising. But all scientific men are not of this class.

We again affirm that the task which Mr. Spencer accepted, of investigating the general principles of evolution, was one that stood clearly in the pathway of Science, and was not to be escaped. He was the first to grasp the full breadth of its implications, the first to analyze it into its elements, the first to organize its varied facts into a coherent system, and make it the basis of a comprehensive philosophy of Nature. His "First Principles," containing the full exposition of the doctrine, has now been before the world thirteen years, and its essential positions have not yet been impugned. There has not been even an attempt to invalidate his proofs that the processes of universal change are from the homogeneous to the heterogeneous. There has never been even an attempt to invalidate his universal principle of the "Instability of the Homogeneous." There has not been even an attempt to invalidate the principle of the "Multiplication of Effects;" nor have his critics ever even tried to show that these great principles are not essential and fundamental factors of evolution; and until this is done they may as well hold their peace in regard to his claims as an original explorer in this field.

Finally, in his zeal to upset Spencer, the *Nation's* writer throws Bacon at his head, but he sadly misses his aim. It is now well understood that Bacon's attempt to lay down the rules of scientific pursuit was a signal failure. He tried his own rules in the investigation of heat, without discovering any thing about it; he was grossly inappreciative of the science and scientific men of his day, rejecting the Copernican system, and neglecting the immortal researches of Harvey. It will hardly be believed that the *Nation's* critic quotes against Spencer one of the most unfortunate passages that Bacon ever wrote: that in which he condemns the chemists of his day for philosophizing "from a few experiments of the furnace;" and disparages the work of the celebrated founder of the science of magnetism, Dr. Gilbert. Mr. Spencer can very well afford to be condemned with such company. Whatever weight, indeed, Bacon has as a philosopher must go into the other side of the scale. If he failed as a scientist, or in laying down the special rules of research, he did great service in calling men away from scholastic verbalism, and inciting them to the study of Nature; while there can be no doubt that he had great insight for comprehensive relations, and saw with the eye of prophetic genius the coming day when human knowledge would be so perfected and marshaled as to represent the unity and continuity of Nature. When Bacon is appealed to against Spencer, we say that if he had lived in our day, with the ripened sciences at command, it is not unlikely that he might have written "First Principles." At all events, if his eminent German interpreter, Dr. Hans Fischer, is to be trusted, his mind ran very much in the same direction of thought. In his work, "Francis Bacon of Verulam," Dr. Fischer says: "What in Bacon's sense is the proposed Fundamental Philosophy (*Philosophia Prima*)? The unity of all the sciences. Bacon seeks this unity by the method of analogy. Not on dialectical but on real grounds should the universal predicates of things (such as much and little, like and different, possible and impossible, essential and contingent, etc.) be determined." Again: "The very design of Bacon's analogies shows that he sought more than can be afforded by experience. He sought by this road what he could not discover by that of induction alone, namely, the unity of Nature as manifested in the affinity of all things, or the harmony of the universe."

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## LITERARY NOTICES.

Annual Report of the Board of Regents of the Smithsonian Institution, showing the Operations, Expenditures, and Condition of the Institution for the Year 1874. Washington: Government Printing-Office, 1875. Pp. 416.

We had occasion in the October number of The Popular Science Monthly to notice the last report of the Astronomer Royal of England, and to remark upon the great persistency with which "the fundamental idea" of the Royal Observatory had been followed out for forty years, and the great success which had attended its work.

We have a no less remarkable instance of the intelligent, careful, and devoted following out of a well-considered plan and of great success, in the case of our own Smithsonian Institution, under the direction of Prof. Henry and his most efficient seconders and collaborators. The Smithsonian Institution was founded by James Smithson of England, "for the increase and diffusion of knowledge among men." In the first annual report of the secretary (Prof. Henry), for 1846, a definite "plan of organization" was proposed, which has been adequate to all the conditions which then existed and which have since arisen.

It proposed in brief: "To increase Knowledge: 1. To stimulate men of talent to make original researches, by offering suitable rewards for memoirs containing new truths; and, 2. To appropriate annually a portion of the income for particular researches, under the direction of suitable persons. To diffuse Knowledge: 1. To publish a series of periodical reports on the progress of the different branches of knowledge; and, 2. To publish occasionally separate treatises on subjects of general interest." This plan has been devotedly carried out, and we propose to extract from Prof. Henry's report for 1874 enough to show in part how important and useful the work of the institution is, and how large a field it covers.

In direct compliance with the programme above given, the institution publishes three classes of works: *first*, the "Contributions to Knowledge" (quarto), which are memoirs "containing some positive addition to science resting on original research, and which are generally the result of investigations to which the institution has, in some way, rendered assistance;" *second*, the "Miscellaneous Collections" (octavo), which consist of works "intended to facilitate the study of branches of natural history, meteorology, etc., and are designed especially to induce individuals to engage in these studies as specialties;" *third*, the "Annual Reports" (octavo) contain, besides the accounts of the operations, expenditures, etc., "translations from works not generally accessible to American students, reports of lectures, abstracts of correspondence, etc." These are liberally distributed free of cost to public libraries, institutions, colleges, States, and Territories, in such a way, and under such conditions, as shall secure them to be most generally accessible and useful. No copyright has ever been secured on any of the publications of the Institution. They are left perfectly free to be used by the compilers of books and all other persons, on the express condition that due credit is to be given, not only to the author of the book, but to the Smithsonian Institution. This is eminently just, because in most cases the researches have been prosecuted with the aid of funds from the Smithson bequest. The publications for 1874 have been Volume XIX. of the "Contributions to Knowledge," which contains the results of three most important researches: 1. On Problems of Rotary Motion, by General J. G. Barnard, pp. 74. 2. On Fresh-water Algæ, by Prof. H. C. Wood, pp. 274, 21 colored plates. 3. Orbit and Tables of Uranus, by Prof. S. Newcomb, pp. 296.

Besides this, the eleventh and twelfth volumes of the "Miscellaneous Collections" have been issued, containing nine contributions: On the Families of Mammals and Fishes, by Dr. Theodore Gill; On the Diptera of North America, by H. Loew; Directions for collecting and preserving Insects, by Dr. Packard; two papers on Coleoptera, by Dr. John Le Conte; Review of American Birds, by Prof. Baird; On the Constants of Nature, Part I., boiling-points, specific gravities, etc., by Prof. Clarke (noticed in The Popular Science Monthly, August, 1874); and Rules for the Telegraphic Announcement of Astronomical Discoveries, by Prof. Henry. Several of the separate memoirs which will make up Volume XX. of the "Contributions to Knowledge" have already been printed and distributed: 1. On the General Integrals of Planetary Motion, by Prof. Newcomb; 2. On the Haidah Indians of Queen Charlotte Islands, by James G. Swan. At the time of making the report, there were *in the press*, and intended for the quarto publications: 1. The Antiquities of Tennessee, by Dr. Joseph Jones; 2. The Harmonies of the Solar System, by Prof. S. Alexander (noticed in The Popular Science Monthly for September, 1875); 3. The Winds of the Globe, by the late Prof. J. H. Coffin; 4. The Temperature-Tables of North America, by C. A. Schott. There were also *in the press* a monograph of American Wasps, by Prof. de Saussure, of Geneva, and a botanical index to all known American species of plants.

For many years the Smithsonian Institution had a large corps of volunteer meteorological observers distributed all over the United States, who forwarded their reports for discussion to Washington. These observers have been transferred to the United States Signal Bureau of the War Department, to whom their reports are now furnished. But an immense amount of valuable meteorological material has accumulated at the Smithsonian Institution, which is to be discussed and published. The first work of this series, on "Rainfall," has already been printed, the discussion of the observations having been done by Prof. Schott, of the Coast Survey. The second volume, on the "Winds of the Globe," by Prof. J. H. Coffin, and continued by his son and by Dr. Woeikof, will be published in 1875. The next work of the series treats of the "Temperature of the United States," and will also be published during this year. It deals with all available observations of temperature in the United States from the earliest times to the present: these have been discussed by Prof. Schott, aided by computers paid from the Smithson fund. Still another work of this series is in progress on the "Geographical Distribution of Thunder-Storms," and another work will soon be commenced on the deductions from barometrical observations in the United States.

The Institution is also aiding in a research on the orbit of the periodic comet of Tuttle (time of revolution thirteen years), prosecuted under the direction of Prof. Stone. An investigation into the efficiency of steam-heaters has been aided by the Institution during the year.

"The *diffusion* of knowledge among men" is powerfully aided by the Smithsonian system of exchanges. The Institution is in correspondence with more than two thousand institutions, whose publications, etc., it distributes in this country, and to whom it forwards works relating to scientific and literary advances in America. As is said by the secretary in his report, "the effect of this system on the diffusion of knowledge cannot be too highly estimated." The exchanges in books and pamphlets alone amount to 5,546 in 1874, and these are deposited in the Library of Congress, where they are available for research. The telegraphic announcements of astronomical discoveries in Europe and America have been in operation since 1873, and are of the highest benefit to astronomical science. *Six* asteroids and *six* comets were so announced in 1874.

The National Museum is deposited in the building of the Institution, and is under the care of Prof. Baird, Assistant Secretary. Constant additions are yearly made to it from all parts of the world, and all sources are laid under contribution. Mr. P. T. Barnum gives to the institution all animals which die in his menagerie, and Mr. Blackford, of Fulton Market, New York City, selects, from the thousands of fish which come weekly into his hands, all rare and curious ones, which are at once sent in ice to the museum. There is, indeed, no part of the globe from which contributions are not received. All the War Department and other surveys in the West, the Navy Department surveys and exploring expeditions, the State Department Boundary Survey, and many other collectors, deposit the results of their work here, where they are discussed and elaborated. The museum furnishes also, from its duplicates, specimens for study to specialists who desire them. Its collections of insects, etc., are deposited with the Department of Agriculture, and exchanges are constantly kept up with this and other institutions. The United States Fish Commission may be almost considered as a part of the Institution; the valuable results which have already accrued from its scientific and energetic labors are too well known to need more than a mention.

The secretary of the Institution has for twenty years been a member of the Light-house Board, and is now its chairman, and to this connection Science owes the extensive series of experiments on sound in its relation to fog-signals, which are published in the appendix to the light-house report for 1874. The results from these experiments will undoubtedly be a guide for all governments in their choice of a method of fog-signaling.

Besides the valuable report of the secretary, of which the above is an abstract, there are given: Eulogies on Laplace, Quetelet, and De la Rive, by Arago, Mailly, and Dumas; a lecture on Tides and Tidal Action in Harbors, by Prof. Hilgard; Observations of Atmospheric Electricity and Aurora, by Lemström; an essay on a Dominant Language for Science, by De Candolle; Underground Temperature, by Schott and Everett; The North Carolina Earthquakes, by Du Pre and Henry; Warming and Ventilation, by Morin; and several short communications on Ethnology. All of these translations and memoirs are interesting and valuable, and many of them deserve a special review, but we must be content to notice how carefully they are selected to aid in the diffusion of information not generally aeeessible.

Enough has been given to show that the closing words of the secretary's report are but a mere statement of present facts: "The Institution is successfully prosecuting the plan adopted for realizing the benevolent intention of its founder, in the way of increasing and diffusing knowledge among men; its funds are again in a prosperous condition, and its reputation and usefulness are still on the increase."

The adoption of a wise and well-considered plan and a steady adherence to "the fundamental idea" have resulted in this instance, as they will result in all, in lasting and permanent good and in brilliant success. Perhaps the most valuable lesson to be derived from the present report is in its unwritten precepts, which show how a scientific trust may be administered so as to produce the greatest return to the world, and at the same time to preserve for science the full benefit of the endowment. There is no country where these lessons deserve more careful study than in our own, and we are fortunate in having in our midst an example of good administration based on wise prevision, and guided by high scientific intelligence.

Bacteria and their Influence upon the Origin and Development of Septic Complications of Wounds. By L. A. Stimson, M. D. Wood Prize Essay of the Alumni Association of Bellevue Hospital Medical College. 34 pages. New York: D. Appleton & Co., 1875.

In the early pages of this pamphlet the author explains what is meant by the terms *bacterium* and *vibrio*, gives the various classifications that have been proposed for them, and then goes into an account of their natural history, including structure, development, motions, nourishment, functions, and distribution. Briefly summed up, "Bacteria are microscopical vegetable organisms of two main varieties: 1. Round or oval cells 0.0005—0.0010 mm. in diameter, single or arranged in lines or groups. . . . 2. Cylindrical cells, 0.002—0.003 mm. long, single or arranged in lines. . . . There is no genetic relationship between them and ordinary mould and fungus. They are found in the air, water, and most animal and vegetable tissues. They are *saprophytes*, not *parasites*, and are unable in themselves to cause infectious diseases." The remainder of the essay is on the second branch of the subject, viz., what these organisms have to do with the origin and development of the putrid conditions of wounds, and on the treatment to be adopted for the prevention or relief of such conditions.

Fire-Burial among our Germanic Forefathers. By Karl Blind. London: Longmans, Green & Co. 24 pp.

The author shows that fire-burial was once the ruling custom with the Germanic races, and thinks it not strange that the German people should so readily accept the views of Sir Henry Thompson on cremation. Their occasional torchlight processions at night in honor of departed princes are lingering relics of fire-burial.

The Saxons and Frisians of old were terrified at the dark, narrow grave when the change was made from burning to burial. With the Northmen, cremation succeeded mound-burial. In Gaul, Cæsar observed that the natives practised cremation, and Tacitus mentions fire-burial as a Germanic custom, special kinds of wood being set apart for chieftains.

The dog of the Norse warrior was burnt with him. Horses, too, were burned, and in some countries the custom of leading his horse after the coffin of a chief still prevails.

"We burn the corpses of those we love," said a Norseman in the tenth century to an Arab embassador, "but you bury in the earth where vermin and worms devour."

The Northmen buried the ashes after cremation, and planted flowers over the tomb. These practices have found expression in many poems and legends of the races where they prevailed, and the author is exceedingly happy in pressing them into service in his historical notice.

Report of the Curators of the Missouri State University for the Year ending June, 1875. Pp. 208.

From this Report we learn that during the past year the Curators purchased, as a *locale* for the School of Mines, the public school-building in the town of Rolla, at a cost of $25,000. Since 1867 the library has grown from 2,000 volumes to 9,000; scientific apparatus has been increased in a yet greater ratio. The School of Mines numbered last year over 100 students. In addition to the School of Mines, the following professional schools are now fully organized in connection with the university, viz.: Normal School, Agricultural and Mechanical College, College of Law, Medical College, and Department of Analytical and Applied Chemistry.

Sixth Annual Report of the Geological Survey of Indiana. By E. T. Cox. Indianapolis, 1875. Pp. 287.

In this volume we have the results of the detailed survey of five counties, viz., Jefferson, Scott, Jackson, Brown, and Morgan, as also of special researches in other parts of the State. In a former number of the Monthly we gave the result of one of these special researches, viz., the discovery of a considerable bed of white porcelain clay, in Lawrence County. Another inquiry prosecuted by the State surveyors during the year 1874 had reference to the archæology of Indiana: attention was directed to collecting stone implements and other relics of the mound-builders, and to the mapping of tumuli and walled or fortified prehistoric village-sites. Only a small portion of the State has been as yet examined, with a view to researches of this kind, yet the results attained are highly gratifying. The volume before us gives a detailed description of some very remarkable monuments of the mound-builders. One of these, built on a high bluff which overlooks the Ohio River, consists of two circular piles of stone with neck-like prolongations lying in opposite directions; greatest diameter, twenty-two feet; length, forty feet. The mounds are built of stones piled up regularly and lapped so as to break joints, but without mortar. Another curious monument is an earthwork, circular in shape, six hundred yards in circumference, ten or twelve feet wide, and at present fifteen to twenty inches above the general surface. There is a gap six to eight feet wide in the northeast part of this circular wall. Four or five other mounds are described in the work.

In the chapters devoted to the several counties, the economic geology of each receives due attention. The principal minerals of economic value found in Jackson County are building-stone, brick-clay, and ochre. In Brown County gold is found in the bed or on the bars of all the brooks that flow into Bean Blossom Creek from Indian Creek Ridge. Fine dust and minute scales may be found in the county wherever black sand and small pebbles indicate former currents of ice-water. The metal is of unusual purity, but the total product of gold in the county has not exceeded ten thousand dollars. There are numerous quarries of valuable building-stone in the county. The manganiferous iron-stone of Scott County yields an excellent quality of mill and foundery iron. There are as many as thirteen distinct seams of the ore, ranging from three inches to one foot or more in thickness, in a vertical space of twenty feet. Beyond brick-clay and building-stone, Jefferson County possesses no minerals of any considerable economic importance.

The volume contains a "Synopsis of the Fishes of Indiana," by D. S. Jordan, M. D., and a "Partial List of the Flora of Jefferson County," by John M. Coulter.

Scripture Speculations; with an Introduction on the Creation, Stars, Earth, Primitive Man, Judaism, etc. By Halsey R. Stevens. Newburg: The Author. For sale by C. P. Somerby, New York. Pp. 419. Price, $2.00.

This work may be called a running commentary on the text of the Scriptures. The author has no hesitation in expressing his opinions, but yet he does not transgress the limits of just criticism. He has no prejudices against the "sacred books," but he is unwilling that they should be reverenced without discrimination. "Faith," says he, "is excellent if founded on a noble life. . . We have no intention of setting at naught infinite wisdom or of treating eternal things with irreverence. The manly course for all writers is to say what they think just and true, and leave the event to God. Keeping back truth is a sin."

First Book in Arithmetic. Pp. 154. Price, 50 cents. Also, The Complete Arithmetic, Oral and Written. Pp. 498. Price, $1.40. By Daniel W. Fish, A. M. New York: Ivison, Blakeman, Taylor & Co.

Algebraic Problems. By Joseph Ficklin, Ph. D. (same publishers). Pp. 184. Price, $1.50.

These books belong to the series known as "Robinson's Shorter Course." In paper, print, and binding, they are very attractive. The "First Book in Arithmetic" abounds in pictures, which are employed not so much for the purpose of embellishment, as in order to make plain to the infant mind the problems and operations set before it. "The

Complete Arithmetic" is designed to fill the place usually occupied by three or more graded text-books. "Algebraic Problems" is intended for the use of teachers. It contains a great variety of problems, by means of which the student's knowledge of the principles of algebra may be tested.

Half-Hours with Insects. By A. S. Packard, Jr. Parts VI., VII., and VIII. Price per Part, 25 cents. Boston: Estes & Lauriat.

The numbers of this series cost but a trifle each, and when completed they will make a volume, not only of fascinating interest, but full of valuable practical information. Of the parts before us, VI. is on the "Population of an Apple-Tree," VII. on "Insects of the Field," and VIII. on "Insects of the Forest." The illustrations are numerous and well executed, and the descriptions are admirably clear.

A Manual of Metallurgy. Vol. II. By W. H. Greenwood. New York: Putnams. Pp. 371. Price, $1.50.

We have here a comprehensive account of the usually accepted methods of extracting the useful metals from their ores. The scientific principles involved in each process are clearly set forth, and the processes themselves described with considerable detail, though the author does not descend to the ultimate technical minutiæ. The metals treated of in this volume are copper, lead, zinc, mercury, silver, gold, nickel, cobalt, aluminium. The subject of assaying, although it forms an important branch of metallurgy, is not touched upon, as being too large for the compass of the work. Numerous excellent woodcuts serve to illustrate the text.

Nature and Culture. By Harvey Rice. Boston: Lee & Shepard. Pp. 202. Price, $1.50.

This book is made up of six unconnected essays, the first, "Nature and her Lessons," being an exposition of current scientific theories of the origin of the universe, and the history of the earth's changes. The author's style is very attractive, and doubtless this essay will tend to suggest many a novel line of thought to the reader previously unacquainted with the current of modern scientific research and speculation. The other subjects treated are: "Woman and her Sphere;" "Education and its Errors;" "America and her Future;" "Life and its Aspirations." The final chapter contains an address delivered by the author on the occasion of the dedication of a "Mission Monument" apparently on the grounds attached to Williams College.

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PUBLICATIONS RECEIVED.

The Border-Lands of Insanity. By A. Wynter, M. D. New York: Putnams. Pp. 321. Price, $2.00.

Weights, Measures, and Money, of All Nations. By F. W. Clarke, S. B. New York: Appletons. Pp. 117. Price, $1.50.

The Mechanic's Friend. By W. E. A. Axon. New York: Van Nostrand. Pp. 348. Price, $1.50.

Report on United States Marine Hospital Service. Pp. 260.

Health Fragments. By G. H. Everett, M. D. New York: Somerby. Pp. 312. Price, $2.00.

Soul Problems. By Joseph E. Peck. New York: Somerby. Pp. 63. Price, 70 cents.

Elements of Meteorology. Part II. By John H. Tice. St. Louis: the Author. Pp. 216. Price, $2.50.

Politics as a Science. By Charles Reemelin. Cincinnati: Clarke & Co. Pp. 186.

The Taxidermist's Manual. By Captain Thomas Brown. New York: Putnams. Pp. 163. Price, $1.25.

Daily Bulletin of the United States Signal Service. 4 vols.

The Mechanical Engineer. An Address by R. H. Thurston. New York: Van Nostrand. Pp. 24.

Water and Water Supply. By W. H. Corfield. New York: Van Nostrand. Pp. 145. Price, 50 cents.

Course to be pursued with an Eye lost through Accident. By J. J. Chisolm, M. D. Pp. 8.

## MISCELLANY.

**United States Board for testing Iron and Steel.**—We have already (in the July number of the Monthly) called attention to the researches proposed to be made by the United States Board for testing Iron and Steel, and recur to the subject in order to stimulate those of our readers who may be in possession of facts bearing on the inquiry to communicate with the chairmen of the various committees into which the board has been divided. These committees are fifteen in number. The committee on abrasion and wear, chairman, R. H. Thurston, has to examine and report upon the abrasion and wear of railway wheels, axles, rails, and other materials. Another subject of investigation by this committee is the wear of tools under the various conditions of workshop practice. The committee on armor-plate, chairman, Lieutenant-Colonel Q. A. Gillmore, U. S. A., will make tests of armor-plate, and collect data derived from experiments already made to determine the characteristics of metal suitable for such use. A. L. Holley is chairman of the committee on chemical research, whose duty it is to plan and conduct investigations of the mutual relations of the chemical and mechanical properties of metals. The committee on chains and wire-ropes, whose chairman is Commodore L. A. Beardslee, U. S. N., is charged to determine the character of iron best adapted for chain-cables, the best form and proportions of link, and the qualities of metal used in the manufacture of iron and steel wire-rope. The committee on corrosion of metals, W. Sooy Smith, chairman, is to investigate the subject of corrosion of metals under the conditions of actual use.

The committee on the effects of temperature, chairman, R. A. Thurston, will investigate the effects of variations of temperature upon the strength and other qualities of metals. That on girders and columns will arrange and conduct experiments to determine the laws of resistance of beams, girders, and columns, to change of form and to fracture. Two committees on iron, wrought and cast, chairmen, Commander Beaslee and Lieutenant-Colonel Gillmore, will examine and report on the mechanical and physical properties of wrought and cast-iron. The committee on metallic alloys, chairman, Prof. Thurston, is to make experiments on the characteristics of alloys and to investigate the laws of combination. That on orthogonal simultaneous strains, chairman, W. Sooy Smith, will experiment on such strains with a view to the determination of laws. W. Sooy Smith is also chairman of the committee of physical phenomena, who will investigate the physical phenomena accompanying the distortion and rupture of materials. The committee on reheating and rerolling, chairman, Commodore Beaslee, will observe and experiment on the effects of reworking metals; of hammering as compared with rolling, and of annealing metals. A committee on steels produced by modern processes, A. L. Holley, chairman, will investigate the constitution and characteristics of steels made by the Bessemer, open-hearth, and other modern methods. Finally, the committee on steels for tools, chairman, Chief-Engineer D. Smith, U. S. N., is directed to determine the constitution and characteristics and the special adaptations of steels used for tools. Each of these committees has issued a circular, more particularly defining the researches in which it is engaged; they can be obtained from the secretary of the board, Prof. Thurston, Stevens Technological Institute, Hoboken, New Jersey, or from the respective chairmen.

**Stanley's Expedition.**—Letters have been received by James Gordon Bennett, of this city, from Henry M. Stanley, commander of the expedition fitted out for the exploration of the interior of Africa by the proprietors of the *New York Herald* and the London *Telegraph.* The letters were written at a village called Kagehyi, on the extreme southern shore of Victoria Niyanza. The expedition reached that point on February 27, 1875, after an arduous march of 103 days from the sea-coast. There were in the expedition, as soldiers and carriers, over 300 men, all native Africans except five, the commander and four Englishmen. For the first 175 miles Stanley followed Livingstone's route nearly due west, but, having reached the western frontier of Ugogo, he quitted the beaten path, and, for the remaining 550 miles, his line of march lay steadily in a northwestern direction. A few days later, the guides who had been hired in Ugogo deserted, and the trail which the expedition had been following was lost in a labyrinth of elephant and rhinoceros tracks. Still continuing his march to the northwest, Mr. Stanley's men, with great difficulty, forced and cut their way through a dense jungle on the third day after the guides had deserted. The following two days' march was very trying to the men, who suffered from hunger and thirst, and a halt was ordered until provisions could be got from Suna, a place distant nearly thirty miles. While waiting, the men had two scanty meals of gruel, which was made in a sheet-iron trunk. At a point 400 miles from the sea, Edward Pocock, one of the four Englishmen, died of typhoid fever. Thirty of the blacks were on the sick list, and six had died at Suna. The most stirring incident of the entire march to Victoria Niyanza was the three-days' battle with the people of the Lewumbu Valley. The savages were soundly whipped, and many of their villages burned. The plunder of the villages supplied the force with provisions for six days. Stanley lost twenty-one men in this little war; and when, three days later, he numbered the expedition, it was found that there remained only 194 men, and the number was still further reduced before he reached the shores of Victoria Niyanza. On his arrival at Kagehyi, he had only 166 native soldiers and carriers, and three white men.

The second letter gives an incomplete account of a reconnoissance of the coast of Victoria Niyanza. This reconnoissance was made in a cedar boat, which had been carried in sections from the sea-coast. Mr. Stanley, in this boat, the Lady Alice, surveyed all the coasts of the lake, sailing over 1,000 miles in fifty-eight days. In the letter which we call the *second*, Mr. Stanley mentions a previous letter which he wrote at Mtesa, on the north shore of the lake, latitude 0° 20′ north, longitude 33° east. There he met Colonel Linaut de Bellefonds, of Gordon's staff, and gave him a letter for transmission to England. Strange to say, this letter has not yet reached its destination, while two other letters, one of them of later date, and which were sent *via* Unyanyembe to Zanzibar by caravan, have been received. A map accompanies the "second" letter. This map, being based on actual survey, decides the question, long discussed, whether Victoria Niyanza is one lake or a multitude of lakes. It is seen to be one vast sheet of water, with length and breadth nearly equal, but with its largest diameter lying from northeast to southwest. Its extreme northern limit is in latitude 0° 30′ north, and its extreme southern limit in latitude 2° south. East and west it reaches longitude 34° 30′ east, and 31° 50′ east, respectively. During Stanley's absence from Kagehyi, Frederick Barker, one of his English followers, died there of fever. The newspapers in whose service Mr. Stanley is engaged ought to have attached to his staff a secretary possessed of some little literary tact. Mr. Stanley's own communications are verbose to the last degree: they give no clear idea of the nature of the countries visited; their inhabitants; how the expedition obtained supplies, etc. The two letters already published purport to give the history of about six months, but they are in volume equal to about one-fourth of Cæsar's famous memoirs of the Gallic War, which extended over nine years.

**Putrefaction arrested by Pressure.**—A communication to the Paris Academy of Sciences, by M. Paul Bert, on the "Influence of Air-Pressure on Fermentation," a summary of which appears in the *Academy*, states that a piece of meat placed in oxygen, with a pressure of twenty-three atmospheres, remained from July 26th to August 3d without putrescence or bad odor. It consumed in that time 380 cubic centimetres of the gas. A similar piece, suspended in a bell-glass full of air at the ordinary pressure, acquired a bad smell, consumed all the oxygen, amounting to 1,185 centimetres, and was covered with mould. Another trial was made with oxygen at a pressure of forty-four atmospheres; no oxygen was absorbed between December 19th and January 8th, and no bad odor was exhaled. M. Bert could eat cutlets preserved in this way for a month, and found them only a little stale in flavor. After being exposed to air at this pressure, allowing an escape so that only normal pressure remained, the meat suffered no damage, provided the bottle was well corked, so that no external germs could enter. Thus it appears that the micro-ferments which cause fermentation can be killed, when they are moist, by a sufficient tension of oxygen. Fermentations of milk and wine are arrested by high pressure, and fruits keep sound. Diastase continues to act as a ferment, and bodies of this description preserve their properties indefinitely if retained under pressure.

**Meeting of the French Association for the Advancement of Science.**—The President of the French Association for the Advancement of Science, M. d'Eichthal, delivered an address at the opening of the Nantes meeting, on the connection between pure science and the various methods employed to satisfy the wants of humanity. The text of this address has not yet come to hand, but we give herewith the summary of it, which is published in *Nature*. It would be almost impossible, he said, to enumerate all the branches of human activity which owe their success to the researches of pure science—hygiene, medicine, surgery, the fine arts, mechanics, industry in all its branches, mining, metallurgy, textile industries, lighting, warming, ventilation, water-supply, etc. He then referred in detail to several examples of the influence which the results of science have had upon progress in the arts, with the motive forces of water, air, and steam, mentioning a multitude of names of men eminent in pure science, from Pascal and Boyle down to Faraday and Sir William Thomson, upon the results of whose researches the great advances which have been made in machinery of all kinds have depended. He then spoke of electricity in connection with the names of Oerstedt, Ampère, Faraday, Becquerel, and Ruhmkorff; passing on to speak, at some length, of the steam-engine in its various forms, of the progress which, by means of scientific research, is being made in its construction and its uses, and of the great services which this powerful application of a scientific discovery renders to man. M. d'Eichthal advocated the establishment of local centres of culture as the best counterpoise to that over-centralization to which France owes so many of its social misfortunes. "In our time," said he, "science, history, and literature, have great wants. Libraries, lecture-halls, laboratories, costly materials, instruments numerous and expensive, are indispensable to pupils for learning, and to teachers for carrying on their researches; it is by putting, on a large scale, these resources at their disposal, that we can attract and fix in our midst men eminent in all branches of human knowledge."

**Thermo-diffusion.**—In the Physical Section, M. Merget stated the results of his researches on the thermo-diffusion of porous and pulverulent bodies in the moist state. A "thermo-diffuser" is any vessel of porous material, filled with an inert powder, into which is plunged a glass or metal tube pierced with holes. On heating this apparatus, after it has been wetted, water-vapor is given off copiously, passing through the porous substance, while dry air passes through the apparatus in the contrary direction, escaping through the tube. If we stop the mouth of the tube, there is produced a pressure amounting to three atmospheres at the temperature of a dull-red heat. If the pulverulent mass or the porous body ceases to be moist, all passage of gas is stopped. These facts the author does not explain, but he shows that De la Rive's explanation cannot be accepted. M. Merget is satisfied that he has here to do with a thermo-dynamic phenomenon. Thermo-diffusion must play an important part in the gaseous exchanges of vegetal life, as the author showed by taking a leaf of *Nelumbium* as a thermo-diffuser. M. Merget also offered some observations on the Respiration of Plants. He said: If under the influence of light, however feeble, we plunge into water containing carbonic acid, an aërial, or, better, an aquatico-aërial leaf, passing the extremity of the petiole into a test-tube, where the pressure will be a little less than that of the atmosphere, then there will form around the stomata of the leaf an atmosphere of carbonic acid, and oxygen will be discharged from the end of the petiole.

The more intense the light, the more rapid the disengagement of oxygen, and under the influence of solar light a single leaf of *Nuphar* has yielded as much as five cubic centimetres of oxygen per minute—corresponding to the fixation of one gramme of carbon in ten hours. But, if we preserve all the other conditions, abstracting only light, the bubbles of carbonic acid at the stomata disappear, the cell fills with water, and ceases to respire. Thus it is in the *gaseous state* that carbonic acid is decomposed by the chlorophyll; and, according to the author, chlorophyll possesses the property of directly breaking up gaseous carbonic acid into its elements, carbon and oxygen.

From all this it follows that the passage of carbonic acid through the stomata is a purely physical phenomenon, not vital—a phenomenon of thermo-diffusion.

**Religion of the Canarians.**—The superstitious practices in use among the primitive Canarians was the subject of a paper read by Señor Chil y Naranjo. On Gran Canaria, he says, the natives believed in an infinite being, Alcorac or Alchoran. Him they worshiped on the summits of mountains, as also in little temples called almogaren. Their priests were women, and were bound by a vow of chastity. The sacred places were also asylums for criminals. The Canarians believed in the existence of an evil spirit, Gabio. On Teneriffe the Guanchos worshiped Achaman, and used to assemble in consecrated places for common prayer. On Palma, the name given to the Supreme Being was Abara. In all the islands homage was rendered to the emblems of fecundity and to the four elements. Their sacrifices were such as would be esteemed most precious by a pastoral people. They attributed will to the sea; it was the sea that gave them rain. In time of drought they scourged the sea, and implored the aid of Heaven with great ceremony.

**Microcephaly.**—Dr. Laennec exhibited a microcephalous idiot, aged fourteen years, of the male sex. This child is entirely unconscious of his own actions, and his intellectual operations are very few in number and very rudimentary. His language consists of two syllables, *oui* and *la*, and he takes an evident pleasure in pronouncing them. He takes no heed in what direction he walks; he would step off a precipice or into a fire. Dr. Laennec called attention to the idiot's hands; the thumbs are atrophied and cannot be opposed to the other fingers. The palms of the hands have the transverse creases, but not the diagonal—the result of the atrophy of the thumbs. Hence the hand resembles that of the chimpanzee. The dentition too is defective. Though fourteen years of age, the child has only twelve teeth.

**The Booted Eagle.**—M. Louis Bureau stated the results of observations on varieties of the booted eagle (*Aquila pennata*), the smallest European bird of the eagle tribe. M. Bureau, having examined a number of broods of the booted eagle, says that all the varieties of this species may be reduced to two chief types, white and black. In pairs, both of the sexes sometimes belong to one type, but they more usually are of different types. In fact M. Bureau has found in the same forest, and at but little distance from one another, two pairs, in one of which the male was black, and the female white, and, in the other, the male white and the female black. As a rule, the young birds are either all black or all white. But in one nest, containing two chicks, the one was white, the other black. From this it follows that these variations of color are not correlated with the age of the bird.

**St. Louis Academy of Science.**—At a recent meeting of the St. Louis Academy of Science, Prof. Riley read a paper on the canker-worm, in which he says that two sorts have hitherto been confounded under this name, that are not only specifically, but he thinks generically, distinct. They present important structural differences in the egg, the larva, the chrysalis, and the moth states; and also differ in the time of their appearance: one species rising from the ground mostly in early spring, the other mostly in the fall. Both attack fruit and shade trees, but, while the spring sort is common and very injurious in the apple-orchards of the Western States, the other is rare there, and most common in the elms of New England. To combat the former, or spring species, fall ploughing under the trees, which breaks up their fragile cocoons that lie secreted in the soil, and in early spring scraping the trunks of the trees where their eggs are lodged in the crevices of the bark, are recommended. These measures fail with the fall sort, and, in the abstract of the paper now before us, nothing is suggested to take their place.

At the same meeting Prof. Riley also presented a paper giving an account of some recent experiments with the grape phylloxera, undertaken for the purpose of determining when the winged female deposits her eggs. He built a tight gauze house six feet high and four square over a Clinton vine. The house was built so as not to permit even so small an insect as the winged phylloxera to get in or out, and the vine was trimmed so that but few branches and leaves remained to be examined. Into this inclosure he brought an abundance of infested roots, and from these obtained a supply of the winged females, confined where he could watch their ways. The result of these observations is that, as has been surmised, the eggs are often laid in crevices on the surface of the ground, but still more often on the leaves, attached generally by one end amid the natural pubescence of the under surface; and, while heretofore all efforts to artificially hatch the progeny from these eggs have failed, Prof. Riley has this year succeeded in hatching them, and presented a tube filled with living females.

**Condensed Beer.**—A process for condensing beer, recently patented in England, is described as follows in the *English Mechanic*: Beer or stout is taken at any stage of fermentation, though the process is better applied when it is fit for drinking, and evaporated in a vacuum-pan until it becomes a thick, viscous fluid. The alcohol and water of course pass off in vapor, which, in turn, is condensed in a receiver, and the alcohol recovered by redistilling the liquid. This alcohol may be mixed again with the condensed beer. By this process of condensation, the beer is reduced to one-eighth or one-twelfth of its original bulk, and, as the fermentation is suspended by the heat employed, the condensed mixture will keep in any climate for any length of time. The process of reconverting the mixture into beer is also a simple one, consisting merely in adding the bulk of water originally abstracted, and setting up fermentation again by the use of a small quantity of yeast or other ferment. Within forty-eight hours the beer may be drawn from the tap for use, or bottled in the ordinary way; or, without using any ferment, the beer may be bottled, and charged with carbonic-acid gas

**Is Consumption contagious?**—Some experiments and observations recently made, on the transmission of tuberculosis or phthisis from one animal to another, are worthy of note, as indicating one fruitful source of pulmonary disease. Thus it has been found that when an animal with tuberculated lungs is made the yoke-fellow of a perfectly healthy animal, and the two are housed and fed together, so as to inhale one another's breath, the one which at first was sound, before long exhibits the symptoms of tuberculosis. Again, Krebs has produced tuberculosis by giving animals milk from those which were diseased. In addition to rabbits and Guinea-pigs (which animals are very susceptible to the artificial production of the malady), he accidentally induced the disease in a dog by feeding it with the milk of a cow in the last stage of phthisis. As a result of his observations, he asserts that tubercle virus is present in the milk of phthisical cows, whether they are slightly or gravely affected. On vigorous subjects such milk may produce no injurious effects, but the case is likely to be different with children, and those of enfeebled constitution. Similar effects may result from eating the flesh of animals affected with tubercle, and by inoculation with the virus. Thorough cooking of milk and flesh-meat neutralizes their injurious action.

**Continuity of the Guano-Deposits.**—Are guano-deposits of recent formation, or do they date from a geological epoch prior to the present? The latter opinion has been held by many eminent scientific men, among them Humboldt. The observations of Boussingault, however, go to prove the recent origin of these deposits. One fact, cited by Boussingault in support of this theory, is the existence in the guano of the bodies of birds with their soft parts preserved. These remains have been attentively studied by Barral, who shows that they belong to existing species. One of these birds was identified as a species of cormorant, which is common on the coast of Peru. Then there is a sort of gannet, which frequents all parts of the Pacific; a species of petrel; and finally the penguin. There are also fragments of the bones of mammals belonging to the eared seal. All these species extend very much farther south than the guano islands, and if deposits of guano have not been found in the colder islands of the Pacific Ocean, it is probably because the rainfalls have removed the birds' excrement, which in other localities has accumulated.

**Centennial Display of Mineral Products.**—It is the intention of the Department of the Interior to have at the Centennial Exhibition a collection of the mineral products of the United States. The Smithsonian Institution has been charged with the work of making this collection, and accordingly Prof. Joseph Henry has published a circular, inviting the coöperation of mine-owners, superintendents, engineers, geologists, and all others who are able to contribute to the attainment of the object in view. "Such a collection," says the circular, "formed and arranged with skill and discrimination, is important, for the purpose of presenting a general view of the extent and variety of these productions at the Exhibition, and will constitute a portion of the National Museum, where it will be permanently arranged after the Exhibition." Letters of inquiry, with regard to this collection of minerals, should be addressed to Prof. W. P. Blake, New Haven, Conn.

**Resuscitation of the Drowned.** — The Massachusetts Humane Society has published the following plain directions for saving the lives of persons rescued from drowning after they have become insensible:

1. Lose no time. Carry out these directions on the spot. 2. Remove the froth and mucus from the mouth and nostrils. 3. Hold the body, for a few seconds only, with the head hanging down, so that the water may run out of the lungs and windpipe. 4. Loosen all tight articles of clothing about the neck and chest. 5. See that the tongue is pulled forward if it falls back into the throat. By taking hold of it with a handkerchief, it will not slip. 6. If the breathing has ceased, or nearly so, it must be stimulated by pressure of the chest with the hands, in imitation of the natural breathing, forcibly expelling the air from the lungs, and allowing it to reënter and expand them to the full capacity of the chest. Remember that this is the most important step of all. To do it readily, lay the person on his back, with a cushion, pillow, or some firm substance, under his shoulders; then press with the flat of the hands over the lower part of the breastbone and the upper part of the abdomen, keeping up a regular repetition and relaxation of pressure twenty or thirty times a minute. A pressure of thirty pounds may be applied with safety to a grown person. 7. Rub the limbs with the hands or with dry cloths constantly, to aid the circulation and keep the body warm. 8. As soon as the person can swallow, give a tablespoonful of spirits in hot water, or some warm coffee or tea. 9. Work deliberately. Do not give up too quickly. Success has rewarded the efforts of hours.

**Trout-Culture.**—In a communication to *Forest and Stream*, Mr. M. Goldsmith, one of the Fish Commissioners for Vermont, states the results of an experiment in trout-culture, which, if verified, cannot fail to have a great influence on the development of artificial fish-breeding. Mr. Hale, of the town of Rutland, has for some months fed the trout in his ponds with bread made of Indian-corn. He adds to the meal a little sugar or molasses of the cheapest sort, and it is stated that the trout eat the bread thus prepared with as much avidity as they do chopped liver or other animal food. The fish are in good condition, though they do not grow quite so rapidly, perhaps, as they would on a flesh diet. Their flesh is firm and has a fine flavor. This discovery, adds Mr. Goldsmith, makes trout-culture not only possible in localities where it would not otherwise be practicable, but in all cases more economical. Whether the vegetable diet can be rigidly practised, is a matter for further inquiry. Even if the result should prove that a certain quantity of animal food is necessary to the most perfect health of the trout, it is still a fact of great value that they can live, and grow, and fatten, on a vegetable diet.

**Changes in the Skin of Fur-bearing Animals.**—The obvious difference between the fur of animals in summer and in winter is found by Dönhoff to be associated with an equally striking difference in the texture and thickness of their skin. Thus, the average weight of an ox-hide in winter is seventy pounds; in summer, fifty-five pounds; the hair in winter weighs about two pounds, and in summer about one pound; leaving fourteen pounds to be accounted for by the proper substance of the skin. These differences are quite as decided in fœtal animals as in adults. Calves born in winter have a longer and thicker coat than those born in summer; moreover, there is a difference of more than a pound in the weight of their skins after the hair has been removed. Similar facts may be observed in the case of goats and sheep. That these differences are not to be ascribed to any corresponding change in the diet and regimen of the parent animals, is proved by the fact that they are equally manifest in the young of individuals kept under cover, and on the same food all the year round.

**Intensity of Solar Radiation.**—In a letter to Ste.-Claire Deville, Soret alludes incidentally to some recent optical observations which show the great intensity of solar radiation. If we look at an ordinary flame through plates of glass colored blue with cobalt, we observe that with a certain thickness of glass the flame presents a purple color, as the glass transmits the extreme red rays, and the highly-refrangible blue and violet rays, while it intercepts the rays of intermediate refrangibility. If the source of light have a high temperature, and therefore emit highly-refrangible rays, the flame appears blue, and it requires a number of superposed plates in order to develop the purple tint. Thus it was found that, at the temperature at which platinum fuses, two plates would give a purple color; at the fusion of iridium three plates were required, and on observing the sun the purple color was not developed even with half a dozen plates.

**Extinction of Animals in Rodriguez.**—Alphonse Milne-Edwards, in a communication to the Paris Academy of Sciences, shows from documentary evidence that the solitaire and the other gigantic birds of the Island of Rodriguez became extinct between 1730 and 1760. Reports addressed to the Compagnie des Indes show that the island was regarded as a sort of provisioning-store, not only for the Isle of France and the Island of Bourbon, but also for the ships frequenting these parts. One object of their visits was the collection of land-tortoises, and efforts were made by the compagnie to put some restrictions on this business. The land-tortoise has long since disappeared from the island. As for the great birds of Rodriguez, owing to their undeveloped wings they were easily captured, while the delicacy of their flesh caused them to be much sought after.

**Terrestrial Radiation.** — Prof. Thiselton Dyer, at a recent meeting of the British Horticultural Society, made the following communication upon the phenomena of terrestrial radiation and its effects on vegetation, basing his remarks upon the observations of Buchan. The effects of radiation, he said, are at the maximum when the air is calm and very dry, and its temperature rather low. If, however, the cold air produced through the influence of terrestrial radiation be allowed to accumulate close to the ground, no small amount of damage may be done by a comparatively light frost. On sloping ground such accumulation of cold air cannot go on, because, cold air being heavier than air which is warmer, as soon as the air in immediate contact with sloping ground is cooled it flows down to a lower level, just as water would do, and its place is taken by the warmer current of air immediately above. In this way a higher night temperature is maintained in situations where the ground slopes down to lower levels, and accordingly such situations should be chosen for those plants which, at any stage of their growth, are peculiarly liable to be injured by frost. If the air be not calm, but a wind—even a slight wind—be blowing, the different layers of air are thereby mixed; and thus the air cooled by contact with the cold ground is not suffered to rest thereon, but is mixed with the air above it, and the temperature is thus prevented from falling as low as it otherwise would.

**Trapping Wild-Turkeys.**—There is a touch of cynic humor in a peculiar mode of trapping wild-turkeys in Virginia, as described by a writer in *Forest and Stream.* Having discovered one of the familiar haunts of the birds, the trapper digs a trench eighteen inches deep and about as wide, and four or five feet long, with a slope from the outer end deepening to the middle. A pen of fence-rails is now built, the first rail being laid across the middle of the trench; this is the width of the pen, and it has the length of two rails. It is built to the height of eight or ten rails and covered over with the same. Some grain is now scattered around and in the trench, and a large quantity within the pen. The turkeys get on the train of bait leading into the pen, and with heads down, eagerly picking up the grain, they go under the sill-rail in quest of food. Half a dozen or so will perhaps enter in thus, and then they find themselves imprisoned. They go round and round to find an exit, but it never occurs to them to *look down*, and thus they never find the passage through which they entered.

**Rationale of the Welding of Iron.**—The welding of iron and the regelation of water are very ingeniously traced to the same cause by Mr. M. Jordan. Faraday was the first to observe the phenomenon afterward called "regelation." By this term we imply that when two pieces of ice are pressed even very gently together, the temperature being just below zero, they at once become welded to each other. Of this Thompson offers the following explanation: For all bodies which, like water, have the property of diminishing in volume as they liquefy, pressure, which tends to bring the molecules closer together, lowers the temperature of fusion. Consequently, when two pieces of ice are rubbed against each other, fusion takes place between the surfaces in contact, at a temperature below zero. But as soon as the pressure ceases solidification is again produced, and the pieces are welded together. With iron, observes Mr. Jordan, the case is the same. The two pieces to be welded together are brought to a white heat, i. e., more or less *near* to the fusing-point. The repeated blows of the hammer, or the pressure of the rolls, lowers the point of fusion, causing a superficial liquefaction of the parts in contact, and thus welding the masses together; and this because, like water, iron dilates in passing from the liquid to the solid state. "The careful comparative study of these two bodies," adds Mr. Jordan, "even though at first sight apparently so dissimilar, cannot fail to furnish results of great interest to the metallurgist. The work of the puddler is also based upon the same phenomenon as that of welding. When the puddler forms his ball in the furnace, it is done by rolling together or aggregating the crystals of iron as they form in the mass of melted iron and slag. In other words, the semi-fused crystals are welded or regelated together by the mechanical action of the puddler."

**Propagation of Waves in Liquids.**—At a late meeting of the Paris Physical Society, M. Marey exhibited certain apparatus which he has employed in studying the propagation of waves in liquids. His method consists in producing, at a given point in an India-rubber tube filled with water, a sudden compression or dilatation, either by pressing on the walls of the tube, or by means of a piston. Small clips arranged along the tube at equal distances from each other signal the passage of the wave of compression or dilatation to a registering apparatus. In this way M. Marey has found that the velocity of the waves decreases with the size and increases with the elasticity of the walls. The density of the liquid has also some effect, but this is not of sufficient importance to be taken into account in applying this method of observation to physiology.

**Restoration of Faded Writings.**—Very often paper and parchment documents are illegible owing to the ink with which they were written having faded. The *Revue Industrielle* gives a very simple method of restoring to the ink its color. It is as follows: First, wet the paper and then pass over it a brush dipped in a solution of ammonia sulpho-hydrate. The writing quickly reappears, the characters being of a very deep black color. In parchment this color is permanent, but in paper it is only temporary. Old parchment chronicles in the Nuremberg Museum which have been treated in this way are now as legible as when first they were written, though before the application of the process all color had faded out of the ink. The *rationale* of the process is, that by the action of the ammonia sulpho-hydrate, the iron of the ink is changed into a black sulphuret.

**An Optical Illusion.**—St. Simon, in his famous "Mémoires," describing the personal appearance of the twelfth Duke of Albuquerque, characterizes his hair as "coarse and *green*." The question here arises, Was the duke's hair really of this color, or was St. Simon the victim of an optical illusion? That the latter was in all probability the fact, is shown in a communication made to the Paris Academy of Sciences by the venerable M. Chevreul, "the oldest student in France." On the day when the Duke de St. Simon saw Albuquerque, the latter wore a *bullock's-blood coat* of coarse cloth, with buttons of the same, and his hair hung down on his shoulders. "Now," says Chevreul, "if we take hairs of a certain color, and arrange them on a red ground in parallel lines, making a small ribbon of them, and place beside them exactly similar hairs on a white ground, the former relatively to the latter will appear green. If for white we substitute orange, the hairs on the red ground will assume a bluish tint; if violet, a yellow tint; if green, a ruddy tint; if blue, an orange tint; if violet, a greenish yellow; and, finally, if we substitute black for the white ground, the hairs on the red ground will become whitened. In short, if we look at a broad surface of one simple color, we see it and appreciate it *absolutely*. If we see it in juxtaposition with another color, or, still better, at the centre of a broad surface of another color, we see it *relatively*, and the sensation produced by it will be quite different."

**A Rat in the Telegraph Service.**—A telegraph-inspector in England recently pressed into his service a rat under the following peculiar circumstances: It was necessary to overhaul a cable of wires inclosed in iron tubes. A certain length of the cable had to be taken out of the tube, and the men commenced hauling at one end without having taken the precaution to attach to the other a wire by which it might be drawn back into the tube after inspection and repairs. The question arose, how the cable was to be restored to its proper place; and here the ingenuity of the inspector was manifested. He invoked the aid of a rat-catcher, and, provided with a large rat, a ferret, and a ball of string wound on a Morse paper drum, he repaired to the opening in the tube. The "flush-boxes" were opened, and the rat, with one end of the string attached to his body, was put into the pipe. He scampered away at a racing pace, dragging the twine with him until he reached the middle of the length of pipe, and there stopped. The ferret was then put in, and off went the rat again until he sprang clear out of the next flush-box. One length of the cable was thus safe, and the same operation was commenced with the other; but the rat stopped short a few yards in the pipe and boldly awaited the approach of the ferret. A sharp combat here commenced, and it was feared that one or both of the animals would die in the pipe. But, after sundry violent jerks had been given to the string, the combatants separated; the ferret returned to his master, and the rat, making for the other extremity of the pipe, carried the string right through, and so relieved the inspector from his anxiety.

**Behavior of Metals with Hydrogen.**—From researches carried on conjointly by Messrs. Troost and Hautefeuille, and reported to the French Academy of Sciences, it appears that potassium, sodium, and palladium, combine with hydrogen, while a considerable number of other metals merely dissolve this gas. Iron, nickel, and manganese, offer striking analogies in their behavior with hydrogen at different temperatures. The facility with which they absorb or give off hydrogen gas depends greatly on their physical condition. An ingot of pure nickel gave out in a vacuum, at a red heat, one-sixth of its volume of hydrogen. Pulverulent nickel gave out 100 times its volume, and remained pyrophoric after the escape of the hydrogen. An ingot of cobalt gave out one-tenth of its volume, electrolytic laminæ of cobalt 35 times their volume, and pyrophoric cobalt powder 100 times. It also remained pyrophoric after the loss of the hydrogen. Soft iron in ingots gave off one-sixth of its volume, and gray cast-iron more than half. Electrolytic laminæ of iron gave off 260 volumes.

**Disproportion of the Sexes in Germany.**—The proportion of males to females in the population of the German Empire appears to be steadily declining. In 1855 the excess of females over males in what is now the German Empire was 348,631, which declined in the following nine years of peace to 313,383 in 1864. At the end of 1866, that is, after the Schleswig-Holstein and Austrian Wars, the excess was 471,885. In December, 1871, the effects of the war with France was shown in an ascertained surplus female population of 755,875. Thus in the seven years, from 1864 to 1871, the excess of females over males in the German population had increased by no less than 14 per cent. Although no inconsiderable portion of this loss to the German male population is due to actual slaughter on the battle-field, it is undoubtedly caused principally by emigration. Even if emigration could now be checked, it would take more than one generation to restore the proportion between the two sexes in Germany to what it was ten years ago.

**Reduction of Obesity.**—As a means of counteracting a tendency to obesity, and for reducing that habit after it has been established, Philbert recommends a mode of treatment somewhat different from that proposed by Banting. He interdicts the use of carbonaceous food as far as possible, and would augment the amount of oxygen. Hence the food must be nitrogenous, varied with a few vegetables containing no starch, and some raw fruit. The temperament, however, must be taken account of; the lymphatic should have a "red" diet—beef, mutton, venison, pheasant, etc.; the sanguine a "white" diet—veal, fowl, oysters, etc. Vegetables not sweet or farinaceous may be taken. Coffee without cream, and tea with little sugar, may be used. Sugar, butter, cheese, potatoes, beans, etc., are forbidden. In addition to these dietetic precepts, Philbert recommends favoring the action of the skin, supporting the walls of the abdomen by the use of a tight roller, and taking exercise freely. As a purgative, intended to promote the success of the treatment, the author reccommends waters containing sulphate of soda.

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## NOTES.

Sir Charles Wheatstone died at Paris, October 21st, at the age of seventy-three. In England, he is reputed to have been the inventor of the electric telegraph, but in this country his claim is disputed, the credit of that momentous invention being assigned to Morse and Henry. By general consent, he is esteemed one of the most eminent of electricians. He also gained distinction by scientific researches in various other directions, especially in acoustics and optics. At the time of his death, Prof. Wheatstone was Vice-President of the London Royal Society, corresponding member of the Académie des Sciences, Knight of the Legion of Honor, etc.

In the article entitled "A Home-made Microscope," published last month, regret was expressed that the objectives of Gundlach, of Berlin, had not been introduced into this country. Since the appearance of the article, we have received a note from Mr. James Colegrove, of Kendallville, Ind., stating that Gundlach, of Berlin, has for the past two years resided in Jersey City, where he continues the manufacture of his objectives

Died, in Jersey City, September 4th, Prof. Samuel D. Tillman, for many years Corresponding Secretary of the American Institute, and editor of its annual "Transactions." He was a native of Utica; graduated from Union College at the age of twenty; studied law, and for some time was engaged in legal practice at Seneca Falls. About twenty years ago he quitted the legal profession and devoted himself to the study of science. He was an active and prominent member of the American Association. He was familiar with almost every department of science, and, in addition, possessed a great fund of general knowledge. He was the author of a treatise on the theory of music, originated a very ingenious chemical nomenclature, and proposed a new theory of atoms. At the time of his death he was in his sixty-third year.

In an ancient mound recently opened near Detroit there were found a number of human skulls, unaccompanied by any other bones. Dr. Dalrymple, who described this find at the Maryland Academy of Sciences, says that each of the skulls was pierced at its vertex with a hole about an inch in diameter; this was apparently done some time after death.

Dr. Guillaume-Benjamin Duchenne, recently deceased, was born at Boulogne-sur-Mer, in 1806; graduated M. D., at Paris, in 1831. He practised medicine for a while in his native town, and in 1842 came to reside in Paris. He was one of the founders of electrotherapy. He studied with eminent success the play of the facial muscles in the expression of the passions, and his observations and experiments were of great service to Mr. Darwin in the composition of his work on the "Expression of the Emotions." Not to mention his numerous contributions to medical journals, he was the author of several published works, among them a "Treatise on Localized Electrization;" "Researches on the Muscles of the Feet;" "Mechanism of Human Physiology;" "Anatomy of the Nervous System;" "Physiology of Movement," etc.

On comparing the statistics of the German universities for the summer semester of 1874 with those of the same semester of 1875, the *Allgemeine Zeitung* finds a decrease in the number of medical students; it has fallen from 6,190 to 6,039. One of the causes of this is the fact that now Jewish students devote themselves, in great numbers, to the study of jurisprudence. Until lately, the legal career could hardly be said to be open to Jews in Germany, and hence a great number of them studied medicine.

The California Peat Company are manufacturing peat-fuel at Roberts's Landing, San Joaquin County, at the rate of from fifty to one hundred tons per day. A recent trial of the product in the furnace of a steam-boiler is said, by the *Scientific and Mining Press*, to have been thoroughly satisfactory in its results.

The authorities of Tufts College have lengthened their philosophical course to four years, at the same time giving the student greater freedom in the choice of studies.

According to the *American Railway Times*, the first suspension-bridge was constructed by James Finley over Jacob's Creek, on the turnpike between Uniontown and Greensburg, Pennsylvania, in 1796.

The first shipments of tin from Tasmania have arrived in England. This tin is pronounced by the *Mining Journal* to be of excellent quality, soft and of very good color. It is free from even a trace of wolfram, so often found in combination with tin.

The two-hundredth anniversary of Antony van Leeuwenhoek's discovery of infusoria was celebrated on September 8th at Delft, his birthplace. All the natural history associations of Holland were represented on the occasion, and a fund was established for a Leeuwenhoek gold-medal, worth six hundred marks, to be awarded to distinguished microscopists. The first recipient of this medal was Prof. Ehrenberg, of Berlin, the oldest microscopist of Europe, and Leeuwenhoek's legitimate successor.

A trial-trip was recently made on a Scotch railway with a Scott-Moncrieff tramway-car, worked by compressed air. The vehicle resembles a common railway-car, but is a little higher, the reservoir of air being on the roof. The initial pressure was two hundred pounds, and the speed attained ten miles per hour. The car was fully under control; the speed could be increased or reduced at pleasure, and the operations of starting, stopping, and reversing, were readily performed. The estimated cost of the power is three half-pence per mile, as against seven pence per mile for horse-power.

The cells in a large mushroom, weighing four and a half pounds, were found by Worthington G. Smith to number 106,596,000,000,000. Each of these is furnished with a coat or cell-wall, and contains within itself protoplasm, water, and other materials. These cells are so extremely light that in one species of fungus it takes 1,624,320,000,000 to weigh an ounce troy.

The British Association this year makes grants of money amounting to nearly £1,500 in aid of scientific research. For the prosecution of researches on "British Rainfall," the Association voted £100, and a like sum respectively for the exploration of Settle Cave and Kent's Cavern, for a record of the progress of zoölogy, and an examination of the physical characters of the inhabitants of the British Isles. The sum of £75 was voted in support of Dr. Dohrn's zoölogical station at Naples, and £200 for completing and setting up in London Sir W. Thomson's tide-calculating machine. The number of beneficiaries is in all twenty-seven.

It is proposed to hold, in 1877, at the Palais de l'Industrie, Paris, an exposition of all the applications of electricity to art, science, and household use. The enterprise is zealously patronized by men of high distinction in the world of science and of industry. The necessary funds have been guaranteed. The committee in charge have their temporary headquarters at No. 86 Rue de la Victoire, Paris.

SIR CHARLES WHEATSTONE.

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# THE COMPARATIVE PSYCHOLOGY OF MAN.[1]

By HERBERT SPENCER.

WHILE discussing with two members of the Anthropological Institute the work to be undertaken by its psychological section, I made certain suggestions which they requested me to put in writing. When reminded, some months after, of the promise I had made to do this, I failed to recall the particular suggestions referred to; but, in the endeavor to remember them, I was led to glance over the whole subject of comparative human psychology. Hence resulted the following paper:

That making a general survey is useful as a preliminary to deliberate study, either of a whole or of any part, scarcely needs showing. Vagueness of thought accompanies the wandering about in a region without known bounds or landmarks. Attention devoted to some portion of a subject, in ignorance of its connection with the rest, leads to untrue conceptions. The whole cannot be rightly conceived without some knowledge of the parts; and no part can be rightly conceived out of relation to the whole.

To map out the comparative psychology of man must also conduce to the more methodic carrying on of inquiries. In this, as in other things, division of labor will facilitate progress; and, that there may be division of labor, the work itself must be systematically divided.

We may conveniently separate the entire subject into three main divisions, arranged in the order of increasing specialty.

The first division will treat of the degrees of mental evolution of different human types, generally considered: taking account of both the mass of mental manifestation and the complexity of mental manifestation. This division will include the relations of these characters to physical characters—the bodily mass and structure, and the cere

[1] Read before the London Anthropological Institute.

bral mass and structure. It will also include inquiries concerning the time taken in completing mental evolution, and the time during which adult mental power lasts; as well as certain most general traits of mental action, such as the greater or less persistence of emotions and of intellectual processes. The connection between the general mental type and the general social type should also be here dealt with.

In the second division may be conveniently placed apart, inquiries concerning the relative mental natures of the sexes in each race. Under it will come such questions as these: What differences of mental mass and mental complexity, if any, existing between males and females, are common to all races? Do such differences vary in degree, or in kind, or in both? Are there reasons for thinking that they are liable to change by increase or decrease? What relations do they bear in each case to the habits of life, the domestic arrangements, and the social arrangements? This division should also include in its scope the sentiments of the sexes toward one another, considered as varying quantitatively and qualitatively; as well as their respective sentiments toward offspring, similarly varying.

For the third division of inquiries may be reserved the more special mental traits distinguishing different types of men. One class of such specialties results from differences of proportion among faculties possessed in common; and another class results from the presence in some races of faculties that are almost or quite absent from others. Each difference in each of these groups, when established by comparison, has to be studied in connection with the stage of mental evolution reached, and has to be studied in connection with the habits of life and the social development, regarding it as related to these both as cause and consequence.

Such being the outlines of these several divisions, let us now consider in detail the subdivisions contained within each.

I.—Under the head of general mental evolution we may begin with the trait of—

1. *Mental Mass.*—Daily experiences show us that human beings differ in volume of mental manifestation. Some there are whose intelligence, high though it may be, produces little impression on those around; while there are some who, when uttering even commonplaces, do it so as to affect listeners in a disproportionate degree. Comparison of two such makes it manifest that, generally, the difference is due to the natural language of the emotions. Behind the intellectual quickness of the one there is not felt any power of character; while the other betrays a momentum capable of bearing down opposition—a potentiality of emotion that has something formidable about it. Obviously the varieties of mankind differ much in respect of this trait. Apart from kind of feeling, they are unlike in amount of feeling. The dominant races overrun the inferior races mainly in virtue of the

greater quantity of energy in which this greater mental mass shows itself. Hence a series of inquiries, of which these are some: (*a.*) What is the relation between mental mass and bodily mass? Manifestly, the small races are deficient in it. But it also appears that races much upon a par in size—as, for instance, an Englishman and a Damara—differ considerably in mental mass. (*b.*) What is its relation to mass of brain? and, bearing in mind the general law that, in the same species, size of brain increases with size of body (though not in the same proportion), how far can we connect the extra mental mass of the higher races with an extra mass of brain beyond that which is proper to their greater bodily mass? (*c.*) What relation, if any, is there between mental mass and the physiological state expressed in vigor of circulation and richness of blood, as severally determined by mode of life and general nutrition? (*d.*) What are the relations of this trait to the social state, as predatory or industrial, nomadic or agricultural?

2. *Mental Complexity.*—How races differ in respect of the more or less involved structures of their minds will best be understood, on recalling that unlikeness between the juvenile mind and the adult mind among ourselves which so well typifies the unlikeness between the minds of savage and civilized. In the child we see absorption in special facts. Generalities even of a low order are scarcely recognized; and there is no recognition of high generalities. We see interest in individuals, in personal adventures, in domestic affairs; but no interest in political or social matters. We see vanity about clothes and small achievements; but little sense of justice: witness the forcible appropriation of one another's toys. While there have come into play many of the simpler mental powers, there has not yet been reached that complication of mind which results from the addition of powers evolved out of these simpler ones. Kindred differences of complexity exist between the minds of lower and higher races; and comparisons should be made to ascertain their kinds and amounts. Here, too, there may be a subdivision of the inquiries: (*a.*) What is the relation between mental complexity and mental mass? Do not the two habitually vary together? (*b.*) What is the relation to the social state, as more or less complex?—that is to say, Do not mental complexity and social complexity act and react on each other?

3. *Rate of Mental Development.*—In conformity with the biological law, that the higher the organisms the longer they take to evolve, members of the inferior human races may be expected to complete their mental evolution sooner than members of the superior races; and we have evidence that they do this. Travelers from all regions comment, now on the great precocity of children among savage and semi-civilized peoples, and now on the early arrest of their mental progress. Though we scarcely need more proofs that this general contrast exists, there remains to be asked the question, whether it is

consistently maintained throughout all orders of races, from the lowest to the highest—whether, say, the Australian differs in this respect from the Hindoo, as much as the Hindoo does from the European. Of secondary inquiries coming under this sub-head may be named several: (*a.*) Is this more rapid evolution and earlier arrest always unequally shown by the two sexes; or, in other words, are there in lower types proportional differences in rate and degree of development, such as higher types show us? (*b.*) Is there in many cases, as there appears to be in some cases, a traceable relation between the period of arrest and the period of puberty? (*c.*) Is mental decay earlier in proportion as mental evolution is rapid? (*d.*) Can we in other respects assert that, where the type is low, the entire cycle of mental changes between birth and death—ascending, uniform, descending—comes within a shorter interval?

4. *Relative Plasticity.*—Is there any relation between the degree of mental modifiability which remains in adult life, and the character of the mental evolution in respect of mass, complexity, and rapidity? The animal kingdom at large yields us reasons for associating an inferior and more rapidly-completed mental type with a relatively automatic nature. Lowly-organized creatures, guided almost entirely by reflex actions, are in but small degrees changeable by individual experiences. As the nervous structure complicates, its actions become less rigorously confined within preëstablished limits; and, as we approach the highest creatures, individual experiences take larger and larger shares in moulding the conduct: there is an increasing ability to take in new impressions and to profit by the acquisitions. Inferior and superior human races are contrasted in this respect. Many travelers comment on the unchangeable habits of savages. The semi-civilized nations of the East, past and present, were, or are, characterized by a greater rigidity of custom than characterizes the more civilized nations of the West. The histories of the most civilized nations show us that in their earlier times the modifiability of ideas and habits was less than it is at present. And, if we contrast classes or individuals around us, we see that the most developed in mind are the most plastic. To inquiries respecting this trait of comparative plasticity, in its relations to precocity and early completion of mental development, may be fitly added inquiries respecting its relations to the social state, which it helps to determine, and which reacts upon it.

5. *Variability.*—To say of a mental nature that its actions are extremely inconstant, and at the same time to say that it is a relatively unchangeable nature, apparently implies a contradiction. When, however, the inconstancy is understood as referring to the manifestations which follow one another from minute to minute, and the unchangeableness to the average manifestations, extending over long periods, the apparent contradiction disappears; and it becomes com-

prehensible that the two traits may, and ordinarily do, coexist. An infant, quickly weary with each kind of perception, wanting ever a new object, which it soon abandons for something else, and alternating a score times a day between smiles and tears, shows us a very small persistence in each kind of mental action: all its states, intellectual and emotional, are transient. Yet, at the same time, its mind cannot be easily changed in character. True, it changes spontaneously in due course; but it long remains incapable of receiving ideas or emotions beyond those of simple orders. The child exhibits less rapid variations, intellectual and emotional, while its educability is greater. Inferior human races show us this combination, great rigidity of general character, with great irregularity in its passing manifestations. Speaking broadly, while they resist permanent modification they lack intellectual persistence, and they lack emotional persistence. Of various low types we read that they cannot keep the attention fixed beyond a few minutes on any thing requiring thought even of a simple kind. Similarly with their feelings: these are less enduring than those of civilized men. There are, however, qualifications to be made in this statement; and comparisons are needed to ascertain how far these qualifications go. The savage shows great persistence in the action of the lower intellectual faculties. He is untiring in minute observation. He is untiring, also, in that kind of perceptive activity which accompanies the making of his weapons and ornaments: often persevering for immense periods in carving stones, etc. Emotionally, too, he shows persistence not only in the motives prompting these small industries, but also in certain of his passions—especially in that of revenge. Hence, in studying the degrees of mental variability shown us in the daily lives of the different races, we must ask how far variability characterizes the whole mind, and how far it holds only of parts of the mind.

6. *Impulsiveness.*—This trait is closely allied with the last: unenduring emotions are emotions which sway the conduct now this way and now that, without any consistency. The trait of impulsiveness may, however, be fitly dealt with separately, because it has other implications than mere lack of persistence. Comparisons of the lower human races with the higher appear generally to show that, along with brevity of the passions, there goes violence. The sudden gusts of feeling which men of inferior types display are excessive in degree as they are short in duration; and there is probably a connection between these two traits: intensity sooner producing exhaustion. Observing that the passions of childhood illustrate this connection, let us turn to certain interesting questions concerning the decrease of impulsiveness which accompanies advance in evolution. The nervous processes of an impulsive being are less remote from reflex actions than are those of an unimpulsive being. In reflex actions we see a simple stimulus passing suddenly into movement: little or no control

being exercised by other parts of the nervous system. As we ascend to higher actions, guided by more and more complicated combinations of stimuli, there is not the same instantaneous discharge in simple motions; but there is a comparatively deliberate and more variable adjustment of compound motions, duly restrained and proportioned. It is thus with the passions and sentiments in the less developed natures and in the more developed natures. Where there is but little emotional complexity, an emotion, when excited by some occurrence, explodes in action before the other emotions have been called into play; and each of these, from time to time, does the like. But the more complex emotional structure is one in which these simpler emotions are so coördinated that they do not act independently. Before excitement of any one has had time to cause action, some excitement has been communicated to others—often antagonistic ones—and the conduct becomes modified in adjustment to the combined dictates. Hence results a decreased impulsiveness, and also a greater persistence. The conduct pursued, being prompted by several emotions coöperating in degrees which do not exhaust them, acquires a greater continuity; and while spasmodic force becomes less conspicuous, there is an increase in the total energy.

Examining the facts from this point of view, there are sundry questions of interest to be put respecting the different races of men: (*a.*) To what other traits than degree of mental evolution is impulsiveness related? Apart from difference in elevation of type, the New-World races seem to be less impulsive than the Old-World races. Is this due to constitutional apathy? Can there be traced (other things equal) a relation between physical vivacity and mental impulsiveness? (*b.*) What connection is there between this trait and the social state? Clearly a very explosive nature—such as that of the Bushman—is unfit for social union; and, commonly, social union, when by any means established, checks impulsiveness. (*c.*) What respective shares in checking impulsiveness are taken by the feelings which the social state fosters—such as the fear of surrounding individuals, the instinct of sociality, the desire to accumulate property, the sympathetic feelings, the sentiment of justice? These, which require a social environment for their development, all of them involve imaginations of consequences more or less distant; and thus imply checks upon the promptings of the simpler passions. Hence arise the questions—In what order, in what degrees, and in what combinations do they come into play?

7. One further general inquiry of a different kind may be added: What effect is produced on mental nature by mixture of races? There is reason for believing that, throughout the animal kingdom, the union of varieties that have become widely divergent is physically injurious; while the union of slightly-divergent varieties is physically beneficial. Does the like hold with the mental nature? Some facts seem

to show that mixture of human races extremely unlike produces a worthless type of mind—a mind fitted neither for the kind of life led by the higher of the two races, nor for that led by the lower—a mind out of adjustment to all conditions of life. Contrariwise, we find that peoples of the same stock, slightly differentiated by lives carried on in unlike circumstances for many generations, produce by mixture a mental type having certain superiorities. In his work on "The Huguenots," Mr. Smiles points out how large a number of distinguished men among us have descended from Flemish and French refugees; and M. Alphonse de Candolle, in his "Histoire des Sciences et des Savants depuis deux Siècles," shows that the descendants of French refugees in Switzerland have produced an unusually great proportion of scientific men. Though, in part, this result may be ascribed to the original natures of such refugees, who must have had that independence which is a chief factor in originality, yet it is probably in part due to mixture of races. For thinking this, we have evidence which is not open to two interpretations. Prof. Morley draws attention to the fact that, during seven hundred years of our early history, "the best genius of England sprang up on the line of country in which Celts and Anglo-Saxons came together." In like manner, Mr. Galton, in his "English Men of Science," shows that in recent days these have mostly come from an inland region, running generally from north to south, which we may reasonably presume contains more mixed blood than do the regions east and west of it. Such a result seems probable *a priori*. Two natures respectively adapted to slightly unlike sets of social conditions may be expected by their union to produce a nature somewhat more plastic than either—a nature more impressible by the new circumstances of advancing social life, and therefore more likely to originate new ideas and display modified sentiments. The comparative psychology of man may, then, fitly include the mental effects of mixture; and among derivative inquiries we may ask, How far the conquest of race by race has been instrumental in advancing civilization by aiding mixture, as well as in other ways?

II.—The second of the three leading divisions named at the outset is less extensive. Still, concerning the relative mental natures of the sexes in each race, questions of much interest and importance may be raised:

1. *Degree of Difference between the Sexes.*—It is an established fact that, physically considered, the contrast between males and females is not equally great in all types of mankind. The bearded races, for instance, show us a greater unlikeness between the two than do the beardless races. Among South American tribes, men and women have a greater general resemblance in form, etc., than is usual elsewhere. The question, then, suggests itself, Do the mental natures of the sexes differ in a constant or in a variable degree? The differ-

ence is unlikely to be a constant one; and, looking for variation, we may ask what is its amount, and under what conditions does it occur?

2. *Difference in Mass and in Complexity.*—The comparisons between the sexes, of course, admit of subdivisions parallel to those made in comparisons between the races. Relative mental mass and relative mental complexity have chiefly to be observed. Assuming that the great inequality in the cost of reproduction to the two sexes is the cause of unlikeness in mental mass, as in physical mass, this difference may be studied in connection with reproductive differences presented by the various races, in respect of the ages at which reproduction commences, and the period over which it lasts. An allied inquiry may be joined with this; namely, how far the mental developments of the two sexes are affected by their relative habits in respect to food and physical exertion? In many of the lower races, the women, treated with great brutality, are physically very inferior to the men; excess of labor and defect of nutrition being apparently the combined causes. Is any arrest of mental development simultaneously caused?

3. *Variation of the Differences.*—If the unlikeness, physical and mental, of the sexes is not constant, then, supposing all races have diverged from one original stock, it follows that there must have been transmission of accumulated differences to those of the same sex in posterity. If, for instance, the prehistoric type of man was beardless, then the production of a bearded variety implies that within that variety the males continued to transmit an increasing amount of beard to descendants of the same sex. This limitation of heredity by sex, shown us in multitudinous ways throughout the animal kingdom, probably applies to the cerebral structures as much as to other structures. Hence the question, Do not the mental natures of the sexes in alien types of man diverge in unlike ways and degrees?

4. *Causes of the Differences.*—Is any relation to be traced between this variable difference and the variable parts the sexes play in the business of life? Assuming the cumulative effects of habit on function and structure, as well as the limitation of heredity by sex, it is to be expected that, if in any society the activities of one sex, generation after generation, differ from those of the other, there will arise sexual adaptations of mind. Some instances in illustration may be named. Among the Africans of Loango and other districts, as also among some of the Indian Hill-tribes, the men and women are strongly contrasted as respectively inert and energetic: the industry of the women having apparently become so natural to them that no coercion is needed. Of course, such facts suggest an extensive series of questions. Limitation of heredity by sex may account both for those sexual differences of mind which distinguish men and women in all races and for those which distinguish them in each race, or each so-

ciety. An interesting subordinate inquiry may be, how far such mental differences are inverted in cases where there is inversion of social and domestic relations; as among those Khasi Hill-tribes whose women have so far the upper hand that they turn off their husbands in a summary way if they displease them.

5. *Mental Modifiability in the Two Sexes.*—Along with comparisons of races in respect to mental plasticity may go parallel comparisons of the sexes in each race. Is it true always, as it appears to be generally true, that women are less modifiable than men? The relative conservatism of women—their greater adhesion to established ideas and practices—is manifest in many civilized and semi-civilized societies. Is it so among the uncivilized? A curious instance of greater adhesion to custom by women than by men is given by Dalton, as occurring among the Juangs, one of the lowest wild tribes of Bengal. Until recently the only dress of both sexes was something less than that which the Hebrew legend gives to Adam and Eve. Years ago the men were led to adopt a cloth bandage round the loins, in place of the bunch of leaves; but the women adhere to the aboriginal habit: a conservatism shown where it might have been least expected.

6. *The Sexual Sentiment.*—Results of value may be looked for from comparisons of races made to determine the amounts and characters of the higher feelings to which the relation of the sexes gives rise. The lowest varieties of mankind have but small endowments of these feelings. Among varieties of higher types, such as the Malayo-Polynesians, these feelings seem considerably developed: the Dyaks, for instance, sometimes display them in great strength. Speaking generally, they appear to become stronger with the advance of civilization. Several subordinate inquiries may be named: (*a.*) How far is development of the sexual sentiment dependent upon intellectual advance—upon growth of imaginative power? (*b.*) How far is it related to emotional advance; and especially to evolution of those emotions which originate from sympathy? What are its relations to polyandry and polygyny? (*c.*) Does it not tend toward, and is it not fostered by, monogamy? (*d.*) What connection has it with maintenance of the family bond, and the consequent better rearing of children?

III.—Under the third head, to which we may now pass, come the more special traits of the different races:

1. *Imitativeness.*—One of the characteristics in which the lower types of men show us a smaller departure from reflex action than do the higher types is, their strong tendency to mimic the motions and sounds made by others—an almost involuntary habit which travelers find it difficult to check. This meaningless repetition, which seems to imply that the idea of an observed action cannot be framed in the mind of the observer without tending forthwith to discharge itself in the action conceived (and every ideal action is a nascent form of the

consciousness accompanying performance of such action), evidently diverges but little from the automatic; and decrease of it is to be expected along with increase of self-regulating power. This trait of automatic mimicry is evidently allied with that less automatic mimicry which shows itself in greater persistence of customs. For customs adopted by each generation from the last, without thought or inquiry, imply a tendency to imitate which overmasters critical and skeptical tendencies: so maintaining habits for which no reason can be given. The decrease of this irrational mimicry, strongest in the lowest savage and feeblest in the highest of the civilized, should be studied along with the successively higher stages of social life, as being at once an aid and a hindrance to civilization; an aid in so far as it gives that fixity to the social organization without which a society cannot survive; a hindrance in so far as it offers resistance to changes of social organization that have become desirable.

2. *Incuriosity.*—Projecting our own natures into the circumstances of the savage, we imagine ourselves as marveling greatly on first seeing the products and appliances of civilized life. But we err in supposing that the savage has feelings such as we should have in his place. Want of rational curiosity respecting these incomprehensible novelties is a trait remarked of the lowest races wherever found; and the partially-civilized races are distinguished from them as exhibiting rational curiosity. The relation of this trait to the intellectual nature, to the emotional nature, and to the social state, should be studied.

3. *Quality of Thought.*—Under this vague head may be placed many sets of inquiries, each of them extensive: (*a.*) The degree of generality of the ideas; (*b.*) The degree of abstractness of the ideas; (*c.*) The degree of definiteness of the ideas; (*d.*) The degree of coherence of the ideas; (*e.*) The extent to which there have been developed such notions as those of *class*, of *cause*, of *uniformity*, of *law*, of *truth*. Many conceptions, which have become so familiar to us that we assume them to be the common property of all minds, are no more possessed by the lowest savages than they are by our own children; and comparisons of types should be so made as to elucidate the processes by which such conceptions are reached. The development under each head has to be observed: (*a.*) Independently in its successive stages; (*b.*) In connection with the coöperative intellectual conceptions; (*c.*) In connection with the progress of language, of the arts, and of social organization. Already linguistic phenomena have been used in aid of such inquiries; and more systematic use of them should be made. Not only the number of general words, and the number of abstract words, in a people's vocabulary should be taken as evidence, but also their *degrees* of generality and abstractness; for there are generalities of the first, second, third, etc., orders and abstractions similarly ascending in degree. *Blue* is an abstraction referring to one class of

impressions derived from visible objects; *color* is a higher abstraction, referring to many such classes of visual impressions; *property* is a still higher abstraction, referring to classes of impressions received not through the eyes alone, but through other sense-organs. If generalities and abstractions were arranged in the order of their extensiveness and in their grades, tests would be obtained which, applied to the vocabularies of the uncivilized, would yield definite evidence of the intellectual stages reached.

4. *Peculiar Aptitudes.*—To such specialties of intelligence as mark different degrees of evolution have to be added the minor ones related to modes of life: the kinds and degrees of faculty which have become organized in adaptation to daily habits—skill in the use of weapons, powers of tracking, quick discrimination of individual objects. And under this head may fitly come inquiries concerning some race-peculiarities of the æsthetic class, not at present explicable. While the remains from the Dordogne caves show us that their inhabitants, low as we must suppose them to have been, could represent animals, both by drawing and carving, with some degree of fidelity, there are existing races, probably higher in other respects, who seem scarcely capable of recognizing pictorial representations. Similarly with the musical faculty. Almost or quite wanting in some inferior races, we find it in other races, not of high grade, developed to an unexpected degree. instance the negroes, some of whom are so innately musical that, as I have been told by a missionary among them, the children in native schools, when taught European psalm-tunes, spontaneously sing seconds to them. Whether any causes can be discovered for race-peculiarities of this kind is a question of interest.

5. *Specialties of Emotional Nature.*—These are worthy of careful study, as being intimately related to social phenomena—to the possibility of social progress, and to the nature of the social structure. Of those to be chiefly noted there are—(*a.*) Gregariousness or sociality—a trait in the strength of which races differ widely: some, as the Mantras, being almost indifferent to social intercourse; others being unable to dispense with it. Obviously the degree of the desire for the presence of fellow-men affects greatly the formation of social groups, and consequently underlies social progress. (*b.*) Intolerance of restraint. Men of some inferior types, as the Mapuché, are ungovernable; while those of other types, no higher in grade, not only submit to restraint, but admire the persons exercising it. These contrasted traits have to be observed in connection with social evolution; to the early stages of which they are respectively antagonistic and favorable. (*c.*) The desire for praise is a trait which, common to all races, high and low, varies considerably in degree. There are quite inferior races, as some of those in the Pacific States, whose members sacrifice without stint to gain the applause which lavish generosity brings; while, elsewhere, applause is sought with less eagerness. Notice should be

taken of the connection between this love of approbation and the social restraints, since it plays an important part in the maintenance of them. (*d.*) The acquisitive propensity. This, too, is a trait the various degrees of which, and the relations of which to the social state, have to be especially noted. The desire for property grows along with the possibility of gratifying it; and this, extremely small among the lowest men, increases as social developement goes on. With the advance from tribal property to family property and individual property, the notion of private right of possession gains definiteness, and the love of acquisition strengthens. Each step toward an orderly social state makes larger accumulations possible, and the pleasures achievable by them more sure; while the resulting encouragement to accumulate leads to increase of capital and further progress. This action and reaction of the sentiment and the social state, should be in every case observed.

6. *The Altruistic Sentiments.*—Coming last, these are also highest. The evolution of them in the course of civilization shows us very clearly the reciprocal influences of the social unit and the social organism. On the one hand, there can be no sympathy, nor any of the sentiments which sympathy generates, unless there are fellow-beings around. On the other hand, maintenance of union with fellow-beings depends in part on the presence of sympathy, and the resulting restraints on conduct. Gregariousness or sociality favors the growth of sympathy; increased sympathy conduces to closer sociality and a more stable social state; and so, continuously, each increment of the one makes possible a further increment of the other. Comparisons of the altruistic sentiments resulting from sympathy, as exhibited in different types of men and different social states, may be conveniently arranged under three heads: (*a.*) Pity, which should be observed as displayed toward offspring, toward the sick and aged, and toward enemies. (*b.*) Generosity (duly discriminated from the love of display) as shown in giving; as shown in the relinquishment of pleasures for the sake of others; as shown by active efforts on others' behalf. The manifestations of this sentiment, too, are to be noted in respect of their range—whether they are limited to relatives; whether they extend only to those of the same society; whether they extend to those of other societies; and they are also to be noted in connection with the degree of providence—whether they result from sudden impulses obeyed without counting the cost, or go along with a clear foresight of the future sacrifices entailed. (*c.*) Justice. This most abstract of the altruistic sentiments is to be considered under aspects like those just named, as well as under many other aspects—how far it is shown in regard to the lives of others; how far in regard to their property, and how far in regard to their various minor claims. And the comparisons of men in respect of this highest sentiment should, beyond all others, be carried on along with observations on the accompanying

social state, which it largely determines—the form and actions of government; the character of the laws; the relations of classes.

Such, stated as briefly as consists with clearness, are the leading divisions and subdivisions under which the Comparative Psychology of Man may be arranged. In going rapidly over so wide a field, I have doubtless overlooked much that should be included. Doubtless, too, various of the inquiries named will branch out into subordinate inquiries well worth pursuing. Even as it is, however, the programme is extensive enough to occupy numerous investigators who may with advantage take separate divisions.

Though, after occupying themselves with primitive arts and products, anthropologists have devoted their attention mainly to the physical characters of the human races, it must, I think, be admitted that the study of these yields in importance to the study of their psychical characters. The general conclusions to which the first set of inquiries may lead cannot so much affect our views respecting the highest classes of phenomena as can the general conclusions to which the second set may lead. A true theory of the human mind vitally concerns us; and systematic comparisons of human minds, differing in their kinds and grades, will help us in forming a true theory. Knowledge of the reciprocal relations between the characters of men and the characters of the societies they form must influence profoundly our ideas of political arrangements. When the interdependence of individual nature and social structure is understood, our conceptions of the changes now taking place, and hereafter to take place, will be rectified. A comprehension of mental development as a process of adaptation to social conditions, which are continually remoulding the mind, and are again remoulded by it, will conduce to a salutary consciousness of the remoter effects produced by institutions upon character, and will check the grave mischiefs which ignorant legislation now causes. Lastly, a right theory of mental evolution as exhibited by humanity at large, giving a key, as it does, to the evolution of the individual mind, must help to rationalize our perverse methods of education, and so to raise intellectual power and moral nature.

# THE HORSESHOE NEBULA IN SAGITTARIUS.

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IN the number of The Popular Science Monthly for July, 1874, I gave a brief account of the successive observations of the great nebula of Orion, from 1656 to 1874, and I pointed out how instructive such an historical review was in its bearing upon the improvement of our means of observation and as an example of how the standard of such work has been gradually raised. It will be interesting to trace in the same way the history of the Horseshoe Nebula in Sagittarius, which, next to the great nebulosities of Orion and Andromeda, is the most curious of these objects, and which perhaps as much as any other deserves careful study.

Its discovery dates back about a hundred years to the time of Messier, the assiduous astronomer of the Observatoire de la Marine at Paris; it is No. 17 of his list, which comprises most of the brighter and more remarkable nebulæ of the northern sky. It was at this time that Sir William Herschel, the famous astronomer of England, with instruments far superior in power to those of Messier, was forming his great catalogues of the nebulæ discovered in his "sweeps." Messier wisely used his smaller instrument in the endeavor to obtain accurate positions for those found by him, and he has left us monographic studies of the Orion and the Andromeda nebulæ ("Mémoires de l'Académie des Sciences," 1771 and 1807), which are almost the first trustworthy works of the kind, and which are the beginnings from which sprang the elaborate drawings of Lassell, Rosse, Struve and Bond.

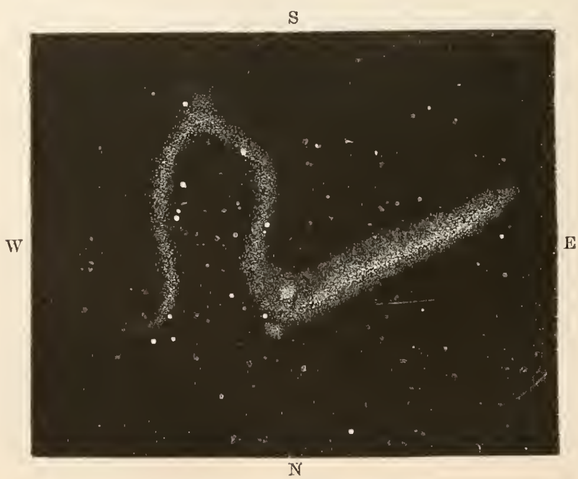


Fig. 1.—J. Herschel, 1833.

From the time of Messier to 1826, when Sir John Herschel published his first figure of the Orion nebula, almost nothing was done in this line of research; but in 1833 a study of the Horseshoe Nebula was published by Sir John Herschel, together with many other similar drawings, in the "Philosophical Transactions" (*see* Fig. 1). This was the first considerable and systematic attempt to accurately figure the nebulæ, and it doubtless turned the attention of astronomers generally to this branch, the importance of which was manifest. If so many of the fixed stars changed in brilliancy and in position, why should not the same thing occur among the nebulæ? And if such changes were once established, would not an important increase of our knowledge accrue, concerning these objects of which almost nothing was known? It was one of the avowed objects of Sir John Herschel's celebrated journey to the Cape of Good Hope to figure the nebulæ of the southern sky, and, while there, the drawing given in Fig. 2 was made, although it was not published until 1847.


FIG. 2.—J. HERSCHEL, 1837.

As we have said, Herschel's paper of 1833 created a wide-spread interest among astronomers, and about 1836 two monographic studies of the Horseshoe Nebula were begun, under circumstances so different as to deserve our attention. Lamont, the accomplished director of the Observatory of Munich, and Mason, an undergraduate of Yale College, commenced observations at about the same time: one being supplied with all the appliances which were known to astronomers, and devoting all his energies to his chosen science in a city which was then the most famous in the world for its astronomical instruments; and the other, a mere boy, oppressed by narrow circumstances, working in the intervals of his college duties with a telescope which he had himself constructed, with a fellow-student (Mr. Hamilton L. Smith) as his only assistant.

The work of both astronomers (for it is impossible to deny to Mason that title) is of great excellence, but it will not be claiming too much to assert that Mason's was by far the most valuable monographic study of a nebula which had appeared, and indeed, in its thorough appreciation of the problems to be solved and in its most skillful adaptation of the existing means toward that end, it deserves to rank with the greatest works of this class, with Bond's, Lassell's, Rosse's and Struve's. It is not only in the observations themselves nor in the exquisite and accurate drawings which accompany the memoir that we feel this excellence, but in the philosophical grasp of the whole subject and the masterly appreciation of the fundamental ideas of the problem. His memoir contains so much that bears on this general aspect, that we quote from it largely, as it is too little known among those not professional astronomers:

"Although a period of nearly fifty years has now elapsed since the researches of the elder Herschel exposed to us the wide distribution of nebulous matter through the universe, we are still almost as ignorant as ever of its nature and intention. The same lapse of time that, among his extensive lists of double stars, has revealed to us the revolution of sun around sun, and given us a partial insight into the internal economy of those remote sidereal systems, has been apparently insufficient to discover any changes of a definite character in the nebulæ, and thereby to inform us at all of their past history, the form of their original creation, or their future destiny. At the same time, the detection of such changes is in the highest degree desirable, since no other sources of evidence can be safely relied upon in these inquiries. That the efforts of astronomers have thus far ended, at least, in vague and contradictory conjectures, is principally attributable to the great difficulty of originally observing, and of describing to future observers, bodies so shapeless and indeterminate in their forms, with the requisite precision. For we cannot doubt, authorized as we are to extend the laws of gravitation far into the recesses of space, that these masses of diffused matter are actually undergoing vast revolutions in form and constitution. The main object of this paper is to inquire how far that minute accuracy which has achieved such signal discoveries in the allied department of the double stars may be introduced into the observation of nebulæ, by modes of examination and description more peculiarly adapted to this end than such as can be employed in general reviews of the heavens. . . . It will conduce to a clearer understanding of our object to point out, generally and rapidly, the distinctions between our own theory of observation and that commonly adopted. It consists not in an extensive review, but in confining the attention to a few individuals; upon these exercising a long and minute scrutiny, during a succession of evenings; rendering even the slightest particulars of each nebula as precise as repeated observation and comparison with varied precautions can make them, and confirming each more doubtful and less legible of its features by a repetition of suspicions, which are of weight in proportion as they accumulate; and, lastly, when practicable, correcting by comparison of the judgments of different persons at the same time.

"The assistance which is rendered to the faithful description of these remarkable objects by thus laying a groundwork of stars, may be well illustrated by the familiar expedient of artists, who divide any complicated engraving which they would copy, into a great number of squares, their intended sketch occupying a similar number. The stars, which are apparently interwoven throughout the whole extent of the nebula, furnish a set of thickly-distributed natural points of reference, which, truly transferred to the paper, are as available as the cross-lines of the artist in limiting and fixing the appearance of the future drawing.

"In nebulæ of great extent, however correctly estimated may be the stars immediately around the standard of reference, those in the distant parts of the nebula are liable to suffer from an accumulation of errors of nearly the same kind as that arising in an extended trigonometrical survey. But if the places of the larger stars are well settled by fixed instruments, there will be far less room for error in *estimations* which spread, as from so many centres, over the remaining intervals.

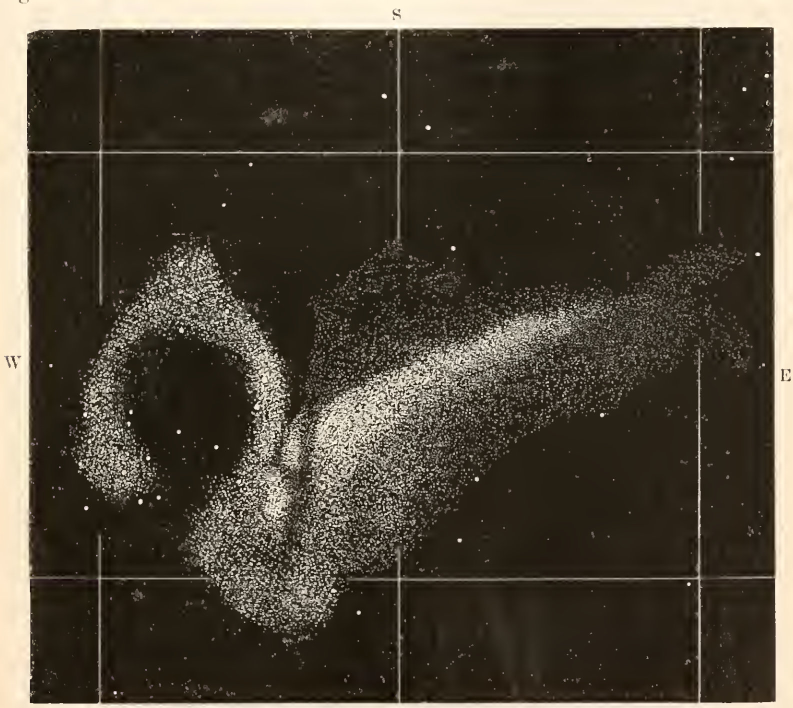


FIG. 3.—MASON, 1839.

"I will here speak of a method that I hit upon for the exact representation of nebulæ, which has essentially contributed to the accuracy of the accompanying delineations. It was first suggested by the method usually adopted for the representation of heights above the sea-level on geographical maps, by drawing curves which represent horizontal sections of hill and valley at successive elevations above the level of the sea—that is, by lines of equal height—and it is the same in its principle. It is obvious that, if lines be imagined in the field of view, winding around through all those portions of a nebula which have exactly equal brightness, these lines, transferred to our chart of stars, will give a faithful representation of the nebula and of its minutiæ, and of the suddenness as well as of the amount of transition from one degree of shade to another.

"By far the greatest obstacles to the successful comparison of modern observations on nebulæ with those which own, at least, a brief antiquity, exist in the want of precision with which the labors of former observers have been conducted, and hence all attempts to trace the slow progress of their changes end in uncertain conjectures and conflicting probabilities. I shall not, therefore, incur the charge of unnecessary minuteness in endeavoring to render, by every means, our knowledge of the present form and state of at least these few nebulæ, as far as possible, standard; and, although laden with the necessary imperfections of original observations, yet free from adventitious and unnecessary vagueness in the communication of them. In order to supply, to any future observer, those slight particulars which a chart cannot easily urge upon the notice of any but the original compiler, and further, to indicate the degree of certainty with which different features of the nebulæ were recognized, it is thought proper to bring under this head the enumeration of various facts not expressed in the journal of observations. These are divided into '*things certain*,' '*nearly certain*,' '*strongly suspected*,' and '*slightly suspected*.' Thus much for observation—for rendering the idea of the object as perfect as may be in the mind of the observer. For the most unimpaired communication of this idea or perception, the theory of the process adopted is briefly—1. To form an accurate chart of all stars capable of micrometrical *measurement* in and around the nebula. 2. From these, as the greater landmarks, to fill in with all the lesser stars, down to the *minimum visibile* by *estimation*, which, with care, need not fall far short of ordinary measurement. 3. On this, as a foundation, to lay down the nebula.

"The first intention was to intrust entirely to careful *estimation* the copying of the stars which were to form the groundwork of the nebula, since no means of measurement were then at hand. The following is a sketch of the course of procedure adopted in pursuance of this plan: The limits of the nebula were traced as far as long and close examination could discern them, and a rough chart was made of the principal stars within it. This preparation was indispensable, because, in the consequent mapping down of all the visible stars in the nebula, it was necessary to use a light out-of-doors, and the object, of course, became invisible. The distance between any two conspicuous stars favorably situated in the nebula was then chosen as a standard of reference; and, from this as a base, a kind of triangulation was carried out by the eye to all the stars in the neighborhood, and these were successively marked on a sheet of paper at the time; their magnitudes were also affixed to each according to a fictitious scale, for which a few stars, conveniently situated, furnished standards of reference as to size. A lamp was close at hand, whose light could be cut off at pleasure; and almost direct comparison was thus instituted between the stars in the field of view and those on the paper, and corrections made where any distortions in the latter were observable. As the work advanced from night to night, the reference to the lamp was necessarily less and less direct, since a longer exclusion of light was necessary to see the fainter stars. Finally, the nebula itself was drawn upon the map by the guidance of the stars already copied; and although only an occasional and unfrequent reference could be made to a lamp, the stars within it had become so familiar by their constant recurrence, that the memory could as easily as before retain its estimates of distance and direction, until mutual comparison could be made between the map and the heavens."

It will be seen what a great advance had been made in the conception of the application of the topographical method of contour lines to the delineation of degrees of brightness, although this method has practical limitations not spoken of by Mason, and we must consider the careful separation of the various results into classes ranged according to their degrees of certainty, as scarcely less important. In all former memoirs the chart included *all* the results reached, and there was no searching division of these in such a way as to give absolute data to the future investigator.

Throughout the entire memoir (which relates also to other nebulæ than the one now in question) the whole endeavor is to reach a perfect *definiteness* of conception; and Mason evidently held the idea that, in the existing state of astronomy, it was eminently "better to do one thing well than many things indifferently."

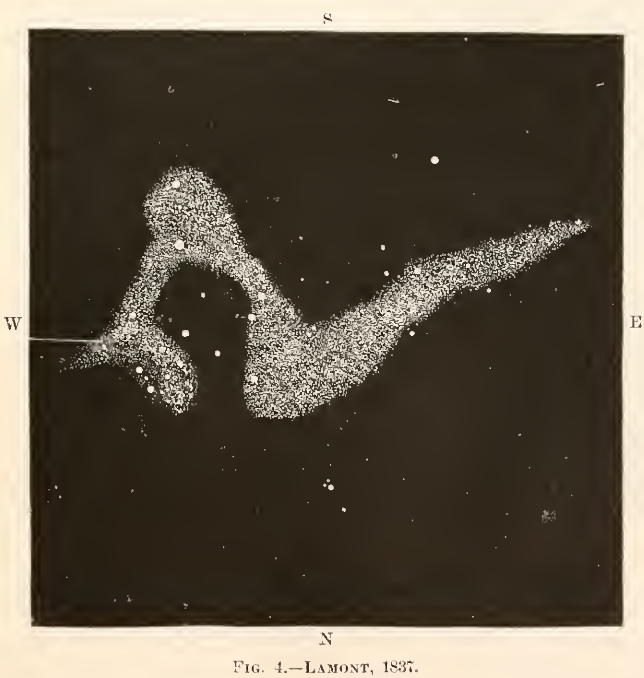


FIG. 4.—LAMONT, 1837.

Lamont tells us in *Annalen der K. Sternwarte bei München*, Band xvii. (1868), that his early researches on this and other nebulæ were prosecuted in the hope that something might be determined as to their real nature, and he expresses his opinion that all nebulæ consist essentially of clusters of stars, more or less remote. His original researches were published in 1837, accompanied by figures, and they are of high authority on this subject. We give Lamont's figure above. These two drawings having been executed by different observers with different telescopes (Lamont's refractor of nine inches aperture, and Mason's reflector of twelve inches) will afford in the cases in which they agree indubitable evidence as to the *existence* of any feature shown in them. The *non-existence* of any feature not shown in either is probable, although not *certain*.

Sir John Herschel's "Results of Astronomical Observations at the Cape of Good Hope" was published in 1847, and his drawing (our Fig. 2), in the order of publication, belongs *after* Fig. 4.

In his first paper he describes Fig. 1 as follows:

"The figure of this nebula is nearly that of a Greek capital omega, Ω, somewhat distorted, and very unequally bright. It is remarkable that this is the form usually attributed to the great nebula in Orion, though in that nebula I confess I can discern no resemblance whatever to the Greek letter. Messier perceived only the bright eastern branch of the nebula now in question, without any of the attached convolutions which were first noticed by my father. The chief peculiarities which I have observed in it are—1. The resolvable knot in the eastern portion of the bright branch, which is, in a considerable degree, insulated from the surrounding nebula; strongly suggesting the idea of an absorption of the nebulous matter; and, 2. The much feebler and smaller knot at the northwestern end of the same branch, where the nebula makes a sudden bend at an acute angle. With a view to a more exact representation of this curious nebula, I have at different times taken micrometrical measures of the relative places of the stars in and near it, by which, when laid down as in a chart, its limits may be traced and identified, as I hope soon to have better opportunity to do than its low situation in this latitude will permit."

This opportunity was afforded him at his southern station, and his Fig. 2 is accordingly much more detailed. He says of it in the work last cited that his Fig. 1 is far from an accurate expression of its shape:

"In particular the large horseshoe-shaped arc . . . is there represented as too much elongated in a vertical direction and as bearing altogether too large a proportion to [the eastern] streak and to the total magnitude of the object. The nebulous diffusion, too, at the [western] end of that arc, forming the [western] angle and base-line of the capital Greek omega (Ω), to which the general figure of the nebula has been likened, is now so little conspicuous as to induce a suspicion that some real change may have taken place in the relative brightness of this portion compared with the rest of the nebula; seeing that a figure of it made on June 25, 1837, expresses no such diffusion, but represents the arc as breaking off before it even attains fully to the group of small stars at the [western] angle of the Omega. . . . Under these circumstances the arguments for a real change in the nebula might seem to have considerable weight. Nevertheless, they are weakened or destroyed by a contrary testimony entitled to much reliance. Mr. Mason, a young and ardent astronomer, . . . . whose premature death is the more to be regretted, as he was, so far as I am aware, the only other recent observer who has given himself with the assiduity which the subject requires to the exact delineation of nebulæ, and whose figures I find at all satisfactory, expressly states that *both* the nebulous knots were well seen by himself and his coadjutor Mr. Smith on August 1, 1839, i. e., two years subsequent to the date of my last drawing. Neither Mr. Mason, however, nor any other observer, appears to have had the least suspicion of the existence of the fainter horseshoe arc attached to the [eastern] extremity of Messier's streak. Dr. Lamont has given a figure of this nebula, accompanied by a description. In this figure [our Fig. 4], the nebulous diffusion at the [western] angle and along the [western] base-line of the Omega is represented as very conspicuous; indeed, much more so than I can persuade myself it was his intention it should appear."

When Lassell mounted his great four-foot reflector at Malta, he devoted much of his time to a systematic review of those nebulæ which had previously been figured either by himself or by Rosse and


Fig. 5.—Lassell, 1862.

others, and, as was expected from the excellence of the climate, the superiority of the great telescope and the skill of the observer, this series of drawings at once took its place among the acknowledged classics on this subject. Too much praise can hardly be given to Lassell for confining his attention principally to objects previously figured, and for resisting the temptation to roam in those fields which his own telescope had opened with its list of six hundred *new* nebulæ. And it may be remarked in passing that it is just this intelligent devotion to a definite aim and object which, in this case as in all, has led to brilliant results. We give Lassell's figure above, remarking that it was constructed, as indeed all the preceding ones had been, by first measuring the relative position of the brighter stars, then inserting by careful eye estimates the fainter ones, and finally by drawing among these stars, guided by their configurations, the details of the nebula itself.

Another, and a very rapid method of drawing nebulæ, is the following. It yields to the first in the accuracy of the positions of the stars, but it is probably even superior to it in facilities for the correct representation of the nebula and stars considered as one mass. A piece of glass is ruled carefully into squares (*see* Figs. 6 and 7) and this is placed in the focus of the telescope so as to be plainly visible; the telescope is then directed upon the nebula, and a clock-work motion is applied to the telescope so that it follows the apparent motion of the nebula from east to west accurately. Some one of the brighter stars is chosen, and it is kept by means of the clock-work accurately in the corner of one of the squares. A piece of paper ruled into squares similar to those of the glass reticle is provided, and on it the observer dots down the various stars in and about the nebula. This may take two, three, or four nights according to circumstances, but in all cases it requires much less time than the micrometric measurements of the brighter stars and the troublesome allineations required to fix the positions of the smaller stars, and it has the great advantage that the work can be done in a perfectly dark field of view, whereas the micrometric measures demand the use of illuminated wires at least. After the stars are inserted, the principal lines are put in, not only by the star-groups, but also by the squares themselves. For my own use I have had constructed two reticles: one ruled in squares like those seen in Figs. 6 and 7, and another in which the heavy-lined large squares (each containing nine small squares, *see* Fig. 6) are still present, but are subdivided into small squares by lines parallel to their own diagonals. After making all the use possible of the first reticle, the second is put in, and an entirely new set of reference-lines is obtained, making an angle of 45° with the old set. This, of course, could be equally obtained by revolving the first reticle through an angle of 45°, but it is not quite so convenient.

After the stars and the principal lines of the nebula are inserted a new and higher power eye-piece is used, and the drawing is concluded by means of this. Fig. 6 is an example of a drawing of the Horseshoe Nebula made in this way by M. Trouvelot, of Cambridge, Massachusetts, the artist to whom we owe the exquisite plates of astronomical engravings published by Harvard College Observatory, under the superintendence of its late director, Prof. Winlock.

During the last summer M. Trouvelot was invited by the superintendent of the United States Naval Observatory to visit Washington for the purpose of making drawings of nebulæ, etc., by means of the twenty-six inch Clark refractor. By the courtesy of Admiral Davis

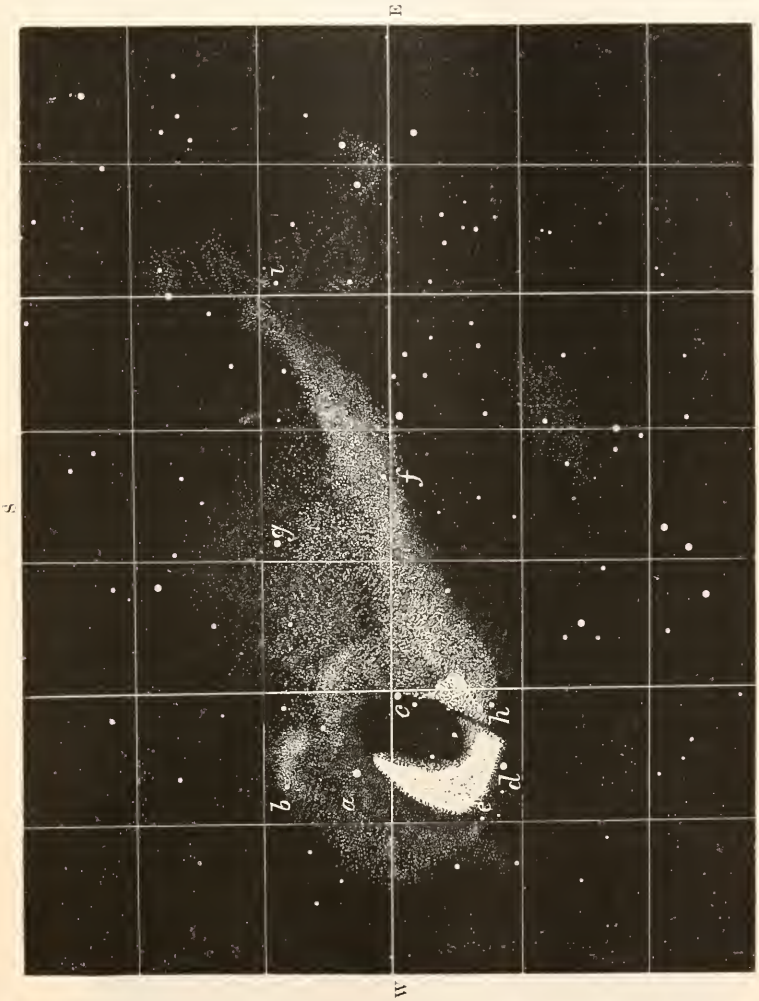


Fig. 6.—Trouvelot, 1875 (with a 6½-inch Refractor).

I am able to give a drawing of the Horseshoe Nebula as delineated by M. Trouvelot from observations made jointly by him and by myself.

Pretty much the same method was adopted in this drawing as in Fig. 6, but the vastly more complex structure of the nebula itself is what might have been expected from an increase of eighteen times in the light, over M. Trouvelot's six-inch telescope.

From careful comparisons of different kinds, it has been found that the power of the Washington telescope is about the same as that of Lassell's great four-foot reflector, and the two drawings, Figs. 5 and 7, are therefore nearly comparable, i. e., almost as if made with the

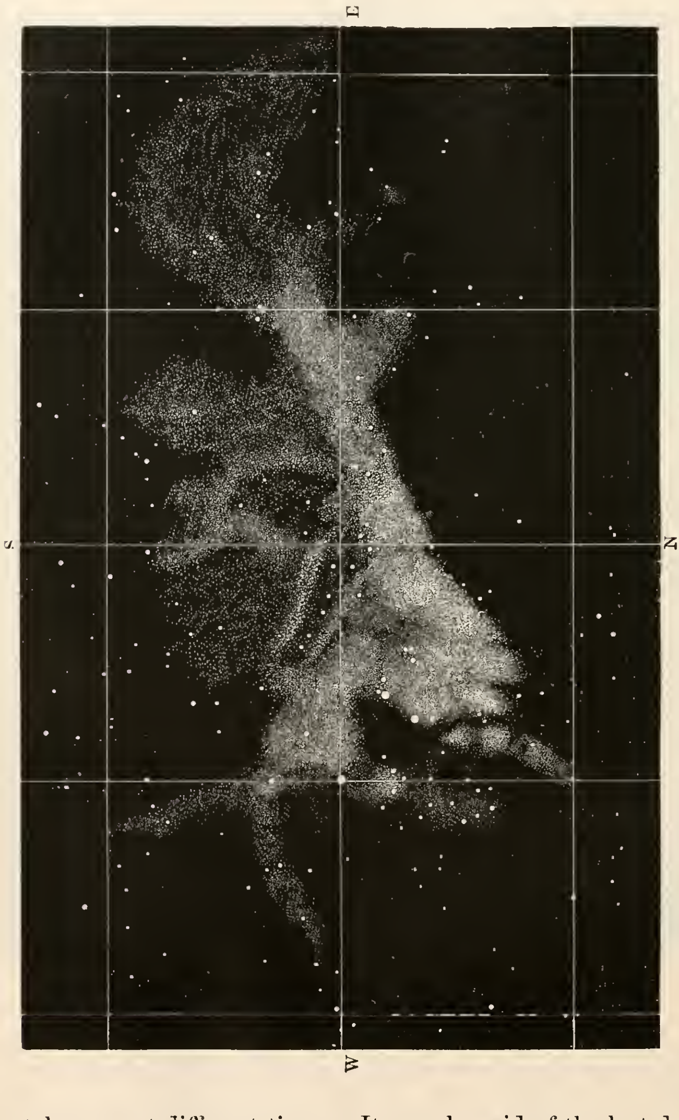


Fig. 7.—Trouvelot, Naval Observatory, 1875 (26-inch Telescope).

same telescope at different times. It may be said of the last drawing that nothing is there laid down about which the slightest doubt is entertained; and although, in some respects, it was made in greater haste than is desirable, yet it is sufficiently accurate to found an argument on, for or against variation in the shape of any of the brighter portions of the nebula.

It is hoped that enough has been said to show how much care, skill, and patience, have been spent upon these drawings, and to show, too, how important are the conclusions which may be drawn from them. Their careful discussion involves considerations which might be out of place here, but which are well worth general attention. A full explanation of different methods has been given in the hope that some of the large telescopes in various parts of the United States in the hands of private gentlemen may be devoted to work of this class, in which it is easy for an amateur, with but a trifling expenditure of time and labor, to produce valuable results. Provided only that the work be done conscientiously and faithfully, it will be a definite gain to astronomy; without such care and fidelity, it will only introduce new confusion.

## SCIENCE-TEACHING IN ENGLISH SCHOOLS.

By Rev. W. TUCKWELL.

THREE times within the last twelve years a royal commission has reported on the science-teaching of our higher schools. In 1864 the Public Schools Commission announced that from the largest and most famous schools of all it was practically excluded. In 1868 the Endowed Schools Commission declared that the majority of school-teachers had accepted it as part of their school-work. The Science Commissioners of 1875, in their sixth report, on "Science-Teaching in Schools," testing this statement by inquiry, state that of 128 endowed schools examined by them not one-half has even attempted to introduce it, while of these only 13 possess a laboratory, and only 10 give to the subject as much as four hours a week. And this statement is curiously illustrated by the statistics of the recent Oxford and Cambridge school examination, which show that out of 461 candidates for certificates, from 40 first-class schools, while 438 boys took up Latin, 433 Greek, 455 elementary mathematics, 305 history, only 21 took up mechanics, 28 chemistry, 6 botany, 15 physical geography.

In a volume whose research and condensation make it not only a monument of conscientious toil, but an invaluable hand-book to all who are laboring to work out practically the great problem of which it treats, the commissioners investigate the obstacles which have caused the endowed schools to defy the weighty recommendations of former commissions, the unanimous verdict of educational authorities outside the scholastic profession, and the increasingly urgent demands of English public opinion. They find the school-masters' excuses to be threefold: absence of funds, want of time, and skepticism as to the educational value of science in comparison with other subjects. A large portion of the appendix is devoted to the consideration of these difficulties; to sifting the allegations on which they rest, and to balancing against them the experience of those teachers who have faced and successfully met them. Showing in detail the comparatively trifling cost at which indispensable apparatus can be obtained, the commissioners nevertheless admit the rarity, in the present state of English culture, either of independent science-teachers suited to the larger schools, or of men, such as poorer schools desiderate, combining literary with scientific knowledge. This, however, is an evil of the past rather than of the future, since not the least among the advantages expected from a reformed system of school-teaching is the creation of a race of able teachers, general as well as special. The relative value of science as an implement of mental training is next discussed. Its peculiar excellence is briefly vindicated, as cultivating, in a way attainable by no other means, the habits of observation and experiment, of classification, arrangement, method, judgment; and its suitability to the capacities of the very youngest boys is testified to by Faraday, Hooker, Rolleston, Carpenter, and Sir W. Thomson. Lastly, it is shown that, if this be so, the argument from want of time is no argument at all; that the hours are already wasted which condemn the half of a boy's faculties to stagnation, and render education one-sided and incomplete; and that the claims of different branches of instruction may be easily adjusted by economy of time, improvement in methods, and excision of superfluous studies.

On a review of all these objections and of the answers offered to them, and taking into account the dicta of former commissioners and the practice of other countries, the report advises that literature, mathematics, and science, should be the accepted subjects of education up to the time at which boys leave school, and should all three be made compulsory in any school-leaving-examination or university matriculation; but that after entering the university students should be left to choose for themselves among these lines of study, and need pass no subsequent examination in subjects other than the one which they select. As regards the teaching of science, they recommend that it should commence with the beginning of the school career; that not less than six hours a week should be devoted to it, and that in all school examinations as much as one-sixth of the marks should be allotted to it.

These recommendations possess the two great excellences of authoritativeness and clearness. They are supported by a host of experienced witnesses, as well as by the eminent names whose signatures follow them. Their ideal of school education is simplicity itself. The supremacy of classics is to be dethroned; the artifices of stratification and bifurcation are to be discarded; literature, mathematics, and science are to share a boy's intellect between them from the very first, until a leaving-examination which shows his progress to have been satisfactory in all three sets him free to follow his inclination by pursuing exclusively the subject which suits him best; happy since eminence in that one will not have been purchased by entire ignorance of all the others. Unfortunately, though most necessarily—for this report concerns schools only—the curtain drops upon this interesting moment of transition, shutting out of view the influence which university scholarships and exhibitions exercise upon school-work, and thus ignoring an obstacle to the realization of the programme far greater than want of money, want of time, or want of appreciation, in the schools themselves.

What is the avowed object and purpose of the higher English school education? Is it the even and progressive development of young minds? the strengthening in equal proportion of the faculties of imagination, memory, reason, observation? the opening doors of knowledge in the plastic time of youth, which if not opened then will be fast closed in later years by the pressure of active work, or habitual exclusiveness, or energies paralyzed through disuse? Nothing of the kind. It is constructed entirely with the aim of winning certain prizes; for scholarships with which a costly university bribes men to come to it for education; for class-lists leading up to college fellowships; for the lucrative posts of military and civil service. In all these, but most of all where the universities can determine the ordeal, one principle of success has been established, and that principle is one-sidedness. The candidate for India, for Woolwich, for Cooper's Hill, must at an early age select certain subjects and throw overboard all the rest. The childish aspirant to the entrance scholarships of a public school is placed in the hands of a crammer at eight years old, that at thirteen he may turn out Latin verses as a Buddhist prayer-mill turns out prayers, and may manifest, as a distinguished head-master has lately said, to the eye of a teacher searching for intelligence, thoughtfulness, promise, intenseness, "a stupidity which is absolutely appalling." His scholarship won, he is pledged to pursue a course whose benefits are tangible and its evil consequences remote. The universities have stamped upon all the schools one deep certainty, that for a boy to be "all around," as it is called, is the irremissible sin; that a school-master who teaches with reference to intellectual growth and width of culture sacrifices thereby all hope of the distinctions which make a school famous and increase its numbers. If a classical scholarship is desired, science and mathematics are abandoned: nay, the palm of literary excellence is conceded even to men ignorant of the noblest literature in the world, their own birthright and inheritance, and knowing less of the history and structure of the English language than a fourth-form boy knows of Greek. If mathematical success is aimed at, literature and science are ignored; if the few science scholarships existing tempt candidates from any of "the thirteen schools which possess a laboratory," mathematics in part and literature altogether must be given up. It would be waste of words to point out the fatal tendency of this separative process; to show how mere linguistic training needs the rationalizing aid of scientific study, or how exclusive science hardens and materializes without the refining society of literature; yet such divorce is inevitably due not to the convictions of school-masters, not to the influence of parents, not to the prepossessions of the public, but to the irresistible force of the university system, which makes narrowness of intelligence and imperfect knowledge the only avenues to distinction or to profit.

It is true that an attempt to alter this involves little short of a revolution; but by all accounts a revolution is at hand. It is not for nothing that a parliamentary investigation into the expenditure of college endowments should have been supported by members of the colleges themselves, or that a proposal to distribute college scholarships and exhibitions by a central authority in accordance with the results of the leaving-examination should have emanated from eminent university teachers. For it cannot be too strongly urged that college scholarships stand on very different ground from university prizes or degrees. It is easy for Parliament to lay down rules which shall control the latter once for all; it is not easy to bind the actions of some forty different foundations, each electing its own scholars according to its own idiosyncrasies, or in obedience to the changing wills of bodies in a perpetual state of flux. It may still be audacious, but it is no longer novel, to suggest that, supposing future legislation to retain the college scholarships at all, they should be awarded by the authority of government, in strict connection with leaving-examinations which government shall conduct, and in reward not of special but of general proficiency. For this the scheme of the commissioners virtually contends; into regions beyond this the report before us necessarily does not enter.

It will be seen that we accept, and recommend all teachers to accept, the scheme of the commissioners unreservedly as a working basis of educational improvement. It may not be ideally perfect; it may invite opposition on points of detail; but it is the resultant of all the intellectual forces which have hitherto been brought to bear upon the subject; and, while agreeing with all its witnesses on the principle that wide general training should precede specialization of study, it attains extreme simplicity of arrangement by allotting the first of these to the schools and the last to the universities. Do not let us forget that the cry which has arisen hitherto from all the head-masters on the point of scientific teaching has been a cry for guidance; for commanding and intelligent leadership; for authoritative enlightenment as to the relative value and the judicious sequence of scientific subjects; for information as to text-books, apparatus, teachers. For the first time this cry is met by an oracle whose authority no one will question, and whose completeness of delivery all who study its utterances will appreciate. School-masters anxious to teach science, and doubtful how to set about it, will meet all the facts which can enlighten them in the appendices to the report. They will find lists of accredited text-books, specimens of examination-papers, varieties of school time-tables, priced catalogues of apparatus, syllabi of lectures and experiments, botanical schedules and tables, plans and descriptions of laboratories, workshops, museums, botanic gardens; programmes and reports of school, scientific, and natural history societies. They will learn how costly a temple could be built to science at Rugby, and how modestly it could be housed at Taunton. They will see how Mr. Foster teaches physics, how Mr. Hale teaches geography, how Mr. Wilson teaches *Erdkunde*. And they will accept all this as coming from men who have a right to speak, and who wield an experience such as has not been amassed before. On any legislative change which impends over the system and the endowments of the higher English education, the body of scientific opinion is strong enough, if united, to impress its own convictions; disunion alone can paralyze it. All who feel the discredit of past neglect, its injury to our national intellect, and its danger to our national prosperity, will do well to support by unqualified adhesion the first attempt that has been made to probe its causes, and the first consistent and well-considered scheme that has been put forth for its removal.—*Nature*.

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# MODERN BIOLOGICAL INQUIRY.

By Dr. JOHN L. LE CONTE.

THE founders of science in America, and the other great students of Nature, who have in previous years occupied the elevated position in which I now stand, have addressed you upon many momentous subjects. In fulfilling the final duty assigned to your Presidents by the laws of the Association, some have spoken to you in solemn and wise words concerning the duties and privileges of men of science, and the converse duties of the nation toward those earnest and disinterested promoters of knowledge. Others, again, have given you the history of the development of their respective branches of study, and their present condition, and have, in eloquent diction, commended to your gratitude those who have established on a firm foundation the basis of our modern systems of investigation.

The recent changes in our constitution, by which you are led to

[1] Address of the retiring President delivered at the Detroit meeting of the American Association for the Advancement of Science.

expect from your two Vice-Presidents, and from the chairman of the Chemical Subsection, addresses on the progress made during the past year, restrain me from invading their peculiar fields of labor, by alluding to scientific work which has been accomplished since our last meeting. While delicacy forbids me from so doing, I am equally debarred from repeating to you the brief sketch I endeavored to give at a former meeting,[1] of the history and present condition of entomology in the United States.

But it has appeared to me that a few thoughts, which have impressed themselves on my mind, touching the future results to be obtained from certain classes of facts, not yet fully developed, on account of the great labor required for their proper comparison, may not be without value. Even if the facts be not new to you, I hope to be able, with your kind attention, to present them in such way as to be suggestive of the work yet to be done.

It has been perhaps said, or at least it has been often thought, that the first mention of the doctrine of evolution, as now admitted to a greater or less degree by every thinking man, is found in Ecclesiastes i. 9:

> "The thing that hath been, is that which shall be: and that which is done, is that which shall be done: and there is no new thing under the sun. Is there any thing whereof it may be said, See, this is new? It hath been already of old time, which was before us."

Other references to evolutionary views in one form or another occur in the writings of several philosophers of classic times, as you have had recent cause to remember.

Whether these are to be considered as an expression of a perfect truth in the very imperfect language which was alone intelligible to the nation to whom this sacred book was immediately addressed on the one hand, and the happy guesses of philosophers, who by deep intuition had placed themselves in close sympathy with the material universe, on the other hand, I shall not stop to inquire. The discussion would be profitless, for modern science in no way depends for its magnificent triumphs of fact and thought upon any utterances of the ancients. It is the creation of patient, intelligent labor of the last two centuries, and its results can be neither confuted nor confirmed by any thing that was said, thought, or done, at an earlier period. I have merely referred to these indications of doctrines of evolution to recall to your minds that the two great schools of thought, which now divide philosophers, have existed from very remote times. They are, therefore, in their origin, probably independent of correct scientific knowledge.

You have learned from the geologists, and mostly from those of

[1] Proceedings of the American Association for the Advancement of Science, Section xxi. (Portland).

the present century, that the strata of the earth have been successively formed from fragments more or less comminuted by mechanical action, more or less altered by chemical combination and molecular rearrangement. These fragments were derived from strata previously deposited, or from material brought up from below, or even thrown down from above, or from the *débris* of organic beings which extracted their mineral constituents from surrounding media. Nothing new has been added, every thing is old; only the arrangement of the parts is new, but in this arrangement definite and recognizable unchanged fragments of the old frequently remain. Geological observation is now so extended and accurate that an experienced student can tell from what formation, and even from what particular locality, these fragments have been derived.

I wish to show that this same process has taken place in the organic world, and that by proper methods we can discover in our fauna and flora the remnants of the inhabitants of former geologic times, which remain unchanged, and have escaped those influences of variation which are supposed to account for the differences in the organic beings of different periods.

Should I succeed in this effort, we shall be hereafter enabled, in groups of animals which are rarely preserved in fossil condition, to reconstruct, in some measure, the otherwise extinct faunæ, and thus to have a better idea of the sequence of generic forms in time. We will also have confirmatory evidence of certain changes which have taken place in the outline of the land and the sea. More important still, we will have some indications of the time when greater changes have occurred, the rock evidence of which is now buried at the bottom of the ocean, or perhaps entirely destroyed by erosion or separations. Of these changes, which involved connections of masses of land, no surmise could be made, except through evidence to be gained in the manner of which I am about to speak.

My illustrations will naturally be drawn from that branch of zoölogy with which I am most familiar; and it is indeed to your too partial estimate of my studies in that science that I owe the privilege of addressing you on the present occasion.

There are, as you know, a particular set of Coleoptera which affect the sea-shore; they are not very numerous at any locality, but among them are genera which are represented in almost every country of the globe. Such genera are called cosmopolitan, in distinction to those which are found only in particular districts. Several of these genera contain species which are very nearly allied, or sometimes in fact undistinguishable and therefore identical along extended lines of coast.

Now, it happens that some of these species, though they never stray from the ocean-shore inland, are capable of living upon similar beaches on fresh-water lakes, and a few are found in localities which are now quite inland.

To take an example, or rather several examples together, for the force of the illustration will be thereby greatly increased.

Along the whole of the Atlantic, and the greater part of the Pacific coast of the United States, is found in great abundance, on sand-beaches, a species of tiger-beetle, *Cicindela hirticollis*, an active, winged, and highly-predaceous insect; the same species occurs on the sand-beaches of the Great Lakes, and, were it confined to these and similar localities, we would be justified in considering it as living there in consequence solely of the resemblance in the conditions of existence. But, it is also found, though in much less abundance, in the now elevated region midway between the Mississippi and Rocky Mountains. Now, this is the part of the continent which, after the division of the great intercontinental gulf in Cretaceous times, finally emerged from the bed of the sea, and was in the early and middle Tertiary converted into a series of immense fresh-water lakes. As this insect does not occur in the territory extending from the Atlantic to beyond the western boundary of Missouri, nor in the interior of Oregon and California, I think that we should infer that it is an unchanged survivor of the species which lived on the shores of the Cretaceous ocean, when the intercontinental gulf was still open, and a passage existed, moreover, toward the southwest, which connected with the Pacific.

The example I have given you of the geographical distribution of *Cicindela hirticollis* would be of small value, were it an isolated case; nor would I have thought it worthy of occupying your time, on an occasion like this, which is justly regarded as one for the communication of important truth. This insect, which I have selected as a type for illustrating the methods of investigation to which I invite your attention, is, however, accompanied more or less closely by other Coleoptera, which like itself are not particular as to the nature of their food, so long as it be other living insects, and apparently are equally indifferent to the presence of large bodies of salt-water. First, there is *Cicindela lepida*, first collected by my father, near Trenton, New Jersey, afterward found on Coney Island, near New York, and received by me from Kansas and Wisconsin; not, however, found west of the Rocky Mountains. This species, thus occurring in isolated and distant localities, is probably in process of extinction, and may or may not be older than *C. hirticollis*. I am disposed to believe, as no representative species occurs on the Pacific coast, and from its peculiar distribution, that it is older. Second, there is *Dyschirius pallipennis*, a small Carabide, remarkable among other species of the genus by the pale wing-covers, usually ornamented with a dark spot. This insect is abundant on the Atlantic coast, from New York to Virginia, unchanged in the interior parts of the Mississippi Valley, represented at Atlantic City, New Jersey, by a larger and quite distinct specific form, *C. sellatus*, and on the Pacific coast by two or three species of larger size and different shape, which in my less experienced youth I was disposed to regard as a separate genus, *Akephorus*. This form is, therefore, in a condition of evolution—how, I know not—our descendants may. The Atlantic species are winged; the Pacific ones, like a large number of insects of that region, are without wings.

Accompanying these are Coleoptera of other families, which have been less carefully studied, but I will not trespass upon your patience by mentioning more than two. *Bledius pallipennis* (*Staphylinidæ*) is found on salt marshes near New York, on the Southern sea-coast, and in Kansas; *Ammodonus fossor*, a wingless Tenebrionide, Trenton seashore near New York, and valley of the Mississippi at St. Louis; thus nearly approximating *Cicindela lepida* in distribution.

We can thus obtain by a careful observation of the localities of insects, especially such as affect sea-shore or marsh, and those which, being deprived of their favorite surroundings, have shown, if I may so express myself, a patriotic clinging to their native soil, most valuable indications in regard to the time at which their unmodified ancestors first appeared upon the earth. For it is obvious that no tendency to change in different directions by "numerous successive slight modifications"[1] would produce a uniform result in such distant localities, and under such varied conditions of life. Properly studied, these indications are quite as certain as though we found the well-preserved remains of these ancestors in the mud and sand strata upon which they flitted or dug in quest of food.

Other illustrations of survivals from indefinitely more remote times I will also give you, from the Coleopterous fauna of our own country, though passing time admonishes me to restrict their number.

To make my remarks intelligible, I must begin by saying that there are three great divisions of Coleoptera, which I will name in the order of their complication of structural plan: 1. Rhynchophora; 2. Heteromera; 3. Ordinary or normal Coleoptera; the last two being more nearly allied to each other than either is to the first. I have in other places exposed the characters of these divisions, and will not detain you by repeating them.

From paleontological evidence derived from other branches of zoölogy, we have a right to suppose, if this classification be correct, that these great types have been introduced upon the earth in the order in which I have named them.

Now, it is precisely in the first and second series that the most anomalous instances of geographical distribution occur; that is to say, the same or nearly identical genera are represented by species in very widely-separated regions, without occurring in intermediate or contiguous regions. Thus there is a genus *Emeax*, founded by Mr. Pascoe, upon an Australian species, which, when I saw it, I recognized as belonging to *Nyctoporis*, a California genus, established many years before; and, in fact, barely specifically distinct from *N. galeata*.

[1] "Origin of Species," 1869, p. 227.

Two other examples are *Othnius* and *Eupleurida*, United States genera, which are respectively equivalent to *Elacatis* and *Ischalia*, found in Borneo. Our native genera *Eurygenius* and *Toposcopus* are represented by scarcely different forms in Australia. All these belong to the second series (*Heteromera*), and the number of examples might be greatly increased with less labor on my part than patience on yours.

A single example from the Rhynchophora, and I will pass to another subject.

On the sea-coast of California, extending to Alaska, is a very anomalous insect, whose affinities are difficult to discern, called *Emphyastes fucicola*, from its occurrence under the sea-weed cast up by the waves. It is represented in Australia by several species of a nearly allied genus, *Aphela*, found in similar situations.

In all entomological investigations relating to geographical distribution, we are greatly embarrassed by the multitude of species, and by the vague and opinionative genera founded upon characters of small importance. The Coleoptera alone, thus far described, amount to over 60,000 so-called species, and there are from 80,000 to 100,000 in collections. Under these circumstances it is quite impossible for one person to command either the time or the material to master the whole subject, and, from the laudable zeal of collectors to make known what they suppose to be new objects, an immense amount of synonymy must result. Thus in the great "Catalogus Coleopterorum" of Gemminger and Harold, a permanent record of the untiring industry of those two excellent entomologists, species of the genus *Trechicus*, founded by me upon a small North American insect, are mentioned under five generic names, only one of which is recognized as a synonym of another. These generic headings appear in such remote pages of the volume as 135, 146, and 289.

The two closely-allied genera of Rhynchophora mentioned above are separated by no less than 168 pages.

It is therefore plain that, before much progress can be made in the line of research which I have proposed to you, whereby we may recover important fragments of the past history of the earth, entomology must be studied in a somewhat different manner from that now adopted. The necessity is every day more apparent that descriptions of heterogeneous material are rather obstructive than beneficial to science, except in the case of extraordinary forms likely to give information concerning geographical distribution or classification. Large typical collections affording abundant material for comparison, for the approximation of allied forms, and the elimination of doubtful ones, must be accumulated, and, in the case of such perishable objects as those we are now dealing with, must be placed where they can have the protecting influences both of climate and personal care.

At the same time, for this investigation, the study of insects is peculiarly suitable; not only on account of the small size, ease of collecting, and little cost of preserving the specimens, but because from their varied mode of life in different stages of development, and perhaps for other reasons, the species are less likely to be destroyed in the progress of geological changes.[1] Cataclysms and submergences, which would annihilate the higher animals, would only float the temporarily asphyxiated insect, or the tree-trunks containing the larvæ and pupæ, to other neighboring lands. However that may be, I have given you some grounds for believing that many of the species of insects now living existed in the same form before the appearance of any living genera of mammals, and we may suppose that their unchanged descendants will probably survive the present mammalian fauna, including our own race.

I may add, moreover, that some groups, especially in the Rhynchophora, which, as I have said above, I believe to be the earliest introduced of the Coleoptera, exhibit with compact and definite limits, and clearly-defined specific characters, so many generic modifications, that I am compelled to think that we have in them an example of the long-sought, unbroken series, extending in this instance from early mesozoic to the present time, and of which very few forms have become extinct.

I have used the word *species* so often, that you will doubtless be inclined to ask, What, then, is understood by a species? Alas! I can tell you no more than has been told recently by many others. It is an assemblage of individuals, which differ from each other by very small or trifling and inconstant characters, of much less value than those in which they differ from any other assemblage of individuals. Who determines the value of these characters? The experienced student of that department to which the objects belong. Species are, therefore, those groups of individuals representing organic forms which are recognized as such by those who from natural power and education are best qualified to judge.

You perceive, therefore, that we are here dealing with an entirely different kind of information from that which we gain from the physical sciences; every thing there depends on accurate observation, with strict logical consequences derived therefrom. Here the basis of our knowledge depends equally on accurate and trained observation, but the logic is not formal but perceptive.

This has been already thoroughly recognized by Huxley[2] and

[1] For a fuller discussion of these causes, and of several other subjects which are briefly mentioned in this address, the reader may consult an excellent memoir by my learned friend Mr. Andrew Murray, "On the Geographical Relations of the Chief Coleopterous Faunæ."—(*Journal of Linnæan Society, Zoölogy*, vol. xi.)

[2] "A species is the smallest group to which distinctive and invariable characters can be assigned." ("Principles and Methods of Paleontology," Smithsonian Report, 1869, p. 378.)

Helmholtz,[1] and others, but we may properly extend the inquiry into the nature and powers of this æsthetic perception somewhat further. For it is to this fundamental difference between biological and physical sciences that I will especially invite your attention.

Sir John Lubbock,[2] quoting from Oldfield,[3] mentions that certain Australians "were quite unable to realize the most vivid artistic representations. On being shown a picture of one of themselves, one said it was a ship, another a kangaroo, not one in a dozen identifying the portrait as having any connection with himself."

These human beings, therefore, with brains very similar to our own, and, as is held by some persons, potentially capable of similar cultivation with ourselves, were unable to recognize the outlines of even such familiar objects as the features of their own race. Was there any fault in the drawing of the artist? Probably not. Or in the eye of the savage? Certainly not, for that is an optical instrument of tolerably simple structure, which cannot fail to form on the retina an accurate image of the object to which it is directed. Where, then, is the error? It is in the want of capacity of the brain of the individual (or rather the race in this instance) to appreciate the resemblance between the outline, the relief, the light and shade of the object pictured, and the flat representation in color: in other words, a want of "artistic tact" or æsthetic perception.

A higher example of a similar phenomenon I have myself seen: many of you too have witnessed it, for it is of daily occurrence. It is when travelers in Italy, having penetrated to the inmost chamber of the Temple of Art, even the hall of the Tribune at Florence, stand in presence of the most perfect works of art which it has been given to man to produce, and gaze upon them with the same indifference that they would show to the conceptions of mediocre artists exhibited in our shops.

Perhaps they would even wonder what one can find to admire in the unrivaled collection which is there assembled.

There is surely wanting in the minds of such persons that high, æsthetic sense, which enables others to enter into spiritual harmony with the great artists whose creations are before them.

Creations I said, and I use the word intentionally. If there is one power of the human soul which, more nearly than any other, ap-

[1] "I do not mean to deny that, in many branches of these sciences, an intuitive perception of analogies and a certain artistic tact play a conspicuous part. In natural history . . . . it is left entirely to this tact, without a clearly definable rule, to determine what characteristics of species are important or unimportant for purposes of classification, and what divisions of the animal or vegetable kingdom are more natural than others." ("Relation of the Physical Sciences to Science in General." Smithsonian Report, 1871, p. 227.)

[2] "Prehistoric Times," p. 440.

[3] "On the Aborigines of Australia." Transactions of Ethnological Society, New Series, vol. iii.

proaches the faculty of creation, it is that by which the almost inspired artist develops out of a rude block of stone, or out of such mean materials as canvas and metallic pastes of various colors, figures which surpass in beauty, and in power of exciting emotion, the objects they profess to represent.

Yet these unæsthetic and non-appreciative persons are just as highly educated, and in their respective positions as good and useful members of the social organism, as any that may be found. I maintain only, they would never make good students of biology.

In like manner, by way of illustrating the foregoing observations, there are some who, in looking at the phenomena of the external universe, may recognize only chance, or the "fortuitous concourse of atoms," producing certain resultant motions. Others, having studied more deeply the nature of things, will perceive the existence of laws, binding and correlating the events they observe. Others, again, not superior to the latter in intelligence, nor in power of investigation, may discern a deeper relation between these phenomena and the indications of an intellectual or æsthetic or moral plan, similar to that which influences their own actions, when directed to the attaining of a particular result.

These last will recognize in the operations of Nature the direction of a human intelligence, greatly enlarged, capable of modifying at its will influences beyond our control; or they will appreciate in themselves a resemblance to a superhuman intelligence which enables them to be in sympathy with its actions.

Either may be true in individual instances of this class of minds; one or other must be true; I care not which, for to me the propositions are in this argument identical, though in speculative discussions they may be regarded as at almost the opposite poles of religious belief. All that I plead for is, that those who have not this perceptive power, and who in the present condition of scientific discussion are numerically influential, will have tolerance for those who possess it; and that the ideas of the latter may not be entirely relegated to the domain of superstition and enthusiasm.

In the case of the want of perception of the Australian, a very simple test can be applied. It is only to photograph the object represented by the artist, and compare the outlines and shades of the photograph with those of the picture. If they accord within reasonable limits, the picture is correct to that extent; at least, however bad the artist, the human face could never be confounded with a ship or a kangaroo.

Can we apply a similar test to the works of Nature? I think we can. Suppose that man—I purposely use the singular noun to indicate that all human beings of similar intelligence and education working toward a definite end will work in a somewhat similar manner—suppose, then, I say, that man, endeavoring to carry out some object of importance, devises a method of so doing, and creates for that purpose a series of small objects, and we find that these small objects naturally divide and distribute themselves in age and locality, in a similar manner to that in which the species of a group of organisms are divided in space, and distributed in time; and that the results of man's labor are thus divided and distributed on account of the necessary inherent qualities of his intelligence and methods of action—is not the resemblance between human reason and the greater powers which control the manifestations of organic Nature apparent?

I now simply present to you this investigation. Time is wanting for me to illustrate it by even a single example, but I feel sure that I have in the minds of some of you already suggested several applications of it to the principle I wish to teach: the resemblance in the distribution of the works of Nature to that of human contrivances evolved for definite purposes.

If this kind of reasoning commends itself to you, and you thus perceive resemblances in the actions of the Ruler of the universe to those of our own race, when prompted by the best and highest intellectual motives, you will be willing to accept the declaration of the ancient text, "He doeth not evil, and abideth not with the evil inclined. Whatever he hath done is good;"[1] or that from our own canon of Scripture: "With him is wisdom and strength, he hath counsel and understanding."[2]

The æsthetic character of natural history, therefore, prevents the results of its cultivation from being worked out with the precision of a logical machine, such as, with correct data of observation and calculation, would be quite sufficient to formulate the conclusions of physical investigation. According as the perception of the relations of organic beings among themselves becomes more and more enlarged, the interpretation of these relations will vary within limits; but we will be continually approximating higher mental or spiritual truth.

This kind of truth can never be revealed to us by the study of inorganic aggregations of the universe. The molar, molecular, and polar forces, by which they are formed, may be expressed, so far as science has reduced them to order, by a small number of simply formulated laws, indicative neither of purpose nor intelligence, when confined within inorganic limits. In fact, taking also the organic world into consideration, we as yet see no reason why the number of chemical elements known to us should be as large as it is, and go on increasing almost yearly with more minute investigations. To all appearance, the mechanical and vital structure of the universe would remain unchanged, if half of them were struck out of existence.

Neither is there any evidence of intelligence or design in the fact that the side of the moon visible to us exhibits only a mass of volcanoes.

[1] "Desatir," p. 2. [2] Job xii. 13

Yet upon the earth, without the volcano and the earthquake, and the elevating forces of which they are the feeble indications, there would be no permanent separation of land and water; consequently no progress in animal and vegetable life beyond what is possible in the ocean. To us, then, as sentient beings, the volcano and the earthquake, viewed from a biological stand-point, have a profound significance.

It is indeed difficult to see in what manner the student of purely physical science is brought to a knowledge of any evidences of intelligence in the arrangement of the universe. The poet, inspired by meditating on the immeasurable abyss of space and the transcendent glories of the celestial orbs, has declared—

"The undevout astronomer is mad,"

and his saying had a certain amount of speciousness, on account of the magnitude of the bodies and distances with which the student of the stars is concerned. This favorite line is, however, only an example of what an excellent writer has termed "the unconscious action of volition upon credence," and it is properly in the correlations of the inorganic with the organic world that we may hope to exhibit, with clearness, the adaptations of plan prefigured and design executed.

In the methods and results of investigation, the mathematician differs from both the physicist and the biologist. Unconfined, like the former, by the few simple relations by which movements in the inorganic world are controlled, he may not only vary the form of his analysis, almost at pleasure, making it more or less transcendental in many directions, but he may introduce factors or relations, apparently inconceivable in real existences, and then interpret them into results quite as real as those of the legitimate calculus with which he is working, but lying outside of its domain.

If biology can ever be developed in such manner that its results may be expressed in mathematical formulæ, it will be the pleasing task of the future analyst to ascertain the nature of the inconceivable (or imaginary as they are termed in mathematics) quantities which must be introduced when changes of form or structure take place. Such will be analytical morphology, in its proper sense; but it is a science of the future, and will require for its calculus a very complex algebra.

In the observation of the habits of inferior animals, we recognize many complications of action, which, though directed to the accomplishment of definite purposes, we do not entirely comprehend. They are, in many instances, not the result of either the experience of the individual, or the education of its parents, who in low forms of animals frequently die before the hatching of the offspring. These actions have been grouped together, whether simple or complex, as directed by what we are pleased to call instinct, as opposed to reason. Yet there is every gradation between the two.

Among the various races of dogs, the companions of man for unnumbered centuries, we observe not only reasoning powers of a rather high order, but also distinct traces of moral sentiments, similar to those possessed by our own race. I will give no examples, for many may be found in books with which you are familiar. Actions evincing the same mental attributes are also noticed in wild animals which have been tamed. You will reply that these qualities have been developed by human education; but not so: there must have been a latent capacity in the brain to receive the education, and to manifest the results by the modification of the habits. Now, it is because we are vertebrates, and the animals of which I have spoken are vertebrates, that we understand, though imperfectly, their mental processes, and can develop the powers that are otherwise latent. Could we comprehend them more fully we would find, and we do find from time to time in the progress of our inquiries, that what was classed with instinct is really intellection.

When we attempt to observe animals belonging to another subkingdom—Articulata, for instance—such as bees, ants, termites, etc., which are built upon a totally different plan of structure, having no organ in common with ourselves, the difficulty of interpreting their intellectual processes, if they perform any, is still greater. The purposes of their actions we can only divine by their results. But any thing more exact than their knowledge of the objects within their scope, more ingenious than their methods for using those objects, more complex, yet well devised, than their social and political systems, it is impossible to conceive.

We are not warranted in assuming that these actions are instinctive, which if performed by a vertebrate we would call rational. Instead of concealing our ignorance under a word which thus used comes to mean nothing, let us rather admit the existence here of a rational power, not only inferior to ours, but also different.

Thus proceeding, from the highest forms in each type of animal life to the lower, and even down to the lowest, we may be prepared te advance the thesis that all animals are intelligent, in proportion to the ability of their organization to manifest intelligence to us or to each other; that wherever there is voluntary motion, there is intelligence: obscure it may be, not comprehended by us, but comprehended by the companions of the same low grade of structure.

However this may be, I do not intend to discuss the subject at present, but only wish in connection with this train of thought to offer two suggestions.

The first is, that by pursuing different courses of investigation in biology, we may be led to opposite results. Commencing with the simplest forms of animal life, or with the embryo of the higher animals, it may be very difficult to say at what point intelligence begins to manifest itself; our attention is concentrated, therefore, upon those functions which appear to be the result of purely mechanical arrangements, acted upon by external stimuli. The animal becomes to our perception an automaton, and in fact, by excising some of the nervous organs last developed in its growth, we can render an adult animal an automaton, capable of performing only those habitual actions to which its brain, when in perfect condition, had educated the muscles of voluntary motion. On the other hand, commencing with the highest group in each type, and going downward, either in structural complication, or in age of individual, it is impossible to fix the limit at which intelligence ceases to be apparent.

I have in this subject, as in that of tracing the past history of our insects, in the first part of this address, preferred the latter mode of investigation; taking those things which are nearest to us in time or structure as a basis for the study of those more remote.

The second consideration is, since it is so difficult for us to understand the mental processes, whether rational or instinctive (I care not by what name they are called), of beings more or less similar but inferior to ourselves, we should exercise great caution when we have occasion to speak of the designs of one who is infinitely greater. Let us give no place to the crude speculations of would-be teleologists, who are, indeed, in great part, refuted already by the progress of science, which continually exhibits to us higher and more beautiful relations between the phenomena of Nature "than it hath entered into the mind of man to conceive." Let not our vanity lead us to believe that, because God has deigned to guide our steps a few paces on the road of truth, we are justified in speaking as if he had taken us into intimate companionship, and informed us of all his counsels.

If I have exposed my views on these subjects to you in an acceptable manner, you will perceive that, in minds capable of receiving such impressions, biology can indicate the existence of a creative or directive power, possessing attributes some of which resemble our own, and controlling operations which we may feebly comprehend. Thus far natural theology, and no further.

What, then, is the strict relation of natural history or biology to that great mass of learning and influence which is commonly called theology; and to that smaller mass of belief and action which is called religion?

Some express the relation very briefly, by saying that science and religion are opposed to each other; others, again, that they have nothing in common. These expressions are true of certain classes of minds; but the greater number of thinking and educated persons see that, though the ultimate truths taught by each are of quite distinct nature, and can by no means come in conflict, inasmuch as they have no point in common, yet so far as these truths are embodied in human language, and manipulated by human interest, they have a common dominion over the soul of man. According to the method of their government, they may then come into collision even as the temporal and spiritual sovereigns of Japan occasionally did, before the recent changes in that country.

In answering the query above proposed, it will be necessary to separate the essential truths of religion from the accessories of tradition, usage, and, most of all, organizations and interpretations which have in the lapse of time gathered around the primitive or revealed truth.

With the latter, the scientific man must deal exactly like other men—he must take it or reject it, according to his spiritual gifts; but he must not, whatever be his personal views, discuss it or assail it *as a man of science*, for within his domain of investigation it does not belong.

With regard to the accessories of traditions, interpretations, etc., our answer may be clearer when we have briefly reviewed some recent events in what has been written about as the conflict of religion and science. Some centuries ago, great theological disgust was produced by the announcement that the sun and not the earth was the centre of the planetary system. A few decades ago profound dissatisfaction was shown that the evidence of organic life on the planet was very ancient. Recently some annoyance has been exhibited because human remains have been found in situations where they ought not to have been, according to popularly received interpretations; and yet more recently much apprehension has been felt at the possible derivation of man from some inferior organism; an hypothesis framed simply because, in the present condition of intellectual advancement, no other can be suggested.

Yet all these facts, but the last, which still is an opinion, have been accepted, after more or less bitter controversy on both sides, and the fountain of spiritual truth remains unclouded and undiminished. New interpretations for the sacred texts supposed to be in conflict with the scientific facts have been sought and found without difficulty. These much-feared facts have, moreover, given some of the strongest and most convincing illustrations to modern exhortation and religious instruction.

Thus, then, we see that the influence of science upon religion has been beneficial. Scholastic interpretations founded upon imperfect knowledge, or no knowledge, but mere guess, have been replaced by sound criticism of the texts, and their exegesis in accordance with the times and circumstances for which they were written.

It must be conceded by fair-minded men of both sides that these controversies were carried on at times with a rudeness of expression and bitterness of feeling now abhorrent to our usages. The intellectual wars of those days partook of the brutality of physical war, and the horrors of the latter, as you know, have been ameliorated only within very few years.

I fear that the unhappy spirit of contention still survives, and that there are yet a few who fight for victory rather than for truth. The deceptive spirit of Voltaire still buds forth occasionally; he who, as you remember, disputed the organic nature of fossil shells, because in those days of schoolmen their occurrence on mountains would be used by others as a proof of a universal Noachian deluge. The power of such spirits is fortunately gone for any potent influence for evil, gone with the equally obstructive influence of the scholastics with whom they formerly contended.

Since, then, there is no occasion for strict science and pure religion to be in conflict, how shall the peace be kept between them?

By toleration and patience—toleration toward those who believe less than we do, in the hope that they, by cultivation or inheritance of æsthetic perception, will be prepared to accept something more than matter and energy in the universe, and to believe that vitality is not altogether undirected colloid chemistry.

Toleration also toward those who, on what we think misunderstood or insufficient evidence, demand more than we are prepared to admit, in the hope that they will revise additional texts which seem to conflict, or may hereafter conflict, with facts deduced from actual study of Nature, and thus prepare their minds for the reception of such truths as may be discovered, without embittered discussions.

Patience, too, must be counseled. For much delay will ensue before this desired result is arrived at; patience under attack, patience under misrepresentation, but never controversy.

Thus will be hastened the time when the glorious, all-sufficient spiritual light, which, though given through another race, we have adopted as our own, shall shine with its pristine purity, freed from the incrustations with which it has been obscured by the vanity of partial knowledge, and the temporary contrivances of human polity.

So, too, by freely-extended scientific culture, may we hope that the infinitely thicker and grosser superstitions and corruptions will be removed which greater age and more despotic governments have accumulated around the less brilliant though important religions of our Asiatic Aryan relatives. These accretions being destroyed, the principal difficulty to the reception by those nations of higher spiritual truths will be obviated, and the intelligent Hindoo or Persian will not be tardy in recognizing, in the pure life and elevated doctrine of the sincere Christian, an addition to and fuller expression of religious precepts with which he is familiar. In this manner alone may be realized the hope of the philosopher, the dream of the poet, and the expectation of the theologian—a universal science and a universal religion, coöperating harmoniously for the perfection of man and the glory of his Creator.

# THE SAND-BLAST.

By W. S. WARD.

PROF. WILLIAM P. BLAKE, in a communication "On the Grooving and Polishing of Hard Rocks and Minerals by Dry Sand," which appeared in the *American Journal of Science and Arts*, September, 1855, describes the phenomena observed by him in 1838, in the Pass of San Bernardino, California, as follows: "On the eastern declivities of the pass, the side turned toward the desert, the granite and associate rocks which form the sharp peak San Gorgonio extend down the valley of the pass in a succession of sharp ridges, which, being devoid of soil and of vegetation, stand out in bold and rugged outlines against the clear, unclouded sky of that desert-region. It was on these projecting spurs of San Gorgonio that the phenomena of grooving were seen; the whole surface of the granite over broad spaces was cut into long and perfectly parallel grooves and little furrows, and every portion of it was beautifully smoothed, and, though very uneven, had a fine polish." While contemplating these curious effects, the solution of the problem was presented. The wind was blowing very hard, and carried with it numerous little grains of sand. A closer examination disclosed the fact that the whole of the polished surface was enveloped in an atmosphere of moving sand, and it was through the grinding and rubbing of these minute but numberless quartz-atoms that the rough surfaces of these rocks had been made smooth, and the natural grooves deepened and polished. "Even quartz," he observed, "was cut away and polished; garnets and tourmaline were also cut and left with polished surfaces. . . . Whenever a garnet or a lump of quartz was imbedded in compact feldspar and favorably presented to the action of the sand, the feldspar was cut away around the hard mineral, which was thus left standing in relief above the general surface."

The traveler whose good fortune it is to visit our Western wonderland, will note among the many fingers in his guide-book one pointing in the direction of the now famous Monument Park. Entering a narrow valley bordered by mountain-walls, he will find himself gazing in wonderment at the rounded stone columns, rising about him in groups or singly, to a height ranging from ten to forty feet, and in many instances surmounted with grotesque cap-like coverings, that rest balanced upon the frail pinnacles of the rock-columns. An inquiry as to the causes of their existence, standing as they do in isolation on the surface of the valley low-lands, will elicit the reply that they were made by the wearing away of the surrounding rocks by sand, which, whirling about in water or air eddies, acted like chisels of the turner's lathe. Where the depressions were deepest there the rocky strata were soft and yielding, and were the more readily cut away; but where the opposing surface was hard, as in the case of the black cap-pieces, the action was less rapid, and the reduction of the rock less decided. Glancing off from these, the whole force of the driving sand was projected against the strata immediately below, thus reducing it in size till there seems hardly circumference enough left to sustain the weight above.

Fig. 1.—Sand-cut Columns in Monument Park.

So much for the observations of the geologist and explorer, made nearly half a century ago, and placed on record as forming but one of the many startling features of that wonderful region, but suggesting to the traveler little else than a reasonable theory by which to account for a hitherto mysterious class of physical phenomena. From this, the record of the student of Nature, we turn to a second record, more practical in character, and having a direct bearing upon the subject under review.

Whether the author or inventor of the modern sand-blast deserves any less credit for having had his idea anticipated in the workshops of Nature, we will not say; certain it is, however, that the former work suggested the latter, though the prior claim does not seem to have been considered by the American Commissioner of Patents.

"On the 18th of October, 1870," we read, "letters-patent of the United States were granted to General B. C. Tilghman, of Philadelphia, for the cutting, grinding, etching, engraving, and drilling stone, metal, wood, or any hard substance, by means of a jet or blast of sand." We are also informed, from the same official source, that the inventor of the sand-blast process obtained his first hints from Nature, and, by means of a mechanism which is a marvel of simplicity, has been able to utilize this same force so as to make it render most efficient service in several departments of the applied arts.

It is the object of the present paper to describe and illustrate the invention known as the Tilghman Sand-Blast, an invention which, in simplicity of construction, and yet extent of application, has hardly an equal in the annals of the American Patent-Office. We are aware that this is a broad claim, when it is remembered that under the protection of the same authority the sewing-machine, reaper, and mower, positive-action loom, and a score or more of great mechanical devices, first saw the light. It is possible that there is that in the idea of the sand-blast which adds to its charm, and secured for it the admiring indorsement of Torrey, Tyndall, and other men of science; and yet a careful study of its principle, and an observance of its practical operation, seem to justify all and more than is claimed for it by the inventor or his distinguished indorsers.

If the reader will refer to the simple "claim" as given above, he will notice that it is proposed to accomplish the several results there named "by means of a *jet* or blast of sand." The italics are our own, and are now introduced since it is in this idea of a *jet* of sand that the first principle of the device rests; and, moreover, it was an attempt made by others to adopt this falling jet of sand that compelled the inventor to institute his first proceeding against infringement. With the legal history of the sand-blast, however, we have nothing to do, save as it concerns the general history of the invention and its progress. In order that the methods by which a simple falling column or stream of sand is made to do service as an engraver of glass and metal plates may be understood, attention is directed to Fig. 2, which may be described as follows:

*A* is a box, elevated as high above the engraver's table as the height of the ceiling will permit. When designed for several workmen, this box may be divided into compartments, as indicated, each compartment being filled with common quartz or sea-sand, of varying degrees of fineness. From the bottom of each division a metal tube, *c*, depends, reaching to within a few inches of the table below. A slide, *B*, serves to regulate or check the flow of the sand. Thus much for the simplest form of sand-blast. A word as to the manner of its operation; and here, again, reference must be made to the original "claim," where it will be found that the operation of the blast is limited to the cutting, grinding, etc., of any *hard* substance. It may be well to note the significance of this word *hard*, since in it lies the secret of the whole process. The substance upon which the sand acts must be a hard or brit-

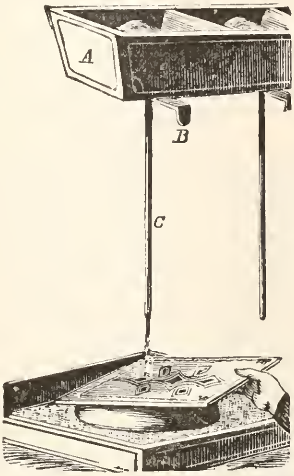

FIG. 2.—DEVICE FOR ETCHING WITH SAND.

tle one, falling or being blown upon which, the angular sand-grains chip away minute portions, till at length the whole surface is reduced or scratched to any desired depth. Thus, if the plate which, as shown in the figure, be a glass one, and the workman wishes to engrave on it a flat design, he has only to protect the portions which are not to be acted upon, by a stencil made from rubber, soft iron, leather, or even paper, since, these substances not being *hard* or brittle, will not be affected by the descending blows of the sand-grains. This the workman has done, and by this means he has been able to depolish or grind the surface of the plate as indicated. Of the methods of constructing and applying these stencils, their variety and several uses, descriptions will be given as we advance.

From the use of a simple jet of falling sand, we pass on a step, and in Fig. 3 present the Tilghman Sand-blast Machine, in its original and complete form, all subsequent improvements having been made only with a view to some special form of service. The feature of this device, it will be observed, is the use of a blast of air or steam which shall be made to accelerate the falling of the sand through the tube, and thus cause each grain to act with additional force upon the opposing surface. If the reader will, by the aid of the illustration, observe closely the construction of this simple device, he will be able to comprehend, once for all, not only the novelty of the invention, but also its extreme simplicity.

Connected with a wooden box, supported on a shelf, as here indicated, is a flexible rubber tube, which in turn is attached at its lower end to an iron tube, that rises through the floor of a miniature wagon. This wagon rests on the roof of a box through which a slit is cut in the direction shown. Through this slit the iron tube passes, projecting into the box below. It is to the structure of this metal tube, or gun, as it is called, that attention is specially directed. As shown in the

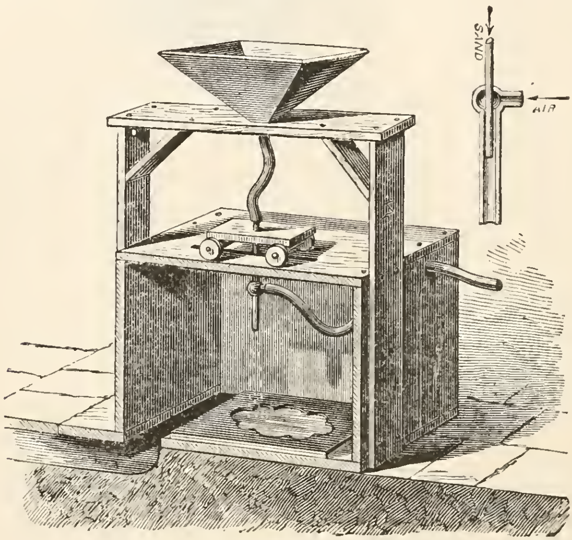


Fig. 3.—The Tilghman Sand-blast Machine.

section at the right, it consists of two tubes, the one leading down from the box and conveying the sand being smaller, thus allowing of an annular space between it and the lower section. Into this lower section, and at a right angle to it, the blast of air is admitted from a suitable reservoir. The sand falling down, as shown by the upper arrow, enters the lower tube at a point below that at which the air is admitted. Having passed below the limits of its conducting-tube, it receives an extra impulse from the air-current that also is passing downward, and by it is projected with greater force upon the *hard* substance below. In addition to the advantage gained by this new impulse, it will also be seen that the blast serves another purpose in blowing away the sand, so soon as its work is done, and thus leaving the surface below clean and in a condition to be the more readily acted upon by the succeeding blasts. The purpose of the wagon is merely to admit of the tube being moved forward and backward along the line of the plate to be engraved, the lateral movement of the plate being effected by a suitable device not here shown. This plate is inclosed in a box, for the reason that the falling grains of sand, while they chip away the surface of the plate, are also broken up and powdered. And it is that this dust may not interfere with the health and comfort of the workmen that the whole is confined in a closed box.

Before describing the several methods by which, through the aid of specially-prepared stencils, the surfaces to be treated are exposed to the action of the blast, we will direct attention to certain of the more recent forms of the machines, all embodying the same general principles, but so modified as to adapt them to the special service for which they are intended.

Foremost among these devices is the large machine, by the aid of which flat plates are ground or engraved.

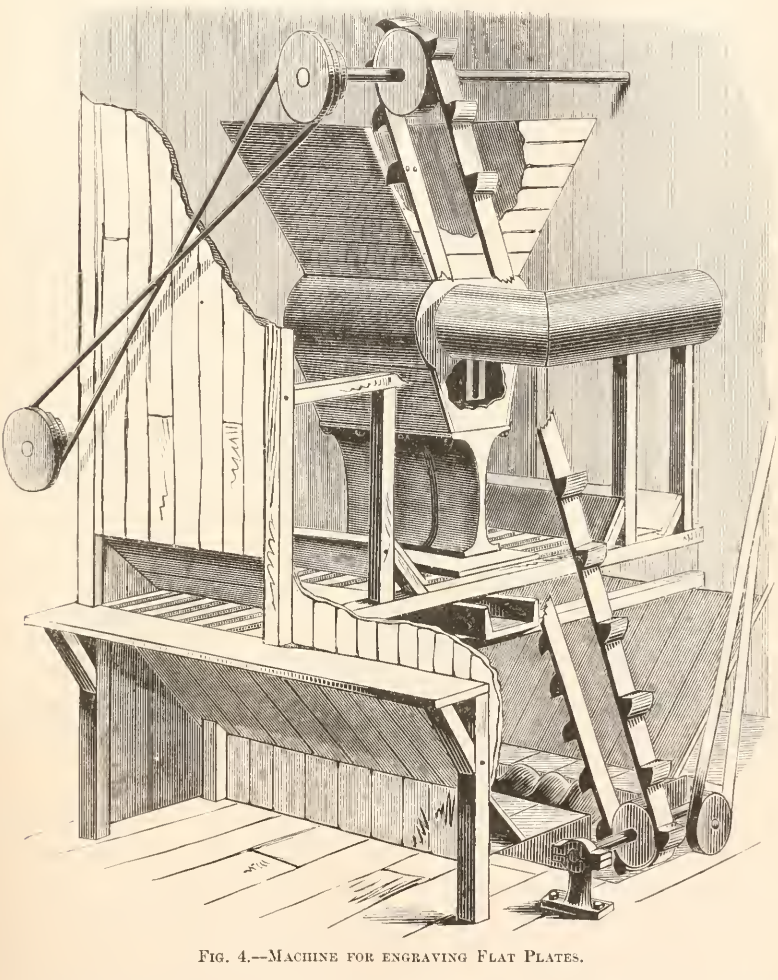

Fig. 4.—Machine for engraving Flat Plates.

The distinctive feature of this machine is the substitution of a long, narrow slit for the tube; through this the sand falls or is blown in a thin sheet. Referring to Fig. 4, we find the machine composed of a large supply-box, into which the sand is elevated by a series of hoppers attached to a moving belt. From this box the sand falls of its own weight into a seeond reeeptaele, which serves also as a receiving-ehamber for the air-blast that enters at the right through the large blast-pipe. From this reeeiver the sand is driven downward through a seeond slit, and emerges from it with great foree.

At right angles with this slit a series of leather straps or moving belts serves to convey the polished plate beneath the sheet of falling sand, and it is during the passage of the plate under this sand-sheet that its surfaee is depolished or ground. As these plates move at the rate of from six to thirty inehes a minute, an estimate ean be made as to the rapidity with which the work of grinding is effeeted. When it is desired to merely roughen the whole surfaee, it is evident that no preliminary proeesses are needed, the plates of glass being fed in at the opening indieated on the right, and passing through to be reeeived and delivered at onee as ground glass.

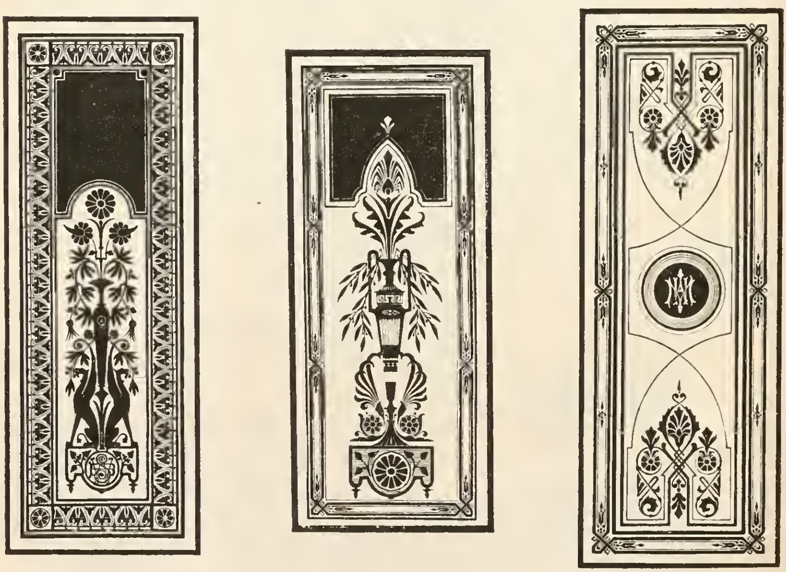

Fig. 5.—Plates engraved by Sand-Blast.

When it is desired, however, to engrave figures or designs upon the plates, a special proeess preeedes the grinding. This eonsists in the designing and attaehing of the stencils, and may be deseribed as follows: The glass plate, whieh it is proposed to ornament with any suitable device, is laid upon the designer's table and eovered over its whole surfaee with a thin sheet of tin-foil. Upon this bright metallie surface the designer sketehes his pattern, and then by the aid of a sharp knife-point euts through the foil along the lines of the pattern. The foil, which indieates the design, is then carefully lifted and removed, leaving the glass exposed, showing the exact form of the pattern. The plate is then removed and placed upon a second table, where it receives over its entire surface a thin layer of melted wax. When this wax has become sufficiently hardened, a knife is introduced beneath the portions of foil that remain, and these are gently lifted and removed with the wax immediately over them. What remains now is the original pattern traced in wax and resting on the glass. The plate thus prepared is then placed on the moving belts, or feeders, of the large machine and by them is conveyed under the falling sand-blast. Of course, this sheet of sand strikes with equal force on the whole surface; but where the wax layers intervene they act as shields, receiving the sand but checking its progress, while the exposed portions being glass, and therefore brittle, are roughened so as to present the appearance of a ground surface. After each plate passes through, it is again slightly heated, the wax removed, and the final appearance is such as indicated in Fig. 5. These illustrations, it may be stated, are from photographic imprints, taken from actual plates, and, as such, indicate with perfect exactness the character of the work. In these the light portions represent the ground or depolished surfaces, while the dark lines are those which, having been protected by the stencil shield of wax, were untouched.

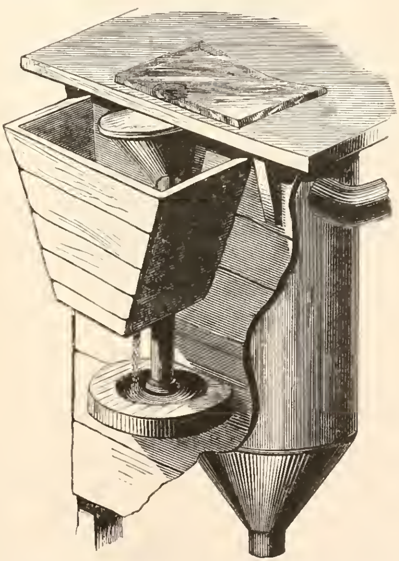

Fig. 6.—Machine operated by Exhaust instead of Blast.

When the surfaces to be acted upon are curved, as in the case of globes, tumblers, etc., a special device is needed. The feature of this is an exhaust-chamber, by the aid of which the sand is drawn up through a tube and projected upward, as shown in Fig. 6. Immediately above the orifice through which the sand rises, the stencil-covered globes are caused to revolve on spindles, and, when finished, have the appearance indicated in Fig. 7.

If the reader has been able to follow this necessarily brief description, he will readily perceive how, by the use of duplicate stencils, constructed of any tough substance, the work of engraving, once an art in itself, becomes merely a mechanical process. As the result of experiments, now nearly completed, a form of rubber ink has been devised which, when laid on paper, converts it into a stencil, sufficiently tough to resist the action of the blast. Then, again, it may be seen how designs, direct from Nature, may be transferred to glass or metal by merely attaching a leaf or vine to the surface, and exposing it to the action of the blast. Nor is glass the only substance that can be ground and engraved. All metals, when hardened, are as

Fig. 7.

readily cut. The zinc plates which are now being substituted for lithographic stone have their surfaces depolished by the sand-blast. As illustrative of the remarkable rapidity with which the sand-blast accomplishes its work, the following facts, regarding the cutting of inscriptions on the head-stones designed to mark the graves of soldiers buried in the national cemeteries, may be cited. The contractor having this work in charge at Rutland, Vermont, has three sand-blast machines, of the form indicated in Fig. 8.

In addition to the one man employed to tend these machines, he has a small force of boys, whose duty it is to attach and remove the cast-iron letters which act as stencils. Thus equipped, the contractor is able to turn out three hundred head-stones a day, upon each of which is a handsomely-cut inscription averaging eighteen raised letters. It is estimated that, to accomplish a like result by the old process, a force of three hundred men would be needed. Another instance of the rapidity with which these little sand-engines do their work is shown in the engraving of glass globes, tumblers, etc., which can be done at the astounding rate of one a minute.

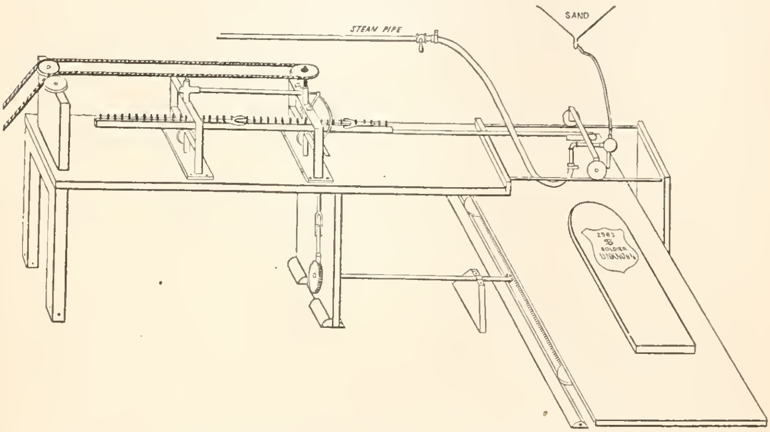


FIG. 8.—TILGHMAN'S SAND-BLAST STONE-MACHINE.

Extended space might be devoted to a mere recital of the actual present accomplishments of the sand-blast, and, were we to enter the field of speculation as to its possibilities, the range of its adaptation would tax the reader's credulity. We will therefore be content to refer to the following extract from the report of the judges at the fortieth exhibition of the American Institute, which, in awarding the inventor the great medal of honor, describes and commends his invention as follows:

"The process is designed to execute ornaments, inscriptions in *intaglio*, or relief, or complete perforations, in any kind of stone, glass, or other hard and brittle substance; or to cut deep grooves in natural rocks, in order to facilitate the process of quarrying; or to make circular incisions around the central mass of rock in the process of tunneling; or to remove slag, scale, and sand, from the surfaces of metal castings; or to clear the interior surfaces of boilers or boiler tubes of incrustations; or to cut ornaments or types from wood as well as from stone; or to depolish the surface of glass, producing by the aid of stencils or other partial protections, as the bichromatized gelatine of photographic negatives, every variety of beautiful figures, including copies of the finest lines, and the most delicate line engravings; or to prepare copper-plates in relief for printing, by making gelatine photographic pictures upon smooth surfaces of resin and pitch, cutting them out by the blast, and afterward moulding from them, and electrotyping the moulds.

"This process is without precedent. The use of sand in sawing marble, or in grinding glass by common methods, hardly furnishes an analogy."

Here follows a description of the device, concluding with the statement that "it is regarded by the judges as being one of the most remarkable and valuable inventions which the age has produced."

When it is announced that the judges who thus emphatically indorsed the claims of the sand-blast were Profs. Barnard, Mayer, and Morton, our readers will demand of the writer no apology for or qualification of his expressed opinion that the "Tilghman sand-blast is an invention which, in simplicity of construction and extent of application, has hardly an equal in the annals of American patents."

## INSTINCT AND ACQUISITION.[1]

By D. A. SPALDING.

SO great was the influence of that school of psychology which maintained that we and all other animals had to acquire in the course of our individual lives all the knowledge and skill necessary for our preservation, that many of the very greatest authorities in science refused to believe in those instinctive performances of young animals about which the less learned multitude have never had any doubt. For example, Helmholtz, than whom there is not, perhaps, any higher scientific authority, says: "The young chicken very soon pecks at grains of corn, but it pecked while it was still in the shell, and when it hears the hen peck, it pecks again, at first seemingly at random. Then, when it has by chance hit upon a grain, it may, no doubt, learn to notice the field of vision which is at the moment presented to it."

At the meeting of this Association in 1872, I gave a pretty full account of the behavior of the chicken after its escape from the shell. The facts observed were conclusive against the individual-experience psychology. And they have, as far as I am aware, been received by scientific men without question. I would now add that not only does the chick not require to learn to peck at, to seize, and to swallow small specks of food, but that it is not a fact, as asserted, and generally supposed, that it pecks while still in the shell. The actual mode of self-delivery is just the reverse of pecking. Instead of striking forward and downward (a movement impossible on the part of a bird packed in a shell with its head under its wing), it breaks its way out by vigorously jerking its head upward, while it turns round within the shell, which is cut in two—chipped right round in a perfect circle some distance from the great end.

[1] Read at the Bristol meeting of the British Association.

Though the instincts of animals appear and disappear in such seasonable correspondence with their own wants and the wants of their offspring as to be a standing subject of wonder, they have by no means the fixed and unalterable character by which some would distinguish them from the higher faculties of the human race. They vary in the individuals as does their physical structure. Animals can learn what they did not know by instinct and forget the instinctive knowledge which they never learned, while their instincts will often accommodate themselves to considerable changes in the order of external events. Everybody knows it to be a common practice to hatch ducks'-eggs under the common hen, though in such cases the hen has to sit a week longer than on her own eggs. I tried an experiment to ascertain how far the time of sitting could be interfered with in the opposite direction. Two hens became broody on the same day, and I set them on dummies. On the third day I put two chicks a day old to one of the hens. She pecked at them once or twice; seemed rather fidgety, then took to them, called them to her and entered on all the cares of a mother. The other hen was similarly tried, but with a very different result. She pecked at the chickens viciously, and both that day and the next stubbornly refused to have any thing to do with them.

The pig is an animal that has its wits about it quite as soon after birth as the chicken. I therefore selected it as a subject of observation. The following are some of my observations: That vigorous young pigs get up and search for the teat at once, or within one minute after their entrance into the world. That if removed several feet from their mother, when aged only a few minutes, they soon find their way back to her, guided apparently by the grunting she makes in answer to their squeaking. In the case I observed the old sow rose in less than an hour and a half after pigging, and went out to eat; the pigs ran about, tried to eat various matters, followed their mother out, and sucked while she stood eating. One pig I put in a bag the moment it was born and kept it in the dark until it was seven hours old, when I placed it outside the sty, a distance of ten feet from where the sow lay concealed inside the house. The pig soon recognized the low grunting of its mother, went along outside the sty struggling to get under or over the lower bar. At the end of five minutes it succeeded in forcing itself through under the bar at one of the few places where that was possible. No sooner in than it went without a pause into the pig-house to its mother, and was at once like the others in its behavior. Two little pigs I blindfolded at their birth. One of them I placed with its mother at once: it soon found the teat and began to suck. Six hours later I placed the other a little distance from the sow; it reached her in half a minute, after going about rather vaguely; in half a minute more it found the teat. Next day I found that one of the two left with the mother, blindfolded, had got the blinders off; the other was quite blind, walked about freely, knocking against things. In the afternoon I uncovered its eyes, and it went round and round as if it had had sight, and had suddenly lost it. In ten minutes it was scarcely distinguishable from one that had had sight all along. When placed on a chair it knew the height to require considering, went down on its knees and leaped down. When its eyes had been unveiled twenty minutes I placed it and another twenty feet from the sty. The two reached the mother in five minutes and at the same moment.

Different kinds of creatures, then, bring with them a good deal of cleverness, and a very useful acquaintance with the established order of Nature. At the same time all of them later in their lives do a great many things of which they are quite incapable at birth. That these are all matters of pure acquisition appears to me an unwarranted assumption. The human infant cannot masticate; it can move its limbs, but cannot walk, or direct its hands so as to grasp an object held up before it. The kitten just born cannot catch mice. The newly-hatched swallow or tomtit can neither walk, nor fly, nor feed itself. They are as helpless as the human infant. Is it as the result of painful learning that the child subsequently seizes an apple and eats it? that the cat lies in wait for the mouse? that the bird finds its proper food and wings its way through the air? We think not. With the development of the physical parts, comes, according to our view, the power to use them, in the ways that have preserved the race through past ages. This is in harmony with all we know. Not so the contrary view. So old is the feud between the cat and the dog, that the kitten knows its enemy even before it is able to see him, and when its fear can in no way serve it. One day last month, after fondling my dog, I put my hand into a basket containing four blind kittens, three days old. The smell my hand had carried with it set them puffing and spitting in a most comical fashion.

That the later developments to which I have referred are not acquisitions can be in some instances demonstrated. Birds do not *learn* to fly. Two years ago I shut up five unfledged swallows in a small box not much larger than the nest from which they were taken. The little box, which had a wire front, was hung on the wall near the nest, and the young swallows were fed by their parents through the wires. In this confinement, where they could not even extend their wings, they were kept until after they were fully fledged. Lord and Lady Amberley liberated the birds and communicated their observations to me, I being in another part of the country at the time. On going to set the prisoners free, one was found dead—they were all alive on the previous day. The remaining four were allowed to escape one at a time. Two of these were perceptibly wavering and unsteady in their flight. One of them, after a flight of about ninety yards, disappeared among some trees; the other, which flew more steadily, made a sweeping circuit in the air, after the manner of its kind, and alighted, or attempted to alight, on a branchless stump of a beech; at last it was no more seen. No. 3 (which was seen on the wing for about half a minute) flew near the ground, first round the Wellingtonia, over to the other side of the kitchen-garden, past the bee-house, back to the lawn, round again, and into a beech-tree. No. 4 flew well near the ground, over a hedge twelve feet high to the kitchen-garden through an opening into the beeches, and was last seen close to the ground. The swallows never flew against any thing, nor was there, in their avoiding objects, any appreciable difference between them and the old birds. No. 3 swept round the Wellingtonia, and No. 4 rose over the hedge just as we see the old swallows doing every hour of the day. I have this summer verified these observations. Of two swallows I had similarly confined, one, on being set free, flew a yard or two too close to the ground, and rose in the direction of a beech-tree, which it gracefully avoided; it was seen for a considerable time sweeping round the beeches and performing magnificent evolutions in the air high above them. The other, which was observed to beat the air with its wings more than usual, was soon lost to sight behind some trees. Titmice, tomtits, and wrens, I have made the subjects of a similar experiment and with similar results.

Again, every boy who has brought up nestlings with the hand must have observed that, while for a time they but hold up their heads and open their mouths to be fed, they by-and-by begin quite spontaneously to snap at the food. Here the development may be observed as it proceeds. In the case of the swallow I am inclined to think that they catch insects in the air perfectly well immediately on leaving the nest.

With regard, now, to man, is there any reason to suppose that, unlike all other creatures, his mental constitution has to be in the case of each individual built up from the foundation out of the primitive elements of consciousness? Reason seems to me to be all the other way. The infant is helpless at birth for the same reason that the kitten or swallow is helpless—because of its physical immaturity; and I know of nothing to justify the contrary opinion, as held by some of our distinguished psychologists. Why believe that the sparrow can pick up crumbs by instinct, but that man must learn to interpret his visual sensations and to chew his food? Dr. Carpenter, in his "Mental Physiology," has attempted to answer this argument in the only way in which it could be answered. He has produced facts which appear to him to prove that "the acquirement of the power of visually guiding the muscular movements is experimental in the case of the human infant." More than forty years ago Dr. Carpenter took part in an operation performed on a boy three years old for congenital cataract. The operation was successful. In a few days both pupils were almost clear; but, though the boy "clearly recognized the *direc-*

*tion* of a candle or other bright object, he was as unable as an infant to apprehend its *distance;* so that, when told to lay hold of a watch, he groped at it just as a young child lying in its cradle." He gradually began to use his eyes; first in places with which he was not familiar, but it was several months before he trusted to them for guidance as other children of his age would do. No one will doubt the accuracy of any of these statements; but I cannot agree with Dr. Carpenter that he had in the case of the boy any thing "exactly parallel" to my experiment of hooding chickens at birth and giving them their sight at the end of one or two days. This boy was couched when three years old. Probably sight would have been at first rather puzzling to my chickens, had they not received it until they were six months old. Dr. Carpenter seems to have forgotten for the moment that instincts as well as acquisitions decay through desuetude, and that this is especially true when the faculties in question have never once been started into action and are of the kind which develop through exercise. Another and vital difference between Dr. Carpenter's experiments and mine is this, that, when at the end of two days I gave my chickens sight, I did not do so by poking out or lacerating the crystalline lenses of their eyes with a needle.

The presumption, then, that the progress of the infant is but the unfolding of inherited powers remains as strong as ever. With wings there comes to the bird the power to use them; and why should we believe that, because the human infant is born without teeth, it should, when they do make their appearance, have to discover their use by a series of happy accidents?

One word as to the origin of instincts. In common with other evolutionists, I have argued that instinct in the present generation may be regarded as the product of the accumulated experiences of past generations. More peculiar to myself, and giving special meaning to the word experience, is the view that the question of the origin of the most mysterious instinct is not more difficult than, or different from, but is the same with the problem of the origin of the physical structures of the creatures. For, however they may have come by their bodily organization, it, in my opinion, carries with it a corresponding mental nature.

In opposition to this view, it has been urged that we have only to consider almost any well-marked instinct to see that it could never have been a product of evolution. We, it is said most frequently, cannot conceive the experiences that might by inheritance have become the instincts; and we *can* see very clearly that many instincts are so essential to the preservation of the creatures that without them they could never have lived to acquire them. The answer is easy. Granting our utter inability to go back in imagination through the infinite multitude of forms, with their diversified mental characteristics, that stand between the greyhound and the speck of living jelly to which, according to the theory of evolution, it is related by an unbroken line of descent—granting that we are, if possible, still less able to picture in imagination the process of change from any one form to another—what then? Not surely that the theory of evolution is false! For the same argument will prove that no man present can possibly be the son of his father. Our ignorance is very great, but it is not a very great argument.

The other objection, that the creatures could never have lived to acquire their more important instincts, rests on a careless misunderstanding of the theory of evolution. It assumes in the drollest possible way that evolutionists must believe that in the course of the evolution of the existing races there must have from time to time appeared whole generations of creatures that could not start on life from the want of instincts that they had not got. There can be no need to say more than that these unfortunate creatures are assumed to have been singularly unlike their parents. The answer is, that it is not the doctrine of evolution that the bodies are evolved first by one set of causes and the minds are put in afterward by another. This notion is but the still lingering shadow of the individual-experience psychology. As evolutionists, whether we take the more common view and regard the actions of animals as prompted by their feelings and guided by their thoughts, or believe, as I do, that animals and men are conscious automata, in either case we are under no necessity of assuming, in explanation of the origin of the most mysterious instincts, any thing beyond the operation of those laws that we see operating around us, but concerning which we have yet to learn more, perhaps, than we have learned.—*Nature.*

## PRINCE RUPERT'S DROPS.

By WILLIAM LEIGHTON, Jr., S. B.

WHEN from fluidity glass is cooled to a solid structure in the ordinary temperature of the atmosphere, it is found to be very brittle or liable to fracture.

If the glass is so shaped as to be of unequal thickness in its different parts, it can seldom be cooled without fracture, and, if unbroken when cool, is liable to fracture with any subsequent change of temperature or by a sudden jar. Often this fracture takes place, in articles of considerable thickness, with an explosive force, perhaps breaking the glass into a thousand pieces. When glass breaks in this manner, it is said to "fly."

In order to prevent such liability to "fly," glass-ware is annealed.

The process of annealing glass consists in reducing its temperature more slowly than would occur in the air at ordinary temperatures.

An oven is so constructed that the heat of the glass is maintained by a current of heated air in which articles to be annealed are placed, and mechanism so contrived as very slowly to draw away the ware into currents of lower temperature. Or the ware is annealed in kilns, which are closed and sealed at a temperature a little less than that at which glass becomes plastic, and heated air being thus confined the kilns are many hours, often many days, in cooling. The more carefully and slowly glass is annealed, the less liable it is to "fly."

By cooling glass *more* rapidly than could occur in ordinary atmospheric temperatures, that is, by a process the reverse of annealing, Prince Rupert's drops are made.

The ordinary way to make these scientific curiosities is to drop a small quantity, usually less than half an ounce, of perfectly fluid glass into water. In falling, the glass will assume the form of a tear, with an elongated end extending into a thread.

Rupert drops are clear, bright, and hard, and may be struck with much violence upon the larger end without fracture, but if the thin, though tough and very elastic thread of the other extremity be broken off, the whole drop will explode into numberless fragments, much finer than the sand of which the glass was originally composed.

Why does this happen? and why must glass-ware be annealed in order to be serviceable? There is evidently such similarity of phenomena occurring in the drops and in unannealed glass that a satisfactory theory for the one ought to lead to the explanation of the other.

In an article on "Tempered Glass" contributed by Perry F. Nursey, C. E., to the *Popular Science Review*, and published in the September number of The Popular Science Monthly, the following theory of the Prince Rupert's drops is given: "Glass and water, and—as far as present knowledge goes—no other substances besides, expand while passing from the fluid into the solid condition. The theory of the Rupert drops is, that the glass being cooled suddenly, by being dropped into cold water, expansion is checked by reason of a hard skin being formed on the outer surface. This exterior coating prevents the interior atoms from expanding and arranging themselves in such a way as to give the glass a fibrous nature, as they would if the glass were allowed to cool very gradually. An examination of the Rupert's drop shows the inner substance to be fissured and divided into a number of small particles. They exist in fact in a state of compression, with but little mutual cohesion, and are only held together by the external skin. So long as the skin remains intact, the tendency of the inner particles to expand and fill their proper space is checked and resisted by the superior compressive strain of the skin. Nor is the balance of the opposing forces disturbed by blows on the thick end of the drop, which vibrates as a whole, the vibrations not being transmitted from the exterior to the interior. But, by breaking off the tail of the drop, a vibratory movement is communicated along the crystalline surface, admitting of internal expansion, by which the cohesion of the particles composing the external skin is overcome, and the glass is at once reduced to fragments."

In the "American Cyclopædia" (revised edition), under the word "annealing," are found the following enplanations: "When this" (glass) "is melted and shaped into articles which are allowed to cool in the air, the glass becomes too brittle for any use. The exterior cools first and forms a contracted crust, which shelters the interior particles; so that these continue longer in a semi-fluid state, and are prevented from expanding, as glass does in cooling, and uniting with the rest to form an homogeneous mass. The inner parts are thus constantly tending to expand. If, on the contrary, the glass is placed in a hot oven, and this is allowed to cool very slowly, the particles of glass appear to assume a condition of perfect equilibrium of cohesive force without tension, so that the mass becomes tough and elastic." And, again, in the same article: "Dr. Ure explains this phenomenon" (the explosive breaking of Prince Rupert's drops) "by referring it to the tendency of a crack once formed in the glass to extend its ramifications in different directions throughout the whole mass."

In the "Encyclopædia Britannica" (ninth edition), under the word "annealing," is found as follows concerning the phenomena of unannealed glass and Prince Rupert's drops: "The particles of the glass have a cohesive polarity which dictates a certain regularity in their arrangement, but which requires some time for its development. When the vessels are suddenly cooled, the surface-molecules only can have had time to dispose themselves duly, while those within are kept by this properly-formed skin in a highly-constrained situation; and it is only so long as the surface-film keeps sound that this constraint can be resisted. In the Rupert's drops it is plainly visible that the interior substance is cracked in every direction, and ready to fly to pieces."

The practical glass-maker, desirous of thoroughly understanding the true theory of annealing glass, that from such a comprehension he may endeavor to accomplish more perfection in his process, refers to the authorities quoted above, and finds himself bewildered by the theories and explanations here given. He notices that the foundation of the theory of the Rupert drop, and of the process of annealing, in the article of The Popular Science Monthly, and in the "American Cyclopædia," is based upon the assertion that in passing from a fluid to a solid condition glass expands. Although well aware that certain substances, as water,[1] bismuth,[2] gray cast-iron,[3] and antimony,[4] expand while solidifying, yet he is constantly reminded, by phenomena occurring in the glass-house every moment under his eye, that the reverse of this takes place in the substance of glass.

[1] Ganot's "Physics," edition of 1873, p. 261.
[2] Miller's "Chemistry," vol. ii., p. 604.
[3] Bauerman's "Metallurgy of Iron," p. 233.
[4] Miller's "Chemistry," vol. ii., p. 595.

Upon the supposition that glass contracts in cooling, he bases the construction and working of his moulds, in which glass-ware is pressed, and the success of their operation assures him that he is working upon a safe conclusion.

For further assurance, he replaces an article of glass-ware, when cold, in the mould in which it was originally pressed, and finds that it easily returns to its place, and fails to fill the mould. With his calipers he measures carefully the glass and the mould, and finds the shrinkage has been about one-fiftieth of the original bulk.

He remembers that he has on his book-shelf a work[1] by Apsley Pellatt, in which that careful and accurate observer states as follows: "A piece of unannealed barometer-tube, forty inches long, measured when just drawn, will become about one-fourth of an inch shorter if annealed; whereas, if quickly cooled without annealing, it will only contract about one-eighth of an inch." It must be borne in mind that the barometer-tube, when just drawn, at the time when it is first measured, has already considerably cooled from a fluid state of the glass, and has effected a part of its shrinkage, although not yet solid or rigid in its structure.

As the gray cast-iron before mentioned is said to expand at the moment of solidifying, but afterward to contract with further cooling, he experiments with the view to ascertain if an analogous action takes place in glass. He tests the cooling of a crucible full of this molten material, to note if at any time in the cooling process an expansion of its substance takes place. Even from the first moment, when the crucible is taken from the extreme heat of the furnace, he finds that the surface of the vitreous mass takes a concave form, this concavity becoming more considerable as the cooling process goes on.

If there were expansion at the moment of solidifying, the mass would then bulge upward, that is, the concave line of the surface would be disturbed. But, as the concavity of this surface constantly and uninterruptedly increases until the mass becomes cold, he finds renewed proof of the shrinkage of solidifying glass.

His ordinary observation thus confirmed by careful tests and by other authority, he feels that there is no possibility for him to be in error in regard to this contraction of glass, which he sees constantly going on.

When he reads, in the article of The Popular Science Monthly, that the exterior coating produced by the immediate chill of the surface of the glass "prevents the interior atoms from expanding and arranging themselves in such a way as to give the glass a fibrous nature, as they would if the glass were allowed to cool very gradually," he tries to remember an instance, where, in some very perfectly-annealed glass, there has been an indication of such fibrous nature, but finds himself unable, in his own experience, or in that of his

[1] "Curiosities of Glass-making," by Apsley Pellatt, London, 1849, p. 63.

workmen, to recall such structure in any case. He finds the substance of glass always presenting the same vitreous, amorphous appearance, except in cases of devitrification, and, in the absence of any proof of such condition, cannot bring himself to believe in glass of a fibrous structure.

He finds in "a cohesive polarity, which dictates to the particles of glass a certain regularity in their arrangement, but which requires some time for its development," as laid down in the "Brittanica," a theory which is far from satisfying or giving him any useful aid, and he requires some proof (which he cannot find) of such "polarity" before absolutely adopting this theory.

He looks in vain for the fissured character of the interior substance of the Rupert drop, mentioned in the article of The Popular Science Monthly, and in the "Encyclopædia Britannica," but finding, even under the microscope, that the substance of the interior, as well as the exterior, of the drop is apparently solid and undisturbed, gives up his attempt to understand the authorities, and even Dr. Ure's explanation in the "American Cyclopædia," of the Rupert-drop phenomena, fails to satisfy him.

He now feels that, to pursue this subject further, he must put together the facts in his possession, and ascertain if their combination will not suggest a more satisfactory theory than those laid down in the books.

He begins, of course, upon the foundation which his twenty years' experience in the glass-house has strongly impressed on him, viz., the fact that in passing from a fluid to a solid state *glass shrinks.*

His next fact is that glass is a poor conductor of heat, as he has often noticed in the manipulation of heated glass, during its process of manufacture, that in the same piece of glass, and close together, are portions, the one solid and the other fluid.

To these facts he puts the third fact, that the surface of fluid or semi-fluid glass chills very quickly upon exposure to the air, and very quickly becomes solid.

Here are all the facts necessary by which to construct a theory for the explanation of the phenomena of fracture in unannealed glass and in the Rupert drops.

Watching a thick mass of glass cool, he notes the color: by an oblique look, he perceives that the surface has a green tint; while through this transparent tinted medium a direct look shows the centre still of a glowing red color. He knows by experience that the green tint in cooling crystal glass indicates solidification, while the red glow tells that such glass is yet soft. But, not depending upon his experience of color, he tests the surface with an iron tool and finds it absolutely rigid; then with a hammer breaks this rigid surface, and finds, as its color indicates, the centre still semi-fluid.

Here is proved the condition of an outer skin or shell of rigid glass, and an interior substance, still soft, plastic, and constantly strained by a tendency to contract, to occupy smaller boundaries; but those boundaries cannot be moved without breaking. It is a struggle of forces. If the thickness of the glass be considerable, the constantly-increasing strain of contraction pulls so hard upon the shell, that the force of cohesion is unable to withstand it, and the shell, yielding with a shock, shivers the whole substance into fragments.

In the process of annealing, the heat of the oven keeps the surfaces of the glass articles from absolutely becoming rigid, so that they yield sufficiently to the strain of the contracting interior portions; and if the whole substance of each article cools exactly together, the exterior and interior all the time at the same temperature, there is no strain and the ware is perfectly annealed.

As it is practically impossible to accomplish a perfect equality of temperature, a perfect equilibrium of the molecules cannot be obtained; but so near an approach to it is accomplished in a well-constructed annealing oven, that the cohesion of the glass is easily able to withstand the trifling strain.

In this view the action of cooling glass is simple and easily understood, surely more simple than to imagine a tendency toward a fibrous constitution of substance, or the imperious "cohesive polarity" of the "Britannica" article.

Test this theory upon the Rupert-drop phenomenon, and its explanation will answer as well.

A small amount of fluid glass, when dropped into water, will immediately, by the action of its heat, envelop itself in a garment of steam, which protects its surface from contact with the water, until that surface is so cooled that such contact fails to crack it. To test this assumption, try the experiment with partially cooled or soft glass, and the result will be that *all* the drops will break in the water, on account of cracked surfaces. With fluid glass, many drops will be lost, not from the same cause, if the drops be not too large, but from excessive contraction; perhaps, out of a dozen only one or two will be saved.

The steam chills the surface of the glass much more rapidly than the air does, consequently the inner and fluid glass in the Rupert drop is inclosed in larger boundaries than if the drop had cooled in the air. Hence contractive force is very strongly exerted to draw in such excessive boundaries, but the curved form of the drop presents arches of strength to aid the power of cohesion and resist destruction.

One drop bursts in the water, another does the same, but perhaps the third is drawn forth entire, though curled and twisted, as if in the agony of its strain. Two of Nature's forces struggle fiercely for the mastery in this little drop, that gives no indication of the contest as it lies quietly before us. But break off the thread, and down goes the first of the little arches, that are holding up the surface against contraction. One arch, falling, brings down another, and, once started, they go in such rapid succession that the ear detects but one sound, one explosive burst, in which the imp of contraction exults in the ruin he has wrought.

The peculiarities of the Rupert drops are toughness, elasticity, and the property of breaking into small fragments when any fracture, however slight, is made; their strength to resist such fracture is, however, greater than that of annealed or unannealed glass.

When we consider that these same peculiarities are the characteristics of the so-called "toughened glass" of M. de la Bastie, and that the method of treating his "toughened" glass, in the cooling process, is at least analogous to that of the Rupert drops, we are forced to believe in a certain relationship between them.

The Rupert drop falls into a water-bath; M. de la Bastie's glass into an oleaginous bath, the exact composition of which has not been made public.

M. de la Bastie's glass is not malleable, is not unbreakable, but simply tougher, harder to break than the ordinary annealed glass; so also is the Rupert drop.

As the characteristic distinction between annealed glass and the Rupert drop is the excessive strain upon the molecules of the latter—contraction *versus* cohesion—it is fair to infer that the superior strength, toughness, and elasticity, of the drop are due to such strain. As it is harder to displace the key-stone of a loaded arch than of an unloaded one, the simile may hold good in this case, and the strain of contraction upon the molecules of the glass of a Rupert's drop may help resist any outside force tending to disturb cohesion. If an outside force could be so exerted as to act exactly in the same direction as the power of contraction acts, undoubtedly such force would be aided by contraction to destroy cohesion; but, acting in any other direction, contraction would aid cohesion to resist it. As the molecules of glass are exceedingly small, and as, in the cooling process, they one after another individually become rigid, the lines of their contractive strain become so complicated that it is very unlikely any outside force can be exerted in such direction as to unite its impulse with theirs against cohesion.

As the toughened glass of M. de la Bastie flies into many pieces when fracture is effected, in a manner analogous to the breaking of the Rupert drop, it is probable, at least, considering the process of the oil-bath, that such flying into fragments is due to a strain of contraction exerted by the molecules of its substance. And if such a strain exists, as the flying seems to prove, it is also reasonable to suppose that, exactly as in the case of the Rupert drop, this strain of contraction among the molecules of its mass produces the superior toughness, strength, and elasticity, which are claimed for this newly-invented glass.

# THE OWNERSHIP OF THE DEAD.[1]

By SAMUEL B. RUGGLES, LL. D.

IN resorting to England for light on this subject, we encounter a body of law grown up under circumstances differing widely from our own. The jurisprudence of that country is peculiarly compounded, embracing largely the ecclesiastical element, from which ours is exempt; and it has given birth to anomalies which we are hardly required to adopt. This is strikingly manifest in the matter of the dead, in which the partition of juridical authority between the Church and the state, forming one composite system, has materially narrowed the powers and the action of the courts of common law. It is believed that an attentive examination of the history of this division of judicial power will show that it is wholly peculiar to England, and that the decisions and *dicta* of their courts and legal writers on this subject ought not to exert any controlling influence over our legal tribunals.

In surveying the various changes in the organization and powers of the British courts of justice, produced successively by the Roman, Saxon, and Norman conquests, it is difficult to fix with precision the period when the judicial authority began to be divided between the state and the Church. Christianity had made some progress in Britain while yet remaining under the Roman power, but does not appear to have mingled itself materially with the governmental administration. The Saxon conquerors, who succeeded the Roman in the fifth century, brought in paganism for about one hundred and fifty years; but it was extirpated about the close of the sixth century by the vigor of St. Augustin, under the pontificate of Gregory the Great. It is quite apparent that the clear-sighted incumbents of the Holy See by that time had perceived in the burial of the dead a very important and desirable element of spiritual dominion. It was the sagacity, not less than the piety, of that distinguished pontiff, which led him to introduce the custom of burial in churches, to the end, as he declared, that the relatives and friends of the dead might be induced more frequently to pray for their repose. Occasional interments in places of worship, or their immediate vicinity, had indeed been made by the early Christians, as far back as the reign of Constantine; but it was not until after the pontificate of Gregory, and the rapid increase by his successors of the temporal power of the Church, that burial-grounds were generally attached to places of worship, and subjected by formal consecration to ecclesiastical authority.

[1] Extract from a report on the "Law of Burial," made to the Supreme Court of the State of New York in 1856, by Hon. Samuel B. Ruggles, referee, in respect to compensation to owners of vaults in cemeteries, and to relatives of individuals buried in graves disturbed by legal proceedings. Reprinted in Providence, R. I., 1872. 46 pages

The judicial history of the Romish Church in England, from the sixth century to the thirteenth, exhibits its earnest efforts and its steady and all but uninterrupted progress, not only in strengthening its proper spiritual power, but in obtaining the exclusive temporal, judicial cognizance of all matters touching the ecclesiastical edifices and their appendages, and especially their places of burial. During that period, the office of sepulture, originally only a secular duty, came to be regarded as a spiritual function—so much so, that the secular courts, in the cases as early as the 20th and 21st Edward I., cited in 2 Inst., 363, in determining whether or not a building was a church, inquired only whether it had sacraments *and sepulture.*

It is generally stated that burial in church-yards was introduced into England by Cuthbert, Archbishop of Canterbury, in the year 750. The form of their consecration is even yet preserved, in some of its essential features, by the Established Church. The invocation, as given by Burn, in his "Ecclesiastical Law," vol. i., p. 334, after declaring that the duty has been taught by God, "through his holy servants, in all ages, to assign places where the bodies of the saints may rest in peace and be preserved from all indignities," asks the divine acceptance "of the charitable work, in separating the portion of ground to that good purpose."

The sagacious policy of the Romish ecclesiastics, in attaching the place of interment to the church, was duly strengthened by the stringent provision of the canon law, which prohibited heretics from Christian burial. To repose in any but consecrated earth soon came to be ignominious; and thus the church-yard became a vital portion of the material machinery for enforcing spiritual obedience and theological conformity. Nor was the power neglected. It governed Europe for several hundred years, and it was but shortly before the Protestant Reformation in England that one Tracy, being publicly accused in convocation of having expressed heretical sentiments *in his will*, and being found guilty, a commission was issued to dig up his body, which was done accordingly.—(1 Burn, "Eccl. Law," p. 266.)

During the early portion of the Anglo-Saxon period, the power of the clergy over the dead was kept in check by uniting the lay with the clerical order in the ecclesiastical tribunals; but their jurisdictions were separated soon after the Norman conquest, and the effect upon the dead is plainly discernible. The exclusive power of the ecclesiastics, denominated in legal phrase "ecclesiastical cognizance," became not only executive, but judicial. It was executive, in taking the body into their actual, corporeal possession, and practically guarding its repose in their consecrated grounds; and it was judicial, as well in deciding all controversies involving the possession or the use of holy places, or the pecuniary emoluments which they yielded, as in a broader field, in adjudicating who should be allowed to lie in consecrated earth, and, in fact, who should be allowed to be interred at all.

The deplorable superstition that could induce people to intrust such a power to any but its civil government and civil courts is amazing, and yet we find the sturdy English nation, under the government of William of Normandy, stripping their cherished Anglo-Saxon courts of all power to protect the dead, and yielding them up blindfold to priestly cognizance. As Sir William Blackstone well says, it was a "fatal encroachment" on the ancient liberties of England. Eight centuries have not sufficed to repair the mischief. Anselm and Becket, in modern garb, live even yet.

The deep-seated, fundamental idea of human burial lies in the mingling our remains with the mother earth. The "dust to dust! earth to earth! ashes to ashes!" of the Church—echoing, in deeper solemnity, the "*ter pulvere*" of Horace, and hallowing the dying wish of Cyrus—finds a universal response in the holiest instincts of man in every age. Here, then, was the tender spot for subtle power to touch. Logically pursuing this idea, the ecclesiastical process of excommunication prohibited burial in the earth at all, whether consecrated or not. The precise words of the *formula*, as used in the tenth century, gave over the body of the contumacious offender for food to the fowls of the air and beasts of the field: "Sint cadavera eorum, in escam volatilibus cœli, et bestiis terræ." In some instances the sentence was more definite and specific, confining the corpse to the hollow trunk of a tree, "in concavo trunco repositum." The essence of the idea being to keep the body out of the earth and on the surface, it was sometimes figuratively expressed, in monkish rhetoric, by "the burial of an ass," or by a stronger and more characteristic image, as "a dunghill:" "Sepultura *asini* sepeliantur, et in *sterquilinium* super faciem terræ sint." The afflicted but sinful laity, to hide the horror of the spectacle, were wont, at times, to cover the festering dead with a pile of stones, thereby rearing a *tumulus*, or "*bloc;*" so that the process came to be commonly known, in mediæval Latin, as "*imblocare corpus.*"—(Du Cange, Glossary, "Imblocare.")

The same dominant idea of the unfitness of spiritual offenders to pollute the earth can be distinctly traced through the judicial ecclesiastical condemnations for several centuries. John Huss and Jerome of Prague being at the stake for heresy, early in the fifteenth century, under the ecclesiastical order of the Council of Constance, their ashes were not allowed to mingle with the earth, but were cast into the Rhine.

The legal process of scattering the ashes of the heretic was evidently a very significant and cherished feature in the ecclesiastical code of procedure, and it was executed in the different portions of Christendom with all attainable uniformity and precision. Within its comprehensive range it embraced not only the ashes of the heretic freshly burnt, but the mouldering remains of any who had been suffered, through mistake or inadvertency, to slip into their graves. Wycliffe, the first English translator of the Scriptures, had ventured, in life, to question certain points of dogmatic theology, but, dying in his bed, in the year 1384, had been allowed to sleep for forty-one years in a church-yard in Leicestershire. The assembled dignitaries in the Council of Constance, after duly disposing of the ashes of Huss and Jerome, judicially declared the heresy of Wycliffe, and his bones were accordingly dug up and burnt, and the ashes thrown into the river Avon, in the due exercise of the executive branch of ecclesiastical cognizance, in the year 1425 of the Christian era.

Nor was the ecclesiastical cognizance of the dead confined to delinquents of low degree, or in the plainer walks of life. The Emperor of Germany, Henry IV., the victor of more than sixty battles, dying under papal excommunication by Hildebrand, the seventh Gregory, was compelled to lie for five years unburied, in the very sight of the majestic cathedral of Spires, which his father had commenced, and he had completed.

But the high and transcendent energy of ecclesiastical cognizance was completely developed in England in the thirteenth century, when it reached its culminating point, with the whole kingdom as the defendant. From the year 1207 to the year 1213, the interdict of Innocent III. kept out of their lawful graves all the dead, from the Channel to the Tweed. No funeral-bell in the kingdom was permitted to toll; the corpses were thrown into ditches, without prayer or hallowed observance, and the last drop of priestly malice and vengeance was exhausted, in compelling all, who wished to marry, to solemnize the ceremony in the church-yard.

It was during this unbridled career of papal aggrandizement through these dark and dismal ages, that the ancient civil courts of England gradually lost their original legitimate authority over places of interment, as private property, and their proper and necessary control over the repose of the dead. The clergy monopolizing the judicial power over the subject, burial was committed solely to ecclesiastical cognizance, while the secular courts, stripped of all authority over the dead, were left to confine themselves to the protection of the monument, and other external emblems of grief, erected by the living. But these they guarded with singular solicitude. The tombstone, the armorial escutcheons, even the coat and pennons, and ensigns of honor, whether attached to the church edifice or elsewhere, were raised as "heirlooms" to the dignity of inheritable estates, and descended from heir to heir, who could hold even the parson liable for taking them down or defacing them.

The reverent regard of the common law for these memorials is curiously manifested by Coke in the "Third Institute," page 203, where he expatiates upon a monumental stone, in his time more than four hundred years old, inscribed with the name of a Jewish rabbi, and inlaid in the ancient wall of London—as if to intimate that the law would protect from injury that venerable piece of antiquity.

But at this point the courts of the common law stopped, and held, in humble deference to the ecclesiastical tribunals, that the heir could maintain no civil action for indecently or even impiously disturbing the remains of his buried ancestor, declaring the only remedy to belong to the parson, who, having the freehold of the soil, could maintain trespass against such as should dig or disturb it. The line of legal demarkation established in this subject, between the ecclesiastical and the common-law courts, is thus defined by Coke: "If a nobleman, knight, esquire, etc., be buried in a church, and have his coat-armor and pennons, with his arms, and such other insigns of honor as belong to his degree or order, set up in the church, or *if a gravestone be laid or made for memory of him*, albeit the freehold of the church be in the parson, and that these be annexed to the freehold, yet cannot the parson, or any, take or deface them, but he is subject to an action to the *heire and his heires*, in the honor and memory of whose ancestor they were set up" (1st Inst., 4, 18 *b*). In the "Third Institute," page 203, he asserts the authority of the Church, as follows: "It is to be observed," says he, "that in every *sepulchre* that hath a monument, two things are to be considered, viz.: the monument, and the *sepulture* or buriall of the dead. The *buriall* of the *cadaver*, that is *caro data vermibus*" (flesh given to worms), "is *nullius in bonis*, and belongs to ecclesiastical cognizance; but as to the monument, action is given, as hath been said, at the common law for the defacing thereof."

With all proper respect for the legal learning of this celebrated judge, we may possibly question both the wisdom and the etymology of this verbal conceit, this fantastic and imaginary gift, or outstanding grant to the worms. In the English jurisprudence, a corpse was not given or granted to the worms, but it was taken and appropriated by the Church. In Latin, it was a "*cadaver*" only because it was some thing *fallen* (*á cadendo*), even as the remains of fallen cities, in the letter of Sulpicius to Cicero ("Lit. Fam.," 7), are denominated "*cadavera oppidorum*."

The learned lexicographers and philologists Martinius and the elder Vossius, both of them contemporaries of Coke, wholly dissent from his whimsical derivation. Martinius derives "cadaver" from "*cadendo, quia stare non potest*," "Lexicon Philologicum Martinii," 1720; while Vossius unequivocally reproves the derivation in question, as an act of pleasant but inflated trifling. "*Suaviter nugantur*," says he, "qui cadaver *conflatum aiunt*, ex tribus vocibus, caro data vermibus" ("Etymologicon Linguæ Latinæ," Amsterdam, 1662). And yet this inflated Latin trifle, the offspring only of Coke's characteristic and inordinate love of epigram, has come down through the last three hundred years, copied and recopied, and repeated again and again by judges and legal writers, until it has imparted its tincture to the laws of the dead, throughout every portion of the earth which listens to the English tongue.

But even the *dictum* itself, if closely examined, will not be found to assert that no individual can have any legal interest in a corpse. It does not at all assert that the corpse, but only that the "*buriall*" is "nullius in bonis;" and this assertion was legally true in England where it was made, for the peculiar reason above stated, that the temporal office of burial had been brought within the exclusive, legal cognizance of the Church, who could and would enforce all necessary rules for the proper sepulture and custody of the body, thus rendering any individual action in that respect unnecessary. The power thus exercised by the ecclesiastical tribunals was not spiritual in its nature, but merely temporal and juridical. It was a legal secular authority, which they had gradually abstracted from the ancient civil courts, to which it had originally belonged; and that authority, from the very necessity of the case, in the State of New York, must now be vested in its secular courts of justice.

The necessity for the exercise of such authority, not only over the burial, but over the corpse itself, by some competent legal tribunal, will appear at once if we consider the consequences of its abandonment. If no one has any legal interest in a corpse, no one can legally determine the place of its interment, nor exclusively retain its custody. A son will have no legal right to retain the remains of his father, nor a husband of his wife, one moment after death. A father cannot legally protect his daughter's remains from exposure or insult, however indecent or outrageous, nor demand their reburial, if dragged from the grave. The dead deprived of the legal guardianship, however partial, which the Church so long had thrown around them, and left unprotected by the civil courts, will become, in law, nothing but public nuisances, and their custody will belong only to the guardians of the public health, to remove and destroy the offending matter, with all practicable economy and dispatch. The criminal courts may punish the body-snatcher who invades the grave, but will be powerless to restore its contents. The honored remains of Alexander Hamilton, reposing in our oldest church-yard, wrapped in the very bosom of the community, built up to greatness by his consummate genius, will become "*nullius in bonis*," and belong to that community no longer. The sacred relics of Mount Vernon may be torn from their "mansion of rest," and exhibited for hire in our very midst, and no civil authority can remand them to the tomb.

Applied to the case now under examination, the doctrine will deny to a daughter, whose filial love had followed her father to the grave, and reared a monument to his memory, all right to ask that his remains, uprooted by the city authorities and cast into the street, shall again be decently interred. In England, with judicial functions divided between the state and the Church, the secular tribunals would protect the monument, the winding-sheet, the grave-clothes, even down to the ribbon (now extant) which tied the *queue;* but the Church would guard the skull and bones. Which of these relics best deserves the legal protection of the Supreme Court of law and equity of the State of New York? Does not every dictate of common-sense and common decency demand a common protection, for the grave and all its contents and appendages? Is a tribunal like this under any legal necessity for measuring its judicial and remedial action by the narrow rule and fettered movement of the common law of England, crippled by ecclesiastical interference? May it not put forth its larger powers and nobler attributes, as a court of enlightened equity and reason?

The due protection of the dead engaged the earnest attention of the great lawgivers of the polished nations of antiquity. The laws of the Greeks carefully guarded the private rights of individuals in their places of interment; and a similar spirit shines forth, in the clear intelligence and high refinement of the Roman jurisprudence. In the "Digest of the Civil Law," pl. 47, title 12, we find the beneficent and salutary provision, which gave a civil remedy, by the "*Sepulchri violati actio*," to every one interested, for any wanton disturbance of a sepulchre, and where "Ulpian, prætor, ait; Cujus dolo malo sepulchrum violatum esse dicetur in eum in factum judicium dabo ut *ei ad quem pertineat*, quanti ob eam rem æquum, videbatur condamnetur. Si nemo erit ad quem pertineat, sive agere nolet; quicunque agere volet, ei centum aureorum, actionem dabo"—a sepulchre being comprehensively defined, by another clause, to be, any place in which the body or bones of a man were deposited: "*Sepulchrum est, ubi corpus ossave hominas, condita sunt.*"—("Dig.," pl. 7, § 2.)

Nor does the *dictum* of Coke, now under consideration, assert—for historically it would not be true—that no individual right to protect the repose of the dead had ever existed, under the common law of England. So far from that, we see in the provision above extracted from the "Digest," that the individual right did exist, during the greater part of the four hundred years when England, then called Britain, formed part of the Roman Empire. In the six centuries of Saxon rule which succeeded, as is forcibly observed by Chancellor Kent, "the Roman civilization, laws, usages, arts, and manners, must have left a deep impression, and have become intermixed and incorporated with Saxon laws and usages, and *constituted the body* '*of the ancient English common law.*'"—(1 Kent's "Commentaries," p. 547.)

The provision in question had been introduced into the Roman jurisprudence, long before its systematic codification by Justinian. It bears on its face the name of Ulpian, the great Roman jurist, who not only lived as early as the second century of the Christian era, but actually assisted (as Selden states in his "Appendix to Fleta") in the judicial administration of Britain. He was the contemporary, and doubtless the personal and professional friend, of the celebrated prætorian-prefect Papinian, himself the most distinguished lawyer of his age, and chief administrator, in the year 210, of the Roman government at York. Selden glowingly depicts the judicial illumination of that early British age, as flourishing alike under the "Jus Cæsareum," the imperial law, and its able administration by those two most accomplished and illustrious Romans, "viri peritissimi, illustrissimique è Romanis.—(Selden's "Appendix to Fleta," p. 478.)

Nor is there any reason to believe that the Romanized British, when released, in the fifth century, from their political allegiance to the empire, abandoned the civilization, or abrogated the laws or usages which they had so long enjoyed; still less that they would seek or desire, in any way, to withdraw from their sepulchres and graves the protection which those laws had so fully secured. There is not a shadow of historical evidence that, under the Saxon invaders, who succeeded the Roman governors, any less respect was shown for the buried dead. On the contrary, it is distinctly shown by the Scandinavian historians, that these partially civilized Saxons had been specially taught to reverence their places of burial by their great leader Odin, the father of Scandinavian letters, distinguished for his eloquence and persuasive power, and especially commemorated as being the first to introduce the custom of erecting gravestones in honor of the dead.

In the dim and flickering light by which we trace the laws of these long-buried ages, the fact is significant and instructive that, of the several founders of the seven little Saxon kingdoms constituting the Heptarchy, nearly all deduced their descent, more or less remotely, from Odin himself. Hengist, who led the Saxon forces into Britain, and became first King of Kent, claimed with peculiar pride to be his great-grandson—rendering it quite improbable that during the rule of himself or his race, or that of his kindred sovereigns, which lasted from three to four hundred years, Saxonized Britain learned to abandon its buried ancestors, or hold them, in law, "nullius in bonis."

Nor do we find, in the occasional inroads of the Danes temporarily disturbing the Saxon governments of England, any evidence that they obliterated, in the slightest degree, the reverential usages in the matter of the dead, coming down from Odin. The early laws of that rude people, carefully collected in the twelfth century by the learned antiquary Saxo Grammaticus, speak with abhorrence of those who insult the ashes of the dead, not only denouncing death upon the "alieni corruptor cineris," but condemning the body of the offender to lie forever unburied and unhonored.—("Law of Frotho," Saxo Grammaticus, lib. v.)

The law of the Franks, near neighbors of the Saxons, cited by Montesquieu ("Spirit of Laws," lib. 30, chap. 19), not only banished from society him who dug up a dead body for plunder, but prohibited any one from relieving his wants, until *the relatives of the deceased* consented to his readmission—thus legally and distinctly recognizing the peculiar and personal interest of the relatives in the remains.

We are, indeed, so surrounded by proof of the universal reverence of the Gothic nations for their buried ancestors that we are justified in assuming it to be historically certain that the barbarous idea of leaving the dead without legal protection never originated with them; that the enlightened provision of the Roman jurisprudence, which protected in Britain the individual right to their undisturbed repose, not only remained unaffected by the Saxon invasion, but was implanted by that event still more deeply in the ancient common law of England; and that it must have been vigorously enforced, as well by the earliest secular courts of the Anglo-Saxons, as in that transition period of their judicial history, when the sheriff and the bishop, sitting side by side on the bench, united the lay and the ecclesiastical authority in a single tribunal.

Nor was the right to protect the dead eradicated by the Norman conquest. It is true that the swarm of Romish ecclesiastics which poured into England with the Conqueror exerted themselves actively and indefatigably to monopolize for the Church the temporal authority over the dead; but that by no means proves that they were left unprotected. On the contrary, it was a concentration in the ecclesiastical body of every right which any individual had previously possessed, to secure their repose. The individual right was not extinguished, it was only absorbed by the Church, and held in suspense, until some political revolution or religious reformation should overthrow the ecclesiastical power which had thus secured its possession.

The ecclesiastical element was not eradicated from the framework of the English Government, either by the Reformation or the act of Parliament establishing the Protestant succession, but in the portion of the world which we inhabit the work has been more thoroughly accomplished. The English emigration to America—the most momentous event in political history—commenced in the very age when Chief-Justice Coke was proclaiming, as a legal dogma, the exclusive authority of the Church over the dead. The liberty-loving, God-fearing Englishmen who founded these American States had seen enough and felt enough of "ecclesiastical cognizance," and they crossed a broad and stormy ocean to a new and untrodden continent, to escape from it forever.

It may well be that some of the legislative enactments of these weather-beaten men, in the early morning of their political life, while yet unused to the meridian light of religious freedom, are disfigured by the same intolerance they had left behind them. They may have even mingled in their general scheme of civil policy an ecclesiastical element sterner and more searching than that of the Church from which they dissented. The curious historian may analyze, if he will, the earnest puritanism of early New England, or even the sturdy bigotry of early New Netherland; it is enough for the Commonwealth of New York, "by the grace of God, free and independent," to know that its first written constitution, born in 1777, in the very depths of the Revolutionary struggle, extirpated from the body politic every lingering element of ecclesiastical cognizance or spiritual authority. On all its features it bears the unextinguishable love of religious freedom, brought to our shores by the refugees from ecclesiastical tyranny, not only in England, but in Holland and France. Its ever-memorable declaration of religious independence—offspring of the lofty intellect and noble heart of John Jay, and growing bright with his Huguenot blood—proclaims to the world the fundamental resolve, "not only to expel civil tyranny, but also to guard against that spiritual oppression and intolerance wherewith the bigotry and ambition of weak and wicked priests and princes have scourged mankind."

Following up this fixed determination, and yet with wise regard and unaffected reverence for the Christian Church in its purity, the illustrious authors of this Magna Charta of our religious liberty, prohibit any "minister of the gospel, or priest of any denomination," from holding any office, civil or military, within the State; inscribing in the organic law, thus unmistakably, their settled purpose to deliver both dead and living from ecclesiastical cognizance, to emancipate the courts of justice from every priestly and mediæval fetter, and to allow them to breathe, through all coming time, the invigorating air of ancient, Anglo-Saxon freedom.

It is a striking proof of the inveterate attachment, even of the most enlightened nations, to prescriptive authority, that the monkish idea of the church-yard as an engine of spiritual power not only lingers in England, but is boldly proclaimed in its very metropolis. Within the last two years, the Archdeacon of London, in an official address to the clergy of the Established Church within his district, openly complains of modern legislation in the British Parliament, in establishing extra-mural cemeteries around their crowded cities; for, says he, "the church and the *church-yard* of the parish have hitherto been one of the strongest ties, to *bind the people* at large to the communion of the Church." And again, "Burial *bound*, I say, *the people*, in the metropolis, to the Established Church."

It certainly is not for us to interfere with the ecclesiastical law of England, nor needlessly to criticise its claims to the respect of the people whom it binds. We only ask to banish its maxims, doctrines, and practices from our jurisprudence, and to prevent them from guiding, in any way, our judicial action. The fungous excrescence which required centuries for its growth may need an efflux of ages to remove. Burial in the British Islands may possibly remain, for many generations, subject exclusively to "ecclesiastical cognizance;" but in the new, transplanted England of the Western Continent the dead will find protection, if at all, in the secular tribunals, succeeding, by fair inheritance, to the primeval authority of the ancient, uncorrupted common law.

It is gratifying, however, to perceive that, even in the English courts, traces are becoming discernible of a disposition to recognize the ancient right of burial at common law. In the year 1820, a legal claim was made by one Gilbert to bury, in a London churchyard, the body of his wife in an iron coffin, but it was resisted by the church-wardens, Buzzard and Boyer, on the ground that it would injuriously prolong the period when the natural decay of the body and of a wooden inclosure would make room in the grave for another occupant. An application had been previously made in the same matter to the King's Bench, for a *mandamus* (reported in 2 Barn. and Ald., p. 806), on which occasion the distinguished counsel, Mr. Scarlett and Mr. Chitty, claimed that the right of interment existed at common law. In refusing the application, Chief-Justice Abbott said: "It may be admitted, for the purpose of the present question, that the right of sepulture is a *common-law right*, but I am of opinion that the *mode of burial* is a subject of ecclesiastical cognizance." Mr. Justice Holroyd, after duly reproducing Coke's *caro data vermibus*, declared that "burial is as much a matter of ecclesiastical cognizance as the prayers that are to be used, or the ceremonies that are to be performed at the funeral."

The matter, which had caused some public disturbance in London, was thereupon carried into the Ecclesiastical Court, then adorned by the learning and talents of Sir William Scott (since Lord Stowell). In the very elaborate and eloquent opinion delivered by the accomplished judge on that occasion (reported in 3 Phillimore, p. 335), he reviews the whole history of burial, from the remotest antiquity, philosophically tracing the progress of interment through the heathen and the Christian ages. Drawing a distinction between the coffined and uncoffined funerals of early times, he admits that many authoritative writers assert the right of a parishioner to be buried in his own parish church-yard, but he denies that it necessarily includes the right to bury a "trunk or chest" with the body. "*The right*," says he, "*strictly taken*, is, to be returned to the parent earth for dissolution, and to be carried there in a decent and inoffensive manner." The honest sense and feeling of the judge were evidently struggling with ecclesiastical law and usage, but he came to the conclusion that no mode of burial could be permitted which would prolong the natural decay of the body, or needlessly preserve its identity; that the lapse of a single generation is practically sufficient for mingling human remains with the earth, and destroying their identity; that, the dead having no legal right to crowd the living, each buried generation must give way to its successor; and that, therefore, an iron coffin, which would unduly and unlawfully prolong the period for identifying the remains, was ecclesiastically inadmissible, unless an extra fee were paid to the Church.

The court will perceive, by the proofs in the case now under examination, that the remains of the exhumed body are identified beyond doubt or question. The skeleton of the "posthumous man" is now legally "standing in court," distinctly individualized; with his daughter, next and nearest of kin, at his side, to ask that the tribunal whose order for widening the street ejected him from the grave will also direct his decent interment.

It was the pride of Diogenes, and his disciples of the ancient school of cynics, to regard burial with contempt, and to hold it utterly unimportant whether their bodies should be burned by fire or devoured by beasts, birds, or worms; and a French philosopher of modern days, in a somewhat kindred spirit, descants upon the "glorious nothingness" of the grave, and that "nameless thing"—a dead body. The secular jurisprudence of France holds it in higher and better regard. In the interesting case reported in "Merlin's Répertoire," title "Sepulture," where a large tract of land near Marseilles had necessarily been taken for the burial of several thousand bodies, after the great plague of 1720, it was adjudicated, by the secular court, that the land should not be profaned by culture even of its surface, until the buried dead had mouldered into dust. The eloquent *plaidoyer* of the *avocat-général* upon that occasion dwells with emphasis on the veneration which all nations, in all ages, have shown for the grave—adding, however, with some little tinge of national irreverence, "C'est une *vénération toujours révocable!* et toujours subordonnée au bien public."

In portions of Europe, during the semi-barbarous state of society in the middle ages, the law permitted a creditor to seize the dead body of his debtor; and, in ancient Egypt, a son could borrow money by hypothecating his father's corpse; but no evidence appears to exist in modern jurisprudence of a legal right to convert a dead body to any purpose of pecuniary profit.

It will be seen that much of the apparent difficulty of this subject arises from a false and needless assumption in holding that nothing is property that has not a pecuniary value. The real question is not of the disposable, marketable value of a corpse, or its remains, as an article of traffic, but it is of the sacred and inherent right to its custody, in order decently to bury it and secure its undisturbed repose. The insolent dogma of the English ecclesiastical law, that a child has no such claim, no such exclusive power, no peculiar interest in the dead body of its parent, is so utterly inconsistent with every enlightened perception of personal right, so inexpressibly repulsive to every proper moral sense, that its adoption would be an eternal disgrace to American jurisprudence. The establishment of a right so sacred and precious ought not to need any judicial precedent. Our courts of justice should place it, at once, where it should fundamentally rest forever, on the deepest and most unerring instincts of human nature, and hold it to be a self-evident right of humanity, entitled to legal protection, by every consideration of feeling, decency, and Christian duty. The world does not contain a tribunal that would punish a son who should resist, even unto death, any attempt to mutilate his father's corpse, or tear it from the grave for sale or dissection; but where would he find the legal right to resist, except in his peculiar and exclusive interest in the body?

The right to the repose of the grave necessarily implies the right to its exclusive possession. The doctrine of the legal right to open a grave in a cemetery, after a certain lapse of time, to receive another tenant, however it may be sanctioned by custom in the English church-yards, or by Continental usage at Père-la-Chaise and elsewhere, will hardly become acceptable to the American mind, still less the Italian practice of hastening the decomposition of the dead by corrosive elements. The right to the individuality of a grave, if it exist at all, evidently must continue, so long as the remains of the occupant can be identified—and the means of identifying can only be secured and preserved by separate burial. The due and decent preservation of human remains by separate burial is preëminently due to Christian civilization, which, bringing in the coffin and sarcophagus, superseded the heathen custom of burning, and "gave," in Lord Stowell's vivid phrase, "final extinction to the sepulchral bonfires."

# THE RELATIONS OF WOMEN TO CRIME.

By ELY VAN DE WARKER, M. D.

II.

I SHALL, in this paper, consider briefly the sexual and other physical and mental conditions which modify woman's relations to crime. These conditions (*B*) mainly depend upon—1. Age; 2. Heredity; 3. Physical; and 4. Mental sexual peculiarities. In a former paper of this series,[1] I believe I proved, beyond a doubt, that there are types of mind which are purely the outcome of sex, and which define the mental condition of the sexes. In that paper, criminal statistics were used to assist in establishing the fact of sexual mental differences. Here the method is reversed, and sexual mental traits are employed to explain the known differences in the extent and degree of crime

[1] Popular Science Monthly, July, 1875.

existing among men and women. This will involve the use of some of the facts already considered. While it is true that the social conditions, which we have so briefly analyzed,[1] bear upon woman chiefly because she is as she is, yet they bear also upon the other sex. Many of the sexual conditions we shall study relate to women alone, and, therefore, in their criminal career, exist as a defining force. If, in the ordinary concerns of life, women exhibit mental traits which serve amply to distinguish them, and place limits to their activity, not less in the tabulated histories of crime are the same distinctions and limits found.

1. Age materially influences the extent and degree of crime in both sexes. In relation to physical and functional development, age exists as a defining force. It appears to affect the criminal careers of the sexes in two ways: by permitting such a degree of bodily power to be reached as to render possible criminal acts in different degrees; and, the bodily powers remaining the same, the varying mental conditions produce changes in the force and direction of the criminal impulse. Each period of life, therefore, is characterized by degrees and qualities of crime which belong to it. In other words, certain phases of crime are perpetrated at one period of life in excess of any other period. These remarks do not apply to both sexes equally, for these periods do not correspond either as to age, or in the nature of the offense, the excess of which distinguishes one period from another.

For the purpose of studying the influence of age upon the criminal career of women, I shall analyze the figures of Mr. F. G. P. Neison.[2] The materials embraced in the table of Mr. Neison are for five years, from 1834 to 1839; for, strange to say, the Home-Office returns, since the year last named, to the date of Mr. Neison's publication, ceased to give the age and sex with reference to classes of crime. In order to simplify the comparison, I shall take the number of male criminals corresponding in age to the female, as the standard of measurement in reference to any given division of crime. Fractions are omitted in reference to both sexes.

At twelve years of age and younger the proportion of females to males is 1 to 6 for crimes against persons, and for crimes against property without violence for the same age the proportion is again 1 to 6. Bearing in mind what has been said in a former chapter,[3] that the ratios of the sexes as to crimes against persons and property are 16 to to 100 for the former, and 26 to 100 for the latter, and which also correspond to the difference in strength between the sexes, we see that the element of sexual inequality in strength does not present itself as a factor. In other words, the correspondence in the proportion of the sexes to the two classes of crime represents physical equality, while

[1] Popular Science Monthly, November, 1875.

[2] "Contributions to Vital Statistics," table xxix., London, 1857.

[3] Popular Science Monthly, November, 1875.

the difference (1 to 6) is the result of mental sexual traits, which, even at this early age, present themselves. During the next four years the proportion in reference to crimes against persons is nearly double, being 1 to 11; while against property the proportion decreases, being 1 to 5. The average physical strength of the sexes for the second period (twelve to sixteen years) is about equal, so that this sudden proportional increase in crimes against persons in the male sex is the result almost entirely of those qualities which mentally characterize the male. This conclusion is rendered nearly positive by the fact that the maximum is attained by the males in the next five years, sixteen to twenty-one, and is only 1 to 12, during which period it is that the greatest difference in strength between the sexes is developed; yet this difference is represented by an increase of only 1 in the proportion. This agrees with what we know of men, that the development of the passions keeps just in advance of the development of the physical strength, just as the strength declines in advance of the passions. Studying for a moment longer this second period of life (twelve to sixteen) we learn this important fact: that in woman's criminal career it is, proportionally with man, the best period in her life, for at this time also occurs the greatest difference in crimes against property, 1 to 5, the maximal difference in the sexes, as to crimes against persons, being reached at twenty-one years. For the periods following of ten years each, the proportion steadily decreases in the following order, 1 to 9, 1 to 7, until at the decade, between forty and fifty years, we reach again the proportion of childhood (1 to 6). Now, the inference is, not that men grow better and women worse; but that the period of greatest passional intensity has been passed, while in both sexes the will has attained its greatest force. In other words, the period of caution has been reached. This accords with the law that the greatest mental vigor corresponds with structural completion. That this explanation is plausible is shown by the fact that the last decade mentioned is the period in which the proportion between the sexes in crimes against property is more nearly equal, being 1 to 2 and a fraction, and which for former decades steadily held at 1 to 3. There is a further confirmation of this, in the fact that for two periods, fifty to sixty, and sixty and upward, crimes against persons increase among men; the proportion being 1 to 9 and 1 to 10 respectively. That this is not the result of any increase of morality in the other sex, the uniform ratio of the sexes for crimes against property, during the ages last named, renders probable. From the same source we may obtain information which tends to show the truth of the remark made by M. Quetelet, that the proportion of women as to men increases "according to the necessity of the greater publicity before the crime can be perpetrated."[1] In the division of crime called offenses against the currency, we have the conditions favorable to a more even proportion of the sexes. In an offense of this kind the

[1] *Loc. cit.*, p. 90.

physical equality is not involved. It becomes a question of secrecy, cunning, and shrewdness. These are mental qualities which exist with equal force in the sexes. Consequently in this division of crime for all ages we find a mean proportion of 1 to 2. Expressed in detail the proportion is equal in childhood, 1 to 2 at the next period, and 1 to 3 for the three following, until, at the decade between forty and fifty years, it drops to 1 to 2, and is equal again for the two following periods. The influences which cause equality in the proportions at the two extremes of ages are probably those which produce the same, or nearly the same, results in relation to the other orders of crime.

This analysis of Mr. Neison's statistics reveals to us a very interesting period in the lives of both sexes—that between forty and fifty years. For all the classes of crime examined, we find the sexes at this period proportionally approaching equality; being in two classes actually at that of childhood. These two classes of crime are those which involve the greatest violence, crimes against persons; and the least, crimes against the currency. For the first, I have already offered a reasonable explanation, that of the period of caution; but, in reference to the latter, we must search further, in order to get at a probable cause. In the last-named offense, we have as a characterizing mental trait the very condition which explains the decrease in the proportion for crimes against persons, and yet at the terminal periods of life we find it obeying the same law. There is one fact which forces itself upon the attention in connection with this; that the first approach to equality in the proportions of the sexes begins suddenly at the term of life between forty and fifty years. This period, for men especially, is that in which the forces engaged in structural repair and waste are in equilibrium. It is one of structural rest, but of functional activity. At no other period in the life of man, therefore, is he physically more competent to meet the demands of his mental life. With women, it is also a period of structural rest, linked to a state of functional completion, so far as the prime motive of sexual life is concerned. It appears reasonable, in view of this, that physical factors be excluded as a probable cause of the phenomenon. But there exist valid reasons for exempting the male sex partly from the operation of the laws affecting this equalization in the proportion of the sexes. These reasons show presumptively that the subtile and obscure laws of crime operate more actively upon the female than the male sex; that, in obedience to these laws, her relations to crime are prolonged into periods of life when men are becoming, to a certain extent, exempt from their operations.

My friend Mr. R. L. Dugdale, of New York, in his brilliant study of the natural history of crime,[1] by an analysis of Tables I. and II. of Mr. Neison,[2] arrives at important facts. In the tables referred to,

[1] "Thirtieth Annual Report of the Prison Association, State of New York," p. 179.

[2] *Loc. cit.*, pp. 303, 304.

crime is classified according to age, and percentages are calculated based upon the total population for each age specified. The maximum for male criminals is found in the period of twenty to twenty-five years, with a percentage to the total population of that age of .7702. Between fifty and sixty years the percentage drops to only .1694. The same law holds good for women, but with modified ratios. Comparing the two sexes, the following results are reached: the tendency to crime, as exhibited in its actual commission, for males at all ages until sixty, diminishes at the rate of 33.333 per centum. For females under similar conditions of age, it diminishes at the rate of 25 per centum. Keeping in view the liability to error in a search through the obscure underlying forces which seem to regulate human conduct in the aggregate, it nevertheless appears reasonable to expect an explanation of this phenomenon to lie in the physical rather than the mental conditions of the sexes at the terminal periods of life. In the decade which was above distinguished as that of physical equilibrium, the governing principles seemed to be the expression of mental forces; but, on reaching the sixtieth year of life, the conditions are reversed. While in the former the conditions of waste and repair were equal, in the latter the repair of the physical forces is exceeded by the waste. This is a law which applies equally to both sexes, but with this difference in the result: the occupation and the crimes which belong in such great excess to men are those which require more physical strength than the occupations and crimes which are adapted to the lesser strength of women. Let us take a familiar illustration: after a man at sixty years of age has retired from the scenes of his labor in the mine, or field, or workshop, the wife of the same age, or older, is yet profitably engaged in her lighter domestic duties. She is yet contributing as materially to the comforts of her family as during the more active years of the husband's life. Now, while it is quite evident that we must regard the cause of the sudden more near equality in the proportion of the sexes which presents itself in the period of life between forty and fifty years as due to psychical changes, the evidence is yet stronger that the ratio of the more rapid decrease of male criminals at the more advanced period of fifty to sixty years is due to the cause I have named—the rapid impairment of physical energy peculiar to the period. Since men greatly preponderate in those phases of crime which demand strength, belligerency, and publicity in the perpetration, the conclusion is legitimate that crime would rapidly decrease at the time of life in which these qualities are wanting, or are impaired. If we examine the relation of men to the orders of crime, in the perpetration of which these qualities are not necessary, and in which strength may be replaced by caution, and belligerency by cunning, as in offenses against the currency, and in the sixth division of Mr. Neison called "other offenses," embracing the lighter shades of criminal conduct, we shall see that the proportions between the sexes characteristic of earlier ages hold on unchanged through this last period of life.

It will be interesting to return for a moment and examine what are the real proportions of the sexes, during the criminally most active period of life, between twenty-one and thirty years. While we would not expect in this period to find the groundwork laid for criminal conduct, yet it is the term of life, in both sexes, in which the effects of heredity, of early training, assume activity, and give shape and color to the destiny of the individual. What goes before may be called the germ period, and this the period of fruition. The years which precede the meridional term of life are under the influence of structural and intellectual genesis. It is the result of an aggregation of forces tending to a common end. Life has not reached the level of the conflicting emotions, passions, and activities, which at the completion of structure exist so potently. Activity at this period is the expression of simple laws, which lead to a uniform result. Mr. Neison, reasoning purely from statistics, arrives at the same conclusion, that "in the juvenile period of life the tendency to crime is under the influence of more constant laws or elements, and therefore shows less fluctuation than in mature life."[1] The same conclusions hold good at the closing years of life. Youth and old age unite in the degree and quality of crime. The aggregate of crime in general is committed at the earlier part of this intermediate period of both sexes. The crime of this decade of life is more than quadruple that of any other. During this period occur those differences in the tendency to crime between the sexes which affect the total results. During this period, sex powerfully asserts its influence. Sex is no longer existing potentially in incomplete structure; but it is partly the sum of completed structural effort. Psychically, it is emotion, passion, and unconscious cerebral activity. Physically, it is the difference in development and mechanical power. Each of these is a factor in the differences real and apparent in the tendency to crime existing between men and women. There are many other causes, some of the more important of which have already been referred to, and are of social rather than sexual origin. But social factors operate more strongly at this period than at any other. Society in all its phases is made up of the activities of this period of life. Those forces which in their totality express all there is of society, seem to concentrate and coincide with those forces which express all there is of sex, and tend to one period of life common to both men and women.

2. In this connection it is proper to examine the bearings of women to the hereditary tendency to crime. Recent study of the relations of sex to crime has shown that the hereditary element in the criminal tendency may assume sexual phases. This is exemplified by the law of movement in the direction of the least resistance. The he-

[1] *Loc. cit.*, p. 407.

reditary taint being a fixed factor, it assumes expression in acts which are most in accord with sexual peculiarities. This is nearly equivalent to Dr. Carpenter's theory of special mental aptitudes as giving direction to the force of habit;[1] except that its operation is extended to the hereditary transmissions of mental or physical qualities. It is only in the early middle period of life that, from the nature of things, we would expect to find the criminal tendency under the complete sway of sexual life. The inherited criminal tendency in childhood and early youth finds its outlet in a viciousness common to both sexes, or in the milder forms of crimes against property. This is asserted on general principles. Dr. Carpenter remarks that "this diversity may be in a great part attributed to changes in the physical constitution. Thus, the sexual feeling, which has a most powerful influence on the direction of the thoughts in adolescence, adult age, and middle life, has comparatively little effect at the earlier and later periods."[2] This also accords with Mr. Dugdale's theory of criminal analogues. This theory, in his important work,[3] is mainly brought out in relation to the entailment of crime, and its truth lies in the fact that, in the same family of criminals, while the males are thieves, the females are prostitutes—one the equivalent or analogue of the other. The same family, in the two extremes of life, childhood and old age, exhibits pauperism as either the reality or promise of a criminal career. From the fact that pauperism exists as a parasite upon productive society, and preys upon society to its permanent injury, and makes no return, it will be regarded in this paper as an equivalent to crime against property. When we consider that criminals by entailment are exposed to environments possessing essential qualities in common, it is reasonable to expect that in such crime would conform in a more regular manner to those laws which seem to govern moral conduct, than in those who drift into crime through impulse or misfortune. This, in a general sense, holds true. M. Prosper Despine, in his "Psychologie Naturelle," shows that incendiarism exists in the young of both sexes with the inherited taint, as a characteristic. M. Despine brings out with great force a mental condition of those who inherit crime that gives an additional cause for the operation of the laws of crime with almost undeviating regularity upon this class. This is the total or nearly total absence of the moral sense—moral idiocy—which isolates the offspring of criminal families from the children of untainted birth. By this moral blindness they are distinguished throughout their lives. Thus there are wanting in this class the moral elements which effect or impede the criminal tendency in others. The sense of right or wrong, the sense of shame or disgrace, in no way interferes with the criminal tendency. This is the very condition necessary for the unembarrassed operation of Mr. Dug-

[1] "Principles of Mental Physiology," p. 374. [2] *Loc. cit.*, p. 365.

[3] "Thirtieth Report," etc., p. 146.

dale's very probable law of criminal analogues or equivalents. Hence we may say, with almost positive certainty, that the children of both sexes, with the inherited taint, are paupers; that adult life in the male is distinguished by pauperism and crime; that adult life in the female is devoted to prostitution, and that old age brings both sexes again to the state of pauperism. And here again we encounter the phenomenon revealed by an analysis of Mr. Neison's statistics: the criminal equivalent existing between childhood and senility. It is childhood and old age joining hands, as it were, over the fevered and crime-laden middle life. But, while the moral faculties are absent, the mental powers are perverted to an equal degree. Any one accustomed to closely observe confirmed criminals must be cognizant of the fact that they are not as other men in their habits of mind. What one observes may not be called insanity, in the full meaning of the word, but it appears to be a departure from the standard one forms from mingling with average men. I have noticed this especially with regard to women. From an experience of two years with criminal women undergoing punishment in the Onondaga Penitentiary, I cannot recall an instance in which mental traits were wanting to distinguish them from the average woman. In this class mental peculiarities may be intensified into actual insanity, and the tendency to it exist stronger than in any other class. M. Ribot[1] shows that hereditary crime and insanity are closely connected, and refers to Drs. Ferrus and Lélut, who have established the great frequency of insanity among criminals. Dr. Bruce Thompson, in a recent work,[2] supports this by figures, and proves that twelve per centum of insanity occurs among prisoners, with fifty per centum of recommittals, revealing the strength of the inherited tendency.

The two more important inherited criminal traits which reveal sexual types in their development are pauperism and prostitution. Pauperism appears to be as characteristic of the male sex as prostitution is of the female. The ratio of sexes receiving relief is twenty per cent. of men to thirteen per cent. of women, in out-door, and thirteen per cent. of men to 9.5 per cent. of women in almshouse relief. De Marsangy fixes the ratio at seven times more vagabondage among men than women.[3] As a rule, women receive relief—if single—while child-bearing, and if married they follow the condition of the husband; while widows drift back into prostitution. "Thus we find," remarks Mr. Dugdale, "that although the rates of wages are lower for women, charity is much more frequent among men."[4] The above relates to those who are known to receive relief. The hereditary strength of the last-named offense is shown by the Juke family, so

[1] "Heredity," p. 29. [2] "The Hereditary Nature of Crime."

[3] "Étude sur la Moralité comparée de la Femme et de l'Homme," par M. Bonneville de Marsangy.

[4] *Loc. cit.*, p. 151.

carefully studied by Mr. Dugdale—52.4 per cent. of the women following prostitution. If hereditary disease accompanies the entailment of crime, pauperism is a matter of course; the subject rarely attaining the rank of a criminal, except in the most petty of the offenses against property. Pauperism is a condition of effeteness. It represents the dregs which drop downward through the several strata of society. Morally, it is the most negative condition of humanity. The pauper has sunk below the level of crime. He abstains from crime, not by moral restraints, but by inertness. The woman with the same taint has sunk below the level of the active phases of crime. She drifts into harlotry because it is easier than to steal. If disabled, she becomes a pauper, and thus oscillates between the almshouse and the brothel—a passionless, nerveless being, with all the normal energies crushed out under the burden of entailed defects.

3. It is a more difficult matter to trace through the complicated net-work of passions, emotions, and motives, which underlies the degrees and varieties of crime, the purely sexual physical factor. The main difficulty consists in discriminating this from the mental sexual differences which may exist as a cause of differentiation in crime. It is essential, if possible, to gain an approximate idea of the limits of these differences. With the present data at command, this can be accomplished only in the most superficial manner. There exists here more than the suspicion of a great law, the operation of which, if fully known, would clear up many of the doubts lingering around this important subject. While the physical differences will serve to explain the varying relations of the sexes to crime in their broader and more superficial aspects, the mental sexual traits will serve to define the differences in motives, tendencies, and innate moral proclivities of the sexes. Instead of being satisfied with the simple explanation, that the extent of man's excess over woman as a criminal represents the excess of woman over man as a moral being, this knowledge would show that this is not a question of comparative morality alone, but one of intellectual equivalents. To study carefully the scope of the moral equivalents of the sexes is to reach the relations of things in their genesis. It is in this way that the relations of the sexes socially, as well as in crime, will be taken out of the realm of sentimentalism and placed upon a basis of fact. Sentimental views of the relationship of women to crime exist so generally, that they act as a force in the way of an unbiased investigation of the subject. Take, for instance, such a writer as M. de Marsangy,[1] whose motive is the serious one of the amelioration of the penal laws in their bearings upon women, who gravely concludes that man has a "nature less noble, less delicate, less perfect than woman," and yet quotes approvingly that, "*Das Weib ist Engel oder Teufel.*" It is this personal bias which has hitherto obscured this subject, and rendered the work of such writers

[1] *Loc. cit.*, p. 133.

as M. de Marsangy useless for scientific purposes. Fortunately, this style of scientific writing belongs to the French school of both sentiment and morals.

The mental reflex result of physical strength, as expressed in the criminal act, is more clearly shown in crimes against property attended with violence. Distinguishing it from the other orders of crime—malicious offenses against property, and offenses without violence—we have the motive in the first-mentioned class narrowed to the desire of possession, but so associated with the consciousness of personal strength that it is employed as an agent of the crime. Belligerency, revenge, and other emotions which tend to crime, are absorbed in the order of malicious offenses, and thus the field is left clear, in the class under analysis, for the full play of the physical factor. Omitting ages under sixteen years, as being too nearly equal physically in the sexes, and basing our proportion on the number of criminals of both sexes from that age to twenty-one years, the proportion is 1 woman to 18 men, while for the ten years following it is 1 to 20.[1] This is twice the proportion between the sexes for crimes against persons, and seven times that for crimes against property without violence, for corresponding ages. When we contrast this with the fact that the mean proportion between the sexes for all crimes against property is 1 to 4, and for crimes against the person it is 1 to 6, we may form an idea of the enormous influence of physical strength as a restraint to woman's criminal tendencies. We have, however, to modify this somewhat, by giving more or less value to woman's tendency to avoid those crimes which require publicity in both the planning and perpetration, and which is implied in violent crimes against property; but even giving this trait due weight, the physical factor as exhibited in this order of crime is the one which, more than any other, defines its character. While woman's deficient physical strength, compared to man's, acts so powerfully as an obstacle in the division of crime just considered, it is highly probable that in other offenses it also acts in the same manner, varying in amount, as this quality is necessary to the successful perpetration of the crime. In those crimes in which this factor does not enter, we at once notice that the ratios of the sexes approximate. In adultery, for instance, the proportion of the sexes is about the same.[2] In infanticide, I have already remarked on the ease with which women enter upon a criminal course, when this conforms to the direction of purely sexual qualities; and, undoubtedly, intensity is added by the absence of physical strength as a requisite to the perpetration of the crime. In crimes against the currency, the same near equality in the number of the sexes involved may be noticed, and the fact that the proportions for the most active period of adult life and for childhood and old age are about the same renders it highly probable that this

[1] Neison, *loc. cit.*

[2] De Marsangy, *loc. cit.*

equality is accounted for by the physical strength required for its perpetration being possessed equally by the sexes. In crimes against persons, the influence of this factor can be traced, but not in so marked a manner as in the crimes referred to. In poisoning, for instance, the ratio between the sexes is 91 women to 100 men,[1] and while active mental traits may in part exist as causes for this nearly equal ratio of the sexes, yet the total absence of any need of physical strength must be given due value. Poison is essentially a weapon of weakness. It figures largely in history as the agent of women and politicians. One reason, which probably existed in mediæval days, but which cannot be regarded in modern times, was the difficulty of detection in cases of death by poisoning. It was surrounded by an atmosphere of horrible suspicion, which was never relieved by certainty. It was selected as a political agent by reason of this secrecy, by both sexes, and thus at this period had no sexual qualities. Modern advances in chemistry have rendered poisoning one of the most surely detected of all crimes, and its perpetration has become a characteristic of the weak and cowardly. In some other offenses, as in incendiarism, in which physical strength is as unessential as in poisoning, the ratio between the sexes falls to 34 in 100. Although this is a crime well within the compass of woman's physical abilities, yet it involves other elements, which deter women from its perpetration. Motive, which is the exciting cause of crime and enters largely into the intensity of the tendency, cannot act so powerfully in the latter as the former crime. In order to kill, a stronger motive is required than to burn. Incendiarism requires considerable personal exposure, and danger of immediate detection. Parricide with a ratio of 50 to 100, and wounding of parents with a ratio of 22 to 100 (Quetelet), offer a remarkable contrast to murder and the wounding of strangers, with a ratio taken together of 9 to 100. The necessity of physical strength exists equally in the perpetration of these crimes. The marked difference in ratio, therefore, must be explained by other means. Opportunity and domesticity, already referred to in a former paper, exist largely as the cause of the difference. M. Quetelet, speaking in general terms of the influence of opportunity and domestic habits upon woman's criminal career, remarks: "They can only conceive and execute guilty projects on individuals with whom they are in the greatest intimacy; thus, compared with man, her assassinations are more often in her family than out of it." It would be difficult to present a stronger argument of the influence of woman's social position as a restraint to crime. As we observe in the crimes just referred to, it is not the enormity of the offense which restrains, for we have in parricide twelve times the frequency of murder; it is not weakness, for then parricide, murder, and wounding, should agree in frequency. We are able to trace in this no influence of morality, it is simply the result of the varying degrees of opportunity, domestic life, and mental peculiarities.

[1] Quetelet, *loc. cit.*, p. 91.

# THE HISTORY OF TWINS, AS A CRITERION OF THE RELATIVE POWERS OF NATURE AND NURTURE.[1]

By FRANCIS GALTON, F.R.S

THE exceedingly close resemblance attributed to twins has been the subject of many novels and plays, and most persons have felt a desire to know upon what basis of truth those works of fiction may rest. But twins have many other claims to attention, one of which will be discussed in the present memoir. It is, that their history affords means of distinguishing between the effects of tendencies received at birth and of those that were imposed by the circumstances of their after-lives; in other words, between the effects of nature and of nurture. This is a subject of especial importance in its bearings on investigations into mental heredity, and I, for my part, have keenly felt the difficulty of drawing the necessary distinction whenever I tried to estimate the degree in which mental ability was, on the average, inherited. The objection to statistical evidence in proof of its inheritance has always been: "The persons whom you compare may have lived under similar social conditions and have had similar advantages of education, but such prominent conditions are only a small part of those that determine the future of each man's life. It is to trifling accidental circumstances that the bent of his disposition and his success are mainly due, and these you leave wholly out of account—in fact, they do not admit of being tabulated, and therefore your statistics, however plausible at first sight, are really of very little use." No method of inquiry which I have been able to carry out—and I have tried many methods—is wholly free from this objection. I have therefore attacked the problem from the opposite side, seeking for some new method by which it would be possible to weigh in just scales the respective effects of nature and nurture, and to ascertain their several shares in framing the disposition and intellectual ability of men. The life-history of twins supplies what I wanted. We might begin by inquiring about twins who were closely alike in boyhood and youth, and who were educated together for many years, and learn whether they subsequently grew unlike, and, if so, what the main causes were which, in the opinion of the family, produced the dissimilarity. In this way we may obtain much direct evidence of the kind we want; but we can also obtain yet more valuable evidence by a converse method. We can inquire into the history of twins who were exceedingly unlike in childhood, and learn how far they became assimilated under the

[1] In my "English Men of Science," 1874, p. 12, I treated this subject in a cursory way. It subsequently occurred to me that it deserved a more elaborate inquiry, which I made, and of which this paper is a result.

influence of their identical nurtures; having the same home, the same teachers, the same associates, and in every other respect the same surroundings.

My materials were obtained by sending circulars of inquiry to persons who were either twins themselves or the near relations of twins. The printed questions were in thirteen groups; the last of them asked for the addresses of other twins known to the recipient who might be likely to respond if I wrote to them. This happily led to a continually-widening circle of correspondence, which I pursued until enough material was accumulated for a general reconnaissance of the subject.

There is a large literature relating to twins in their purely surgical and physiological aspect. The reader interested in this should consult "Die Lehre von den Zwillingen," von L. Kleinwächter, Prague, 1871; it is full of references, but it is also disfigured by a number of numerical misprints, especially in page 26. I have not found any book that treats of twins from my present point of view.

The reader will easily understand that the word "twins" is a vague expression, which covers two very dissimilar events; the one corresponding to the progeny of animals that have usually more than one young one at a birth, and the other corresponding to those double-yolked eggs that are due to two germinal spots in a single ovum. The consequence of this is, that I find a curious discontinuity in my results. One would have expected that twins would commonly be found to possess a certain average likeness to one another; that a few would greatly exceed that degree of likeness, and a few would greatly fall short of it; but this is not at all the case. Twins may be divided into three groups, so distinct that there are not many intermediate instances; namely, strongly alike, moderately alike, and extremely dissimilar. When the twins are a boy and a girl, they are never closely alike; in fact, their origin never corresponds to that of the above-mentioned double-yolked eggs.

I have received about eighty returns of cases of close similarity, thirty-five of which entered into many instructive details. In a few of these not a single point of difference could be specified. In the remainder, the color of the hair and eyes was almost always identical; the height, weight, and strength were generally very nearly so, but I have a few cases of a notable difference in these, notwithstanding the resemblance was otherwise very near. The manner and address of the thirty-five pairs of twins are usually described as being very similar, though there often exists a difference of expression familiar to near relatives but unperceived by strangers. The intonation of the voice when speaking is commonly the same, but it frequently happens that the twins sing in different keys. Most singularly, that one point in which similarity is rare is the handwriting. I cannot account for this, considering how strongly handwriting runs in families, but I am sure of the fact. I have only one case in which nobody, not even the twins themselves, could distinguish their own notes of lectures, etc.; barely two or three in which the handwriting was undistinguishable by others, and only a few in which it was described as closely alike. On the other hand, I have many in which it is stated to be unlike, and some in which it is alluded to as the only point of difference.

One of my inquiries was for anecdotes as regards the mistakes made by near relatives, between the twins. They are numerous, but not very varied in character. When the twins are children, they have commonly to be distinguished by ribbons tied round their wrist or neck; nevertheless, the one is sometimes fed, physicked, and whipped by mistake for the other, and the description of these little domestic catastrophes is usually given to me by the mother, in a phraseology that is somewhat touching by reason of its seriousness. I have one case in which a doubt remains whether the children were not changed in their bath, and the presumed A is not really B, and *vice versa*. In another case an artist was engaged on the portraits of twins who were between three and four years of age; he had to lay aside his work for three weeks, and, on resuming it, could not tell to which child the respective likenesses he had in hand belonged. The mistakes are less numerous on the part of the mother during the boyhood and girlhood of the twins, but almost as frequent on the part of strangers. I have many instances of tutors being unable to distinguish their twin pupils. Thus, two girls used regularly to impose on their music-teacher when one of them wanted a whole holiday; they had their lessons at separate hours, and the one girl sacrificed herself to receive two lessons on the same day, while the other one enjoyed herself. Here is a brief and comprehensive account: "Exactly alike in all, their school-masters never could tell them apart; at dancing-parties they constantly changed partners without discovery; their close resemblance is scarcely diminished by age." The following is a typical school-boy anecdote: Two twins were fond of playing tricks, and complaints were frequently made; but the boys would never own which was the guilty one, and the complainants were never certain which of the two he was. One head-master used to say he would never flog the innocent for the guilty, and another used to flog both.

No less than nine anecdotes have reached me of a twin seeing his or her reflection in a looking-glass, and addressing it, in the belief that it was the other twin in person. I have many anecdotes of mistakes when the twins were nearly grown up. Thus: "Amusing scenes occurred at college when one twin came to visit the other; the porter on one occasion refusing to let the visitor out of the college-gates, for, though they stood side by side, he professed ignorance as to which he ought to allow to depart."

Children are usually quick in distinguishing between their parent and his or her twin; but I have two cases to the contrary. Thus, the daughter of a twin says: "Such was the marvelous similarity of their features, voices, manner, etc., that I remember, as a child, being very much puzzled, and I think, had my aunt lived much with us, I should have ended by thinking I had two mothers." The other, a father of twins, remarks: "We were extremely alike, and are so at this moment, so much so that our children up to five and six years old did not know us apart."

I have four or five instances of doubt during an engagement of marriage. Thus: "A married first, but both twins met the lady together for the first time, and fell in love with her there and then. A managed to see her home and to gain her affection, though B went sometimes courting in his place, and neither the lady nor her parents could tell which was which." I have also a German letter, written in quaint terms, about twin brothers who married sisters, but could not easily be distinguished by them.[1] In the well-known novel by Mr. Wilkie Collins of "Poor Miss Finch," the blind girl distinguishes the twin she loves by the touch of his hand, which gives her a thrill that the touch of the other brother does not. Philosophers have not, I believe, as yet investigated the conditions of such thrills; but I have a case in which Miss Finch's test would have failed. Two persons, both friends of a certain twin lady, told me that she had frequently remarked to them that "kissing her twin sister was not like kissing her other sisters, but like kissing herself—her own hand, for example."

It would be an interesting experiment, for twins who were closely alike, to try how far dogs could distinguish between them by scent.

I have a few anecdotes of strange mistakes made between twins in adult life. Thus an officer writes: "On one occasion when I returned from foreign service, my father turned to me and said, 'I thought you were in London,' thinking I was my brother—yet he had not seen me for nearly four years—our resemblance was so great."

The next and last anecdote I shall give is, perhaps, the most remarkable of those that I have; it was sent me by the brother of the twins, who were in middle life at the time of its occurrence: "A was again coming home from India, on leave; the ship did not arrive for some days after it was due; the twin brother B had come up from his quarters to receive A, and their old mother was very nervous. One morning A rushed in, saying, 'O mother, how are you?' Her answer was, 'No, B, it's a bad joke; you know how anxious I am!' and it was a little time before A could persuade her that he was the real man."

Enough has been said to prove that an extremely close personal

[1] I take this opportunity of withdrawing an anecdote, happily of no great importance, published in "Men of Science," p. 14, about a man personating his twin brother for a joke at supper, and not being discovered by his wife. It was told me on good authority; but I have reason to doubt the fact, as the story is not known to the son of one of the twins. However, the twins in question were extraordinarily alike, and I have many anecdotes about them sent me by the latter gentleman.

resemblance frequently exists between twins of the same sex; and that, although the resemblance usually diminishes as they grow into manhood and womanhood, some cases occur in which the resemblance is lessened in a hardly perceptible degree. It must be borne in mind that the divergence of development, when it occurs, need not be ascribed to the effect of different nurtures, but that it is quite possible that it may be due to the appearance of qualities inherited at birth, though dormant, like gout, in early life. To this I shall recur.

There is a curious feature in the character of the resemblance between twins, which has been alluded to by a few correspondents; it is well illustrated by the following quotations. A mother of twins says: "There seemed to be a sort of interchangeable likeness in expression, that often gave to each the effect of being more like his brother than himself." Again, two twin brothers, writing to me, after analyzing their points of resemblance, which are close and numerous, and pointing out certain shades of difference, add: "These seemed to have marked us through life, though for a while, when we were first separated, the one to go to business, and the other to college, our respective characters were inverted; we both think that at that time we each ran into the character of the other. The proof of this consists in our own recollections, in our correspondence by letter, and in the views which we then took of matters in which we were interested." In explanation of this apparent interchangeableness, we must recollect that no character is simple, and that in twins who strongly resemble each other, every expression in the one may be matched by a corresponding expression in the other, but it does not follow that the same expression should be the dominant one in both cases. Now, it is by their dominant expressions that we should distinguish between the twins; consequently, when one twin has temporarily the expression which is the dominant one in his brother, he is apt to be mistaken for him. There are also cases where the development of the two twins is not strictly *pari passu;* they reach the same goal at the same time, but not by identical stages. Thus: A is born the larger, then B overtakes and surpasses A, and is in his turn overtaken by A, the end being that the twins become closely alike. This process would aid in giving an interchangeable likeness at certain periods of their growth, and is undoubtedly due to nature more frequently than to nurture.

Among my thirty-five detailed cases of close similarity, there are no less than seven in which both twins suffered from some special ailment or had some exceptional peculiarity. One twin writes that she and her sister "have both the defect of not being able to come downstairs quickly, which, however, was not born with them, but came on at the age of twenty." Another pair of twins have a slight congenital flexure of one of the joints of the little finger; it was inherited from a grandmother, but neither parents, nor brothers, nor sisters, show the least trace of it. In another case, one was born ruptured, and the other became so at six months old. Two twins at the age of twenty-three were attacked by toothache, and the same tooth had to be extracted in each case. There are curious and close correspondences mentioned in the falling off of the hair. Two cases are mentioned of death from the same disease; one of which is very affecting. The outline of the story was, that the twins were closely alike and singularly attached, and had identical tastes; they both obtained government clerkships, and kept house together, when one sickened and died of Bright's disease, and the other also sickened of the same disease and died seven months later.

In no less than nine out of the thirty-five cases does it appear that both twins are apt to sicken at the same time. This implies so intimate a constitutional resemblance, that it is proper to give some quotations in evidence. Thus, the father of two twins says: "Their general health is closely alike; whenever one of them has an illness, the other invariably has the same within a day or two, and they usually recover in the same order. Such has been the case with whooping-cough, chicken-pox, and measles; also with slight bilious attacks, which they have successively. Latterly, they have had a feverish attack at the same time." Another parent of twins says: "If any thing ails one of them, identical symptoms *nearly always* appear in the other; this has been singularly visible in two instances during the last two months. Thus, when in London, one fell ill with a violent attack of dysentery, and within twenty-four hours the other had precisely the same symptoms." A medical man writes of twins with whom he is well acquainted: "While I knew them, for a period of two years, there was not the slightest tendency toward a difference in body or mind; external influences seemed powerless to produce any dissimilarity." The mother of two other twins, after describing how they were ill simultaneously up to the age of fifteen, adds that they shed their first milk-teeth within a few hours of each other.

Trousseau has a very remarkable case (in the chapter on asthma) in his important work "Clinique Médicale." (In the edition of 1873, it is in vol. ii., p. 473.) It was quoted at length in the original French, in Mr. Darwin's "Variation under Domestication," vol. ii., p. 252. The following is a translation:

"I attended twin brothers so extraordinarily alike, that it was impossible for me to tell which was which without seeing them side by side. But their physical likeness extended still deeper, for they had, so to speak, a yet more remarkable pathological resemblance. Thus, one of them, whom I saw at the Néothermes at Paris, suffering from rheumatic ophthalmia, said to me, 'At this instant my brother must be having an ophthalmia like mine;' and, as I had exclaimed against such an assertion, he showed me a few days afterward a letter just received by him from his brother, who was at that time at Vienna, and who expressed himself in these words: 'I have my ophthalmia; you must be having yours.' However singular this story may appear, the fact is none the less exact; it has not been told to me by others, but I have seen it myself; and I have seen other analogous cases in my practice. These twins were also asthmatic, and asthmatic to a frightful degree. Though born in Marseilles, they were never able to stay in that town, where their business affairs required them to go, without having an attack. Still more strange, it was sufficient for them to get away only as far as Toulon in order to be cured of the attack caught at Marseilles. They traveled continually, and in all countries, on business affairs, and they remarked that certain localities were extremely hurtful to them, and that in others they were free from all asthmatic symptoms."

I do not like to pass over here a most dramatic tale in the "Psychologie Morbide" of Dr. J. Moreau (de Tours), Médecin de l'Hospice de Bicêtre, Paris, 1859, p. 172. He speaks "of two twin brothers who had been confined, on account of monomania, at Bicêtre. . . . Physically the two young men are so nearly alike that the one is easily mistaken for the other. Morally, their resemblance is no less complete, and is most remarkable in its details. Thus, their dominant ideas are absolutely the same. They both consider themselves subject to imaginary persecutions; the same enemies have sworn their destruction, and employ the same means to effect it. Both have hallucinations of hearing. They are both of them melancholy and morose; they never address a word to anybody, and will hardly answer the questions that others address to them. They always keep apart, and never communicate with one another. An extremely curious fact which has been frequently noted by the superintendents of their section of the hospital, and by myself, is this: From time to time, at very irregular intervals of two, three, and many months, without appreciable cause, and by the purely spontaneous effect of their illness, a very marked change takes place in the condition of the two brothers. Both of them, at the same time, and often on the same day, rouse themselves from their habitual stupor and prostration; they make the same complaints, and they come of their own accord to the physician, with an urgent request to be liberated. I have seen this strange thing occur, even when they were some miles apart, the one being at Bicêtre and the other living at Saint-Anne."

Dr. Moreau ranked as a very considerable medical authority, but I cannot wholly accept this strange story without fuller information. Dr. Moreau writes it in too off-hand a way to carry the conviction that he had investigated the circumstances with the skeptic spirit and scrupulous exactness which so strange a phenomenon would have required. If full and precise notes of the case exist, they certainly ought to be published at length. I sent a copy of this passage to the principal authorities among the physicians to the insane in England, asking if they had ever witnessed any similar case. In reply, I have received three noteworthy instances, but none to be compared in their exact parallelism with that just given. The details of these three cases are painful, and it is not necessary to my general purpose that I should further allude to them.

There is another curious French case of insanity in twins, which was pointed out to me by Prof. Paget, described by Dr. Baume in the "Annales Médico-Psychologiques," 4me série, vol. i., 1863, p. 312, of which the following is an abstract. The original contains a few more details, but is too long to quote: François and Martin, fifty years of age, worked as railroad-contractors between Quimper and Châteaulin. Martin had twice had slight attacks of insanity. On January 15th a box in which the twins deposited their savings was robbed. On the night of January 23d–24th both François (who lodged at Quimper) and Martin (who lived with his wife and children at St.-Lorette, two leagues from Quimper) had the same dream at the same hour, 3 A. M., and both awoke with a violent start, calling out, "I have caught the thief! I have caught the thief! they are doing mischief to my brother!" They were both of them extremely agitated, and gave way to similar extravagances, dancing and leaping. Martin sprang on his grandchild, declaring that he was the thief, and would have strangled him if he had not been prevented; he then became steadily worse, complained of violent pains in his head, went out-of-doors on some excuse, and tried to drown himself in the river Steir, but was forcibly stopped by his son, who had watched and followed him. He was then taken to an asylum by gendarmes, where he died in three days. François, on his part, calmed down on the morning of the 24th, and employed the day in inquiring about the robbery. By a strange chance, he crossed his brother's path at the moment when the latter was struggling with the gendarmes; then he himself became maddened, giving way to extravagant gestures and making incoherent proposals (similar to those of his brother). He then asked to be bled, which was done, and afterward, declaring himself to be better, went out on the pretext of executing some commission, but really to drown himself in the river Steir, which he actually did, at the very spot where Martin had attempted to do the same thing a few hours previously!

The next point which I shall mention, in illustration of the extremely close resemblance between certain twins, is the similarity in the association of their ideas. No less than eleven out of the thirty-five cases testify to this. They make the same remarks on the same occasion, begin singing the same song at the same moment, and so on; or one would commence a sentence, and the other would finish it. An observant friend graphically described to me the effect produced on her by two such twins whom she had met casually. She said: "Their teeth grew alike, they spoke alike and together, and said the same things, and seemed just like one person." One of the most curious anecdotes that I have received concerning this similarity of ideas was that one twin A, who happened to be at a town in Scotland, bought a set of champagne-glasses which caught his attention, as a surprise for his brother B; while, at the same time, B, being in England, bought a similar set of precisely the same pattern as a surprise for A. Other anecdotes of a like kind have reached me about these twins.

The last point to which I shall allude regards the tastes and dispositions of the thirty-five pairs of twins. In sixteen cases—that is, in nearly one-half of them—these were described as closely similar; in the remaining nineteen they were much alike, but subject to certain named differences. These differences belonged almost wholly to such groups of qualities as these: The one was the more vigorous, fearless, energetic; the other was gentle, clinging, and timid; or, again, the one was more ardent, the other more calm and gentle; or again, the one was the more independent, original, and self-contained; the other the more generous, hasty, and vivacious. In short, the difference was always that of intensity or energy in one or other of its protean forms: it did not extend more deeply into the structure of the characters. The more vivacious might be subdued by ill health, until he assumed the character of the other; or the latter might be raised by excellent health to that of the former. The difference is in the key-note, not in the melody.

It follows, from what has been said concerning the similar dispositions of the twins, the similarity in the associations of their ideas, of their special ailments, and of their illness generally, that the resemblances are not superficial, but extremely intimate. I have only two cases altogether of a strong bodily resemblance being accompanied by mental diversity, and one case only of the converse kind. It must be remembered that the conditions which govern extreme likeness between twins are not the same as those between ordinary brothers and sisters (I may have hereafter to write further about this); and that it would be wholly incorrect to generalize, from what has just been said about the twins, that mental and bodily likeness are invariably coördinate, such being by no means the case.

We are now in a position to understand that the phrase "close similarity" is no exaggeration, and to realize the value of the evidence about to be adduced. Here are thirty-five cases of twins who were "closely alike" in body and mind when they were young, and who have been reared exactly alike up to their early manhood and womanhood. Since then the conditions of their lives have changed: what change of conditions has produced the most variation?

It was with no little interest that I searched the records of the thirty-five cases for an answer; and they gave an answer that was not altogether direct, but it was very distinct, and not at all what I had expected. They showed me that in some cases the resemblance of body and mind had continued unaltered up to old age, notwithstanding very different conditions of life; and they showed in the other cases that the parents ascribed such dissimilarity as there was, wholly, or almost wholly, to some form of illness. In four cases it was scarlet fever; in one case, typhus; in one, a slight effect was ascribed to a nervous fever: then I find effects from an Indian climate; from an illness (unnamed) of nine months' duration; from varicose veins; from a bad fracture of the leg, which prevented all active exercise afterward; and there were three other cases of ill health. It will be sufficient to quote one of the returns; in this the father writes:

"At birth they were *exactly* alike, except that one was born with a bad varicose affection, the effect of which had been to prevent any violent exercise, such as dancing or running, and, as she has grown older, to make her more serious and thoughtful. Had it not been for this infirmity, I think the two would have been as exactly alike as it is possible for two women to be, both mentally and physically; even now they are constantly mistaken for one another."

In only a very few cases is there some allusion to the dissimilarity being partly due to the combined action of many small influences, and in no case is it largely, much less wholly, ascribed to that cause. In not a single instance have I met with a word about the growing dissimilarity being due to the action of the firm free-will of one or both of the twins, which had triumphed over natural tendencies; and yet a large proportion of my correspondents happen to be clergymen whose bent of mind is opposed, as I feel assured from the tone of their letters, to a necessitarian view of life.

It has been remarked that a growing diversity between twins may be ascribed to the tardy development of naturally diverse qualities; but we have a right, upon the evidence I have received, to go further than this. We have seen that a few twins retain their close resemblance through life; in other words, instances do exist of thorough similarity of nature, and in these external circumstances do not create dissimilarity. Therefore, in those cases, where there is a growing diversity, and where no external cause can be assigned, either by the twins themselves or by their family for it, we may feel sure that it must be chiefly or altogether due to a want of thorough similarity in their nature. Nay, further, in some cases it is distinctly affirmed that the growing dissimilarity can be accounted for in no other way. We may therefore broadly conclude that the only circumstance, within the range of those by which persons of similar conditions of life are affected, capable of producing a marked effect on the character of adults, is illness or some accident which causes physical infirmity. The twins who closely resembled each other in childhood and early youth, and were reared under not very dissimilar conditions, either grow unlike through the development of natural characteristics which had lain dormant at first, or else they continue their lives, keeping time like two watches, hardly to be thrown out of accord except by some physical jar. Nature is far stronger than nurture within the limited range that I have been careful to assign to the latter.

The effect of illness, as shown by these replies, is great, and well deserves further consideration. It appears that the constitution of youth is not so elastic as we are apt to think, but that an attack, say of scarlet fever, leaves a permanent mark, easily to be measured by the present method of comparison. This recalls an impression made strongly on my mind several years ago by the sight of a few curves drawn by a mathematical friend. He took monthly measurements of the circumference of his children's heads during the first few years of their lives, and he laid down the successive measurements on the successive lines of a piece of ruled paper, by taking the edge of the paper as a base. He then joined the free ends of the lines, and so obtained a curve of growth. These curves had, on the whole, that regularity of sweep that might have been expected, but each of them showed occasional halts, like the landing-places on a long flight of stairs. The development had been arrested by something, and was not made up for by after-growth. Now, on the same piece of paper my friend had also registered the various infantine illnesses of the children, and corresponding to each illness was one of these halts. There remained no doubt in my mind that, if these illnesses had been warded off, the development of the children would have been increased by almost the precise amount lost in these halts. In other words, the disease had drawn largely upon the capital, and not only on the income, of their constitutions. I hope these remarks may induce some men of science to repeat similar experiments on their children of the future. They may compress two years of a child's history on one side of a ruled half-sheet of foolscap paper if they cause each successive line to stand for a successive month, beginning from the birth of the child; and if they mark off the measurements by laying, not the 0-inch division of the tape against the edge of the pages, but, say, the 10-inch division—in order to economize space.

The steady and pitiless march of the hidden weaknesses in our constitutions, through illness to death, is painfully revealed by these histories of twins. We are too apt to look upon illness and death as capricious events, and there are some who ascribe them to the direct effect of supernatural interference, whereas the fact of the maladies of two twins being continually alike shows that illness and death are necessary incidents in a regular sequence of constitutional changes, beginning at birth, upon which external circumstances have, on the whole, very small effect. In cases where the maladies of the twins are continually alike, the clock of life moves regularly on, governed by internal mechanism. When the hand approaches the hour-mark, there is a sudden click, followed by a whirring of wheels; the moment that it touches it, the stroke falls. Necessitarians may derive new arguments from the life-histories of twins.

We will now consider the converse side of our subject. Hitherto we have investigated cases where the similarity at first was close, but afterward became less; now we will examine those in which there was great dissimilarity at first, and will see how far an identity of nurture in childhood and youth tended to assimilate them. As has been already mentioned, there is a large proportion of cases of sharply-contrasted characteristics, both of body and mind, among twins. I have twenty such cases, given with much detail. It is a fact that extreme dissimilarity, such as existed between Esau and Jacob, is a no less marked peculiarity in twins of the same sex, than extreme similarity. On this curious point, and on much else in the history of twins, I have many remarks to make, but this is not the place to make them.

The evidence given by the twenty cases above mentioned is absolutely accordant, so that the character of the whole may be exactly conveyed by two or three quotations. One parent says: "They have had *exactly the same nurture* from their birth up to the present time; they are both perfectly healthy and strong, yet they are otherwise as dissimilar as two boys could be, physically, mentally, and in their emotional nature." Here is another case: "I can answer most decidedly that the twins have been perfectly dissimilar in character, habits, and likeness, from the moment of their birth to the present time, though they were nursed by the same woman, went to school together, and were never separated till the age of fifteen." Here again is one more, in which the father remarks, "They were curiously different in body and mind from their birth." The surviving twin (a senior wrangler of Cambridge) adds: "A fact struck all our school contemporaries, that my brother and I were complementary, so to speak, in point of ability and disposition. He was contemplative, poetical, and literary to a remarkable degree, showing great power in that line. I was practical, mathematical, and linguistic. Between us we should have made a very decent sort of a man." I could quote others just as strong as these, while I have not a single case in which my correspondents speak of originally dissimilar characters having become assimilated through identity of nurture. The impression that all this evidence leaves on the mind is one of some wonder whether nurture can do any thing at all beyond giving instruction and professional training. It emphatically corroborates and goes far beyond the conclusions to which we had already been driven by the cases of similarity. In these, the causes of divergence began to act about the period of adult life, when the characters had become somewhat fixed; but here the causes conducive to assimilation began to act from the earliest moment of the existence of the twins, when the disposition was most pliant, and they were continuous until the period of adult life. There is no escape from the conclusion that nature prevails enormously over nurture when the differences of nurture do not exceed what is commonly to be found among persons of the same rank of society and in the same country. My only fear is, that my evidence seems to prove too much, and may be discredited on that account, as it seems contrary to all experience that nurture should go for so little. But experience is often fallacious in ascribing great effects to trifling circumstances. Many a person has amused himself with throwing bits of stick into a tiny brook and watching their progress; how they are arrested, first by one chance obstacle, then by another; and again, how their onward course is facilitated by a combination of circumstances. He might ascribe much importance to each of these events, and think how largely the destiny of the stick had been governed by a series of trifling accidents. Nevertheless all the sticks succeed in passing down the current, and they travel, in the long-run, at nearly the same rate. So it is with life in respect to the several accidents which seem to have had a great effect upon our careers. The one element, which varies in different individuals, but is constant in each of them, is the natural tendency; it corresponds to the current in the stream, and inevitably asserts itself. More might be added on this matter, and much might be said in qualification of the broad conclusions at which we have arrived, as to the points in which education appears to create the most permanent effect: how far by training the intellect, and how far by subjecting the boy to a higher or lower tone of public opinion; but this is foreign to my immediate object. The latter has been to show broadly, and, I trust, convincingly, that statistical estimation of natural gifts by a comparison of successes in life is not open to the objection stated at the beginning of this memoir. We have only to take reasonable care in selecting our statistics, and then we may safely ignore the many small differences in nurture which are sure to have characterized each individual case—*Frazer's Magazine.*

# THE FORMATION OF SAND-DUNES.

By E. LEWIS, Jr.

ON the south shore of Long Island there intervenes between the uplands and the ocean a narrow beach on which the waves continually break. It is composed chiefly of clean, grayish-white, silicious sand. Other matters present are mica, garnet, and magnetic-iron sands, but, excepting a few localities, these are not in quantity sufficient to alter the general character of the beach. The sand-grains are small; some of them exceedingly minute. We found, in specimens of drifted sand, 1,920 particles in the weight of a troy grain. This will give, for a pound avoirdupois, more than 13,000,000, and about 1,450,000,000 in a cubic foot of sand. The comparison of a "great multitude" to the "sands of the sea-shore" is wonderfully vivid and impressive. Examined by the aid of a microscope, these delicate grains are seen to have lost the sharp, angular features of broken quartz, and closely resemble pebbles, irregular in form, but smooth and rounded. They are wave-worn bowlders on a small scale.

This beach, which is seldom more than one-third of a mile broad, constitutes the coast-line from Coney Island at the entrance to New York Harbor, to the Nepeague Hills, a distance of about one hundred miles, but broken by occasional inlets through which the tides ebb and flow. Throughout this distance, scarcely a pebble of any considerable size occurs. Mather, in the "Geological Survey of the State of New York," commenting on this magnificent beach-line, says, "In Europe, there is no deposit of a similar character to compare with it in extent."

Eastward from the Nepeague hills, which are of sand, along the ocean-side of Montauk Point, high bluffs of bowlder-drift reach the shore, strewing it with their falling *débris*. Here may be seen on a grand scale the process by which rocks are transformed into the fine sand of which the beach is composed. The waves throw their whole force upon the shore, carrying forward with tremendous roar tons of bowlders and pebbles which roll back as the waves recede. This process is repeated with every wave. The stones thus rolled and tossed lose something of their volume, and scarcely one can be found that does not show signs of disintegration and decay. All of them are penetrated by moisture, some are fractured by frost, and others, weakened by chemical changes, are dashed in pieces. The sand-beach represents the silicious matters of these comminuted rocks. Its position along the coast is determined by the set of the waters, but its contour of sand-hills is determined by winds. These, in their endless play, have carved it into every form possible to drifting sands. Mather observed that "where the beach is above the reach of the surf, it is covered by a labyrinth of hillocks of drifting sand, imitating almost all the varieties of form which snow-drifts present after a storm." These are sand-dunes, or dunes, as they are termed by Lyell, and their surprising mobility, in the ever-changing direction and force of the winds, is a subject of scientific and popular interest.

Everywhere on the beach, in a dry, windy day, the sand-grains on the surface are in motion. They are not carried through the air like dust, except to a limited extent, when the winds are violent, but roll or bound along the surface. Their motion, therefore, represents to the eye, although less perfectly than snow or dust, the motions of the invisible air.

The dunes are built up by slow accretions, and at the top the sand-grains are smaller than at the bottom. The process by which they are formed is a continual rolling of sand-grains up-hill by wind-force, and it is obvious that the lightest ones will attain the greatest elevation. These, too, are the ones that, on reaching the top of the hillock, roll over on the protected side of the dune, and there form a mass of fine sand. But the winds are not uniform in force, and a consequence is, the dunes are laminated in their structure, coarse and fine layers alternating. The winds change in direction too, changing the position of the sands, and thus the dunes are not only laminated, but irregularly bedded in their structure, closely resembling in this respect that of beaches formed by the plunge and flow of waves. Both structures simply represent wave-motions, one of the water, the other of the air. Fig. 1 represents a section of a large sand-dune, and Fig. 2 a similar but coarser formation hardened into sandstone.

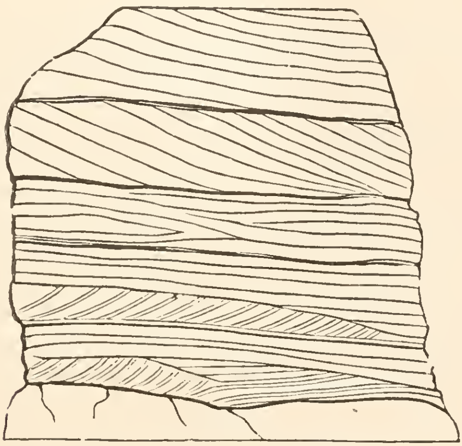

Fig. 1.—Section of a Sand-Hill, the Structure of which may have been produced by the Action of Waves or Wind.

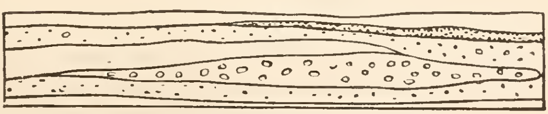

Fig. 2.—Section of Strata of Sandstone.

The exterior form of a dune undergoes continual change in dry weather from gravity. The grains of sand roll down its sides until the fine traces of wind-sculpture are obliterated, and a somewhat uniform outline is obtained. It is found that in case of dry sand the angle the side of the dune will finally assume is about 32°. But the winds rarely permit regularity in the form of dunes. A slight breeze becomes a strong one when it rises to the top of an obstacle, or is turned around it, and every dune, however small, becomes a means of so distributing the air-waves that their force and eroding power are increased. From these and similar causes, the contour of the mobile sand-hills is scarcely more permanent than that of the waves in whose spray they lie. But it is the dry sand only that is put in motion by the winds; only a few inches below the surface it is uniformly moist, and on that account somewhat adhesive. This moisture above where the sand is saturated is capillary water, that is, water held by the attraction of the sand-grains, and is about thirty per cent. of the mass by weight. It rises through the sand to the surface as evaporation goes on, and thus in this climate of rainfall the dunes are rendered more permanent than on rainless deserts.

The formation of a sand-dune seems a simple process, and it is surprising how small an object may be the nucleus of one, and indirectly of a series of them. A bush, or tuft of grass, or only a twig, as we have seen, raised above a level surface, breaks the force of the wind, and immediately the sand-grains, which are rolling along the surface, are arrested, and form a minute hillock on the windward side of the obstacle. This increases in size—the sand-grains, as before observed, are driven up its slope, and fall on the sheltered side. The mound thus formed produces currents and eddies in the moving air, and the form and position of other hillocks are determined by the new conditions. By the means indicated, dunes are formed on our narrow beaches thirty feet high; but there are dunes on our coast much higher than that, as will presently be noticed. Their size depends mainly on the abundance and condition of the material, and exposure to winds. On the coast of France they attain a height of 225 feet, and on the Atlantic border of the Sahara Desert are more than twice that elevation. But the desert sands are exceedingly fine and dust-like from attrition, and move in greater volume than is possible for the coarser sands of our coasts. They are whirled and tossed in the gale like dense smoke, but nowhere do they roll on as do waves of the ocean, as is sometimes stated. The transition of a sand-dune is by transfer and deposition of the individual particles of which it is composed.

A wonderfully vivid description of a sand-storm is given by Mr. Southworth, in his "Four Thousand Miles of African Travel:" "I was sitting at my table in the midst of the glorious sunshine of Africa. Slowly the southern horizon began to grow obscure. A huge mountain of sand, growing grander and grander, advanced rapidly. . . . The doom-palms and date-trees, frosted with clouds of white birds, the spires and minarets slowly losing their outlines in the dense obscurity. . . . It came nearer and nearer. Its front was absolutely perpendicular. To breathe was difficult and oppressive, and it was darker than the darkest night I ever knew. Sand covered the ground to the thickness of an inch."

It is easy to see that this more accurately describes a dust-storm than it does the movement of sand on our beaches. It is the fine material only which is thus swept through the air. The coarser sands are driven along the surface, and constitute the hills of the desert, and they are built up as similar ones are of the still coarser sands of our coast. Grain by grain they rise at the touch of the invisible architect. This is true not only of the great dunes, but of the smaller ones, or ripple-marks, which cover the surface of the sands. These beautifully cut and wavy furrows represent the undulatory movement of the air. With a full breeze, they are all seen to be in motion. The grains hop and bound along as the air passes, and the form shown in Fig. 3 is the one which the sands continually assume. But, even while

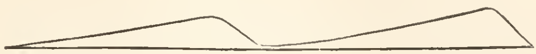

Fig. 3.

we watch, each little ridge or mound has been transferred to the space which was a furrow only a few moments before.

These sand-ripples rise on the sandy floor, however level and smooth they may be, as the wind in passing strikes it, in a series of wave-like undulations.

Ripple-marks thus formed are, sometimes, as we have witnessed, covered by drifting sand, and are retained with wonderful distinctness, when the material is hardened into sandstone. All the vast beds of this material existing in the crust of the globe are but the compacted ruins of rock still older, and their furrowed tablets repeat to our eyes the rhythmic beat of winds and waters in ages long past. Fig. 4 represents a slab of sandstone covered with ripple-marks, evidently produced by water, but which differs in form only from those produced by wind.

Sand-dunes are not only blown away piecemeal, but the winds pour upon their flanks a ceaseless shower of sand, and, as the frail masonry gives way, the falling grains are caught and carried on by the gale. By this natural sand-blast rocks are sculptured on the highlands of the Rocky Mountains, and the glass of windows on exposed beaches is sometimes cut through.

On the north side of Long Island, upon the banks along the Sound, are a great number of sand-hills from twenty to eighty feet high. The banks are of glacial drift, with bowlders of immense size, and eastward of Port Jefferson Harbor, for upward of forty miles, are crowned in many places by these broken, desolate hills. In some places they advance slowly inland. A farm, near the village of Baiting Hollow, in Suffolk County, has lost from this cause thirty acres in half a century. Other farms have lost valuable land in a similar way, and we are informed that, during the time mentioned, 100 acres of arable and timber land have been inundated, and are now deeply covered with drifting sand in this immediate neighborhood. At this point is the great dune known on the Coast Survey charts as Friar's Head. Its top is 150 feet above tide, but it stands on the bank which is half that height, so that 75 feet of that elevation is drifting sand. It was originally formed many yards inland, as others are continually

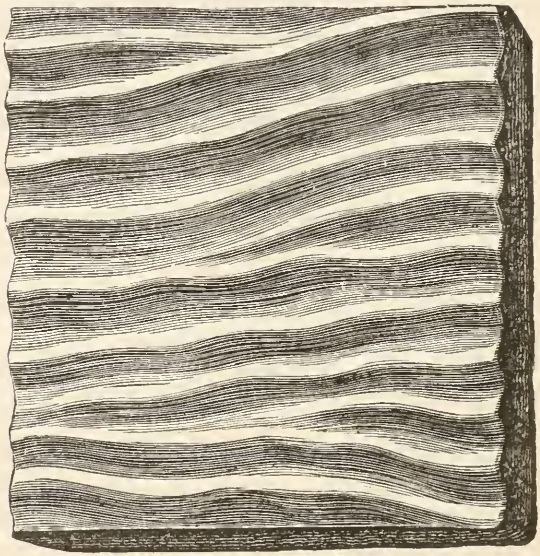

Fig. 4.—Slab of Ripple-marked Sandstone.

forming, but, by the ceaseless wearing away of the bluffs, it is now upon their brink. It is evidently of considerable age, as its windward slope is covered by a thick growth of beach-grass, bayberry and other bushes, with stunted trees of beach and cedar quite at its top.

From this point the weird architecture of the sand-hills is singularly impressive. There is formed, to the southeast of Friar's Head, a great semicircle of sand, between which and the dune is a floor of several acres in extent swept by the winds. This floor, the original surface of the drift now laid bare, is rich in the remains of an old Indian settlement. Hundreds of specimens—including arrow-heads of flint, jasper, and quartz, axes of various sizes, and other articles of utility—have been picked up.

The sand blown from this spot and from the flanks of the dune constitutes the semicircular wall spoken of. It is one-eighth of a mile inland, and lies directly against a forest of oak and pine, burying many of the trees to a height of thirty to forty feet, only their dead and barkless tops being visible. On the surface of these sands beach-grass of several kinds, and young pine-trees (*Pinus rigida*) maintain a doubtful struggle for life. This dune does not materially differ from a very large number which cover the banks on the north shore of Long Island. Their source is the *débris* of the banks reduced to sand by the action of the waves. The lighter portions of this sand are carried up the slope during fierce winds, and the process is now in operation during every gale. The present forests may delay, but cannot arrest, the final inundation of the land where the sand-hills crown the coast. In Europe the maritime pine and other species of plants whose habitat is the silicious sand have not only arrested the movement of it, but have covered immense areas of waste land with valuable forest. Our native pitch-pine, the *Pinus rigida* above mentioned, also flourishes on the most sandy soils. There is proof that it formerly grew on portions of the south beach of Long Island, where its foliage was moistened by the spray of the ocean, nor does the occasional overflow of the tides soon destroy it. If these trees are planted abundantly over the surface of these broken hills of sand, their movement would be delayed if not permanently arrested. The sands lie motionless where the force of the wind is broken.

## SKETCH OF SIR CHARLES WHEATSTONE.

CHARLES WHEATSTONE was born in the city of Gloucester, England, in 1802. In boyhood he attended a private school in his native town, but, while still a lad, he quit school and devoted himself to mechanical pursuits, adopting the trade of a maker of musical instruments. At about the age of twenty-one years he went to London, and there set up in business on his own account. Here the young tradesman evinced a strong liking for scientific research, endeavoring to find out the principles involved in the various forms of musical instruments. He was thus led to the study of acoustics, a branch of science which he cultivated with rare success. His singular mechanical ingenuity enabled him to repeat and extend the experimental results of prior investigators, and the first fruits of his scientific researches were communicated, in 1823, to the *Annals of Philosophy*, in a paper entitled "New Experiments on Sound." Other essays on the phenomena of sound were published by him from time to time; thus, in 1827, he contributed to the *Quarterly Journal of Science* two papers, the one "Experiments on Audition," the other a "Description of the Kaleidophone." In 1828 he published in the same journal a paper entitled "Resonances of Columns of Air;" in 1831, "Transmission of Sounds through Solid Linear Conductors" (*Journal of the Royal Institution*); and the same year read at the meeting of the British Association papers on "Purkinje's Figures," and on "Bernouilli's Wind Instrument." These were followed by papers on "Chladni's Figures" (1833, "Philosophical Transactions"), and "Imitation of Human Speech by Mechanism" ("British Association Report," 1835).

The numerous analogies between the phenomena of sound and those of light early led him to the study of the latter subject. Here, again, his remarkable ingenuity as a mechanician came into play. He undertook to measure the velocity of electricity, and for this purpose he invented the method of revolving mirrors; in this way it was shown that the electric current travels at the rate of 288,000 miles per second. These results were published in the "Philosophical Transactions" in 1834. While engaged in these researches he observed that the sparks emitted from different metals under the influence of electricity differed from one another in color, "thus shadowing forth," says M. Dumas, "the discovery of the spectroscope." In the "British Association Report" for 1835 is a paper by Wheatstone on "Prismatic Decomposition of Electric Light," and in the *Philosophical Magazine* (1837) one on the "Thermo-electric Spark." He had been appointed Professor of Experimental Philosophy in King's College, London, in 1834, and in June, 1836, in his lectures on the velocity of electricity, which were illustrated by experiments with a circuit of copper wire nearly four miles in length, he proposed to convert this apparatus into an electric telegraph. At this time Wheatstone was not aware that Prof. Joseph Henry had five years previously transmitted signals by means of an electro-magnet through a wire more than a mile long, causing a bell to sound at the farther end of the wire. In May, 1837, Charles Wheatstone and William Fothergill Cooke (afterward knighted) took out a patent "for improvements in giving signals and sounding alarms in distant places by means of electric currents transmitted through metallic circuits." The first public line of telegraph was constructed on the Blackwall Railway in the following year.

While investigating the laws of light, Wheatstone was very naturally led to consider the phenomena of vision, and in 1838 he published in the "Philosophical Transactions" two papers entitled "Physiology of Vision" and "Binocular Vision." In the latter he explained the principles of an instrument invented by himself, the stereoscope. This invention was by no means the result of chance, but the fruit of profound study of the physiology of vision. In this matter Wheatstone's merit is unquestioned. Other papers on the phenomena of vision are, "Juxtaposition of Several Colors" (1844); a second communication on "Physiology of Vision" (1852); "Binocular Microscope" (1853); "Fessil's Gyroscope" (1854).

In the "Proceedings of the Royal Society" (1840) is an article by Wheatstone, on an "Electro-magnetic Clock," in which he shows how a number of clocks, situated at a distance from one another, may be actuated by one central clock. In *Comptes Rendus* (1845), he explained the principle of an electro-magnetic chronoscope. Subjects connected with telegraphy and electricity are treated in papers entitled "Electro-magnetic Telegraph" (1840); "Constants of Voltaic Circuit" (1843); "Meteorological Registers" (1844); "Submarine Cable of the Mediterranean" (1854–'55); "Aluminium in Voltaic Series" (1854–'55); "Automatic Telegraphy" (1859). To complete the list of his papers, we name a "Letter to Colonel Sabine on Meteorological Instruments" (1842); "Determination of Solar Time by Polarization" (1848); "Foucault's Rotation of the Earth" (1851); "Powers for Arithmetical Progression" (1854–'55); "Report on Captive Balloons" (1863).

Wheatstone was chosen Fellow of the Royal Society of London in 1836. He was a juror in the class for heat, light, and electricity in the Paris Exposition Universelle, 1855, and was then appointed a knight of the Legion of Honor. In 1868 he received the honor of knighthood from Queen Victoria, and the same year was awarded the Copley medal by the Royal Society for his researches in acoustics, optics, electricity, and magnetism. He was made LL. D. by Edinburgh University in 1869. In 1873 he was elected a corresponding member of the Paris Académie des Sciences, in the place of Baron Liebig, deceased. He was also a member of the chief scientific associations and academies of Europe.

Prof. Wheatstone was married in 1845. His death took place at Paris, on the 19th of October, 1875. He left a numerous family.

In a brief memoir published in the *Academy*, Mr. C. Tomlinson, who was an intimate friend of Wheatstone, states that the latter never obtained eminence either as a writer or as a lecturer: before a large audience he was nervous and hesitating, but in familiar conversation his ideas "would flow so pleasantly and so lucidly, that one could not help reflecting that, if all this had been put into a lecture, Wheatstone might have become a successful rival even of Faraday." On such occasions he spoke unreservedly of the scientific work in which he happened to be engaged, and in this way other men often pilfered his ideas, and took the credit to themselves. On one occasion at least, Wheatstone recognized his error, for he paid ten guineas for a piece of apparatus for the purpose of stopping the inventor's mouth, said "inventor" having derived the idea of it from Wheatstone himself.

## CORRESPONDENCE.

### INFIRMITIES OF SPEECH.

*To the Editor of the Popular Science Monthly:*

THE article in the August number of the Monthly upon "Infirmities of Speech" was a stimulant to much curious reflection. A true student of character will see, among the men and women he meets in the parlor, idiosyncrasies of speech and manner that are common to quite a large class of people. Dr. Trousseau's patient was but one of many. The wife of a physician of this city, formerly an inspector of the Board of Health, created much merriment among acquaintances by the singularity of her answers to the simplest questions. Nearly every expression was a comparative one. To a stranger her conversation appeared of the quality of humorous extravagance. Upon one occasion she was asked the condition of a friend who had been a long time sick. "Oh, she's about like the lid of a stove," was the reply. This excited laughter, but was unsatisfactory. "Was she feverish?" "No." "Was she in a chill?" "No, she was just like the lid of a stove, don't you understand?" Her husband explained the expression by saying that the sick friend was exceedingly *nervous*, and that his wife, in making the comparison, alluded to the dancing of a tea-kettle on a hot stove. From early girlhood she had employed this expression, to the exclusion of the correct one.

In their reminiscences, Charles and Mary Cowden Clarke mention a similarity in the speech of George Dyer. With a question, answer, or other observation, he would begin intelligently; after a few words, fill in the space of several others with a series of abd's, as if choking, and, in concluding, would invariably use "Well, sir, but, however." A gentleman of rich culture and high professional eminence has used "and consequently" since he was a boy, whenever he exhausted breath in his rapid speech, was unable to grasp the correct word, or was interrupted. He was, and still is, unconscious of this peculiarity. He will so designate a man, a woman, a piece of furniture, or any object whose proper name is for the time hidden. This habit, as the untutored would denominate it, is so apparent that a stranger would detect it in five minutes.

The ability to always use the best words to give force to an idea is possessed by so few, that the promiscuous gathering of words, if not too idiotic, is charitably passed over without remark.

A young lady, whose company is much solicited for the graces of her mind, undergoes a most piteous embarrassment from the effects of this infirmity. In the early part of the evening her choice of words will be faultless; and she will render a criticism or narrative with an enviable flow. But, later, she becomes nervous, hesitates, studies her words, trips, and then stumbles on to the climax with nouns, adjectives, adverbs, and verbs that darken, instead of illumine, the "point." It is but a few evenings ago that, in speaking of the influence of Hans Christian Andersen's tales, she said: "Now, how few writers are capable of so effectively consolidating the contradictory impulses that arise in a child's mind! No, I mean so effectively con—con—well, mix up will oil." And, when *conciliate* was mentioned, she said that was the word she desired. If she ventured upon a further observation the infirmity increased, so far as to leave her sentence a hopeless wreck.

Many will say this is a habit, and only becomes an infirmity by being allowed too free scope. Still, the best-educated people are subject to it.

To carelessness is attributed another peculiarity, not of speech, but of action. The physician before alluded to was unable to page his manuscript of stenographic reports of lectures before the College of Physicians and Surgeons. The figure 8 was always uppermost in his mind, and all but the first page would have that numeral in the upper left-hand corner. When arranging the pages for eyelets or tape, he was obliged to read over each one; and he was not assured of the sequence until the mass had been examined by another.

Some writers fasten their best thoughts when penning with the greatest haste. Their manuscript, like that of many careful authors, contains either neglected or erased words—terminations that appear perfectly inexcusable. Think of a scholar tracing with a rush *fixed*, and then adding *tion*, or satisfying himself with *hermeticly;* and yet, in overlooking thousands of pages of copy prepared by authors who would have a delirium if the slightest typographical error appeared in the "revise," I have stricken out countless terminations and intermediate syllables and letters—not specimens of bad spelling, so called—that looked like grammatical refugees, so far were they from their proper place.

Again, in writing, the pen does apparently just what the organs of speech do when certain words are to be produced. In the most delightful stage of composition, when the brain and the pen jog on comfortably together, it will often be found, on looking back a few lines, that a stranger has turned up who the author is positive has no right in such company. There it is, winking at a clever trick that the subject cannot explain.

Here the writer possesses the memory of words and the memory of how to use words. But, while the mind is being tickled with the successful unfolding of a pet theory, or the attractive draping of an important idea, the pen surreptitiously lets in an unblushing beggar.

In writing, the brain will order the pen to inscribe a certain word, and, with voluminous authors, that nimble servant will frequently transfix an unsuspected one before the outrage is detected.

Now, as in the case above, the author possesses the knowledge of the exact word that is desired; but an incorrect one appears. Neither the memory is lost, nor the ability of utilizing it. Think of the results, when the proof-reader strides through the idea, and buries a still more uncongenial word in the prettiest passage.

Recognized carelessness causes omission of words, curtailment of words, and oftentimes incorrect spelling. It is only the carelessness that is not recognized that takes a fancy to giving a word more letters than it craves, changing favorite words at birth, and placing before the eye a stone when bread is wanted.

G. J. Hagar.

New York, *August*, 1875.

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# EDITOR'S TABLE.

## *THE CASE OF GUIBORD.*

ALL over the world, in all times of which we know any thing, and among tribes of men of every grade, the most intense and powerful feelings of human nature have gathered around the dead, the graves where they are buried, and the rites of sepulture. Besides the ties of affection that are sundered by death, and which are often so deep and strong that their rupture leaves life a desolation, the imagination is also brought into exalted activity, and religious hopes, fears, and anxieties, and the terrors of superstition regarding a future life, combine to heighten the solemn interest of the occasion. As men are ruled through their feelings, and as the more powerful the feelings the more complete is their subjection to those who can skillfully work upon them, it is not to be supposed that these potent emotions concerning the dead would remain unutilized by parties ambitious of influence over the consciences and conduct of men. It is an important part of the polity of the Roman Catholic Church to use the powerful sentiments that are associated with death, the dead body, and the grave in which it rests, for the promotion of the objects of ecclesiastical ambition. That corporation assumes the prerogative of consecrating or cursing the ground to be used for the burial of the dead, as a part of its larger claim to control the destiny of people in the future world. And, for many centuries, this has been one of the most potent means of its influence. The case of Joseph Guibord, of Montreal, which has now perhaps reached its close, affords an instructive illustration both of the character of this old churchly assumption, of the tenacity with which it is still held, and of the vigor with which it is maintained wherever there is power to enforce it. The circumstances have been widely published, but it is desirable here briefly to recall the leading facts:

A literary society in Montreal, known as the "Canadian Institute," some years ago introduced into its library a number of works that came under the ban of the Roman Catholic Church. The Bishop of Montreal disapproved them and commanded their exclusion, which being refused by the Institute, the bishop appealed to Rome, and a papal decree was fulminated. The society remaining contumacious, the bishop pronounced a ban upon its members excommunicating them and forbidding them the last offices of the Church in "the article of death." The consequences of this decree first fell upon Guibord, who died in 1869. His estate owned a burial-lot in the Catholic cemetery of Notre-Dame, and the widow applied for ecclesiastical burial for her husband. This was refused: he could not be buried in his own lot, and the only place permitted for the remains was the unconsecrated part of the cemetery devoted to excommunicants, malefactors, suicides, and unbaptized infants. The case was then taken to civil trial and a long lawsuit followed; the Canadian Superior Court, the tribunal of last resort, deciding ultimately against the priest and trustees of the cemetery. This decision not being respected by the Catholic authorities, an appeal was taken to the Privy Council, and a royal decree issued commanding the priest and trustees of the cemetery to inter the mortal remains of Guibord in consecrated ground. The priest replied that he was forbidden to do this by the bishop, and could not comply. An order was then served on him under the decree of the Privy Council, and the funeral appointed for the 2d of September. The priest, however, refused to be present. The members of the "Canadian Institute" and their friends, numbering about three hundred, accompanied Guibord's remains, from the vault of the Protestant cemetery where they had been placed, to the Catholic cemetery, where they were met by a mob of some five hundred French Canadians who closed and barred the gates, and refused entrance to the hearse, which was attacked with stones by the mob that had rapidly increased to about two thousand. They drove back the procession with derisive shouts, filled up the grave, and tore down the cross at its head.

The burial was thus defeated, and riotous demonstrations were continued for two or three days. Preparations were then made by the civil authorities for enforcing the burial, the military were called out to maintain order, and on the 16th of November, after six years of contention and delay, the body of Guibord was placed in his lot, the coffin being bedded in cement as a protection against the violation of the grave.

We do not refer to these facts merely as furnishing a new example of the inevitable collision that arises between the civil authority and the Roman Catholic Church wherever that organization feels able to assert its power—of which so much has recently been said. But the case impressively illustrates a single and most interesting phase of this ancient conflict. In the attempt to get the bones of an old man, long since dead, into their final and chosen resting-place, a city is convulsed with riot, a whole province thrown into excitement, a rancorous religious quarrel aroused, expensive legal proceedings entailed, and battalions of soldiers with muskets and cannon, have at last to be invoked to carry out the mandate of a judicial tribunal. All this has resulted from the action of an ecclesiastical body which for centuries has pursued this policy of using the graveyard and its associated superstitions as a means of spiritual domination and temporal profit. Guibord was in favor of having certain books in a library to read. His Church declared that he should not have them there. He adhered to his opinion, and the Church then declared that he should not have Christian burial. The appeal to his superstitions was not strong enough to move him, but it thrilled the community with a painful agitation, and for many centuries such appeals and threats have been powerful enough to intimidate and keep in subjection countless millions of people. For more than a thousand years the Catholic Church has maintained its claim, against the civil authority, to the ownership and custody of the dead, and by attaching the place of interment to the church, by prohibiting heretics from Christian burial and making it ignominious to repose in any but consecrated earth, and by digging up the bones of those who are alleged to have entertained false opinions, burning them and scattering the ashes to the winds or casting them into the floods, the Romish ecclesiastics have not only made the church-yard a copious source of pecuniary emolument, but "a vital portion of the material machinery for enforcing spiritual obedience and theological conformity."

The history of the antagonism between the ecclesiastical and civil authorities, regarding the ownership and control of the dead, is of great interest; and a very able sketch of this subject by an eminent legal writer will be found in the present number of The Monthly. It is part of a report on the "Law of Burial" made to the Supreme Court of the State of New York, by Hon. Samuel B. Ruggles. When Beekman Street was widened several years ago, a slice of land was taken from the "Brick Church" property to be converted to public use, and the ground thus appropriated embraced certain vaults long ago constructed for the reception of the dead. The question arose in regard to the legal control and redisposition of the bodies contained in these vaults, and Mr. Ruggles was appointed as a referee to take evidence and make a report upon the subject. In this masterly document, he touched upon the historical aspects of the legal question, showing that the old view, held by the Roman and Saxon law, was that the civil authority had jurisdiction in the case, and that under the common law the bodies of deceased persons are subject to the control of those next of kin. The Church, early in the days of its power, subverted this principle, and under the title of "ecclesiastical cognizance" established its exclusive authority over the burial of the dead, and even carried its assumptions so far as to decree, not only who should be allowed to lie in consecrated earth, but who should be allowed to be interred at all! The part of Mr. Ruggles's report which we reprint will be found of general interest to readers, and in a high degree instructive in connection with the Guibord case.

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## *SCIENCE IN GERMANY AND ENGLAND.*

The influence of national characteristics upon the pursuit of science is an interesting subject of observation and reflection. For while there is a broad general agreement among scientific students of all nationalities as to what science is, and the mental methods or processes involved in its extension, there is a marked diversity among the people of different countries in the organized arrangements for its promotion, the feelings that impel its pursuit, and the relations of scientific bodies to what may be called the outlying and adjoining departments of thought, culture, and mental activity. The contrast, for example, between the Germans and the English in the policy and management of their great popular scientific associations is, in various respects, striking and instructive, and an intelligent correspondent of *Nature* has lately drawn attention to some of their peculiarities, which are so suggestive as to deserve a special notiee.

The writer intimates that the "Association of German Natural Philosophers and Physicians," which was founded in 1822, is the original of the British Association, which was established some years later, and modeled in various respects upon the German pattern. Speaking of the late meeting which was held in September at Gratz, the chief town of Styria, in one of the most beautiful valleys of the Austrian Alps, after noting that the number of those in attendance corresponds very nearly with the average number of attendants at the British Association, he adds that, although this may be a merely fortuitous resemblance, yet "both associations are eonvened for the same number of days; both hold the same number of general and sectional meetings; they resemble each other in the nature of the recreations offered to visitors—excursions, dinners, and concerts, to which, in Germany and Austria, are added balls and theatrical performances, while England has the private hospitality of its nobles and rich manufacturers and merchants to offer, which does not enter into the German programme, or certainly does not appear in it to the same extent. A festivity of a peculiar character, in addition to those named, was offered by the municipality of Gratz: an illumination by bonfires of the mountains surrounding the town, a sight of most impressive beauty."

The chief points of contrast in the proceedings of the two bodies are stated to be that, "generally speaking, there are no evening meetings in Germany, and, the festivals being of a public nature (not depending upon private hospitality), the eonnection between the visitors is greater than it is at the British meetings. The peculiarity of the German meetings is the absence of a president; two *chargés d'affaires* being nominated to eonduct the business of the Association—one a natural philosopher and the other a physician. The sections nominate new presidents for each of their daily meetings. A consequence of this arrangement is a certain want of formality. No retrospective introduetions (presidential addresses) are offered at the opening of the sectional meetings, no eriticisms of the work of fellow-workers by more or less competent critics, no sweeping remarks on the state of science in general. In two respects the British Association has an indisputable advantage over the German meetings. Those splendidly illustrated evening lectures addressed to the general public, which form one of the attractions of the meetings in the United Kingdom, are not offered in Germany. Again, the funds of the German Association are small; they are spent for the purposes of each meeting, and no money can be given in grants for scientific purposes, as is done in Great Britain. On the other hand, the German Association offers the advantage of a speedy publication of its transactions. Instead of publishing an annual volume long after the close of the meetings, the German Association offers a daily paper, giving the proceedings in a more or less condensed form, according to the notes given by members to the general or sectional secretaries. Generally, some supplementary numbers are issued completing the report within one month after the conclusion of the meeting."

The German scientists are furthermore eontrasted with those of England by their more pronouneed repudiation of utilitarian aims. English science has flourished under the stimulus of a pressure from the practical arts which has powerfully influenced the direction of investigation; the problems being given by art are accepted by science for solution. The eminence of England in commerce, navigation, manufactures, and locomotion, has impressed itself upon English science, which, while recognizing its true work to be the increase of original knowledge and new discoveries, will yet not lose sight of the great practical results to be attained through such discoveries. German science, on the other hand, still influenced by the spirit of its barren philosophies, vehemently protests against this alliance with the practical and the useful. It is never done denouncing the sordid, bread-and-butter philosophy of the English. In exemplification of this feeling, a passage is given from an address of Lieutenant Weyprecht on arctic explorations, in which he says: "Originally it was the wish for material gain in the shape of fur and fish-oil that prompted arctic exploration. Later on, this cause was replaced by the ambition of geographical discoveries, such as are easily understood by the general public. The running after this sort of fame gradually assumed such proportions that arctic exploration became a sort of international steeple-chase toward the north-pole, a system opposed to true scientific discoveries. Topographical geography must be subordinated, in arctic regions, to physical geography. Geographical discovery derives its value only from scientific discoveries connected with it. The exploration of the great and unknown latitudes near the poles of our globe must be continued without regard to the expenditure of money and of life which it demands. But its ulterior aim must be higher than the mere sketching, and christening in different languages, of islands, bays, and promontories buried in ice, and the mere reaching of higher latitudes than those reached by our predecessors. One reason of the indifferent results of previous expeditions is, that they have been unconnected with each other. The progress of meteorology consists in comparison, and every success it has obtained, such as the laws of storms, the theory of winds, etc., is the result of simultaneous observations. The aim of future arctic explorers must be to make simultaneous observations, extending over the period of a whole year, with identical instruments and according to identical rules. In the first place, they will have to consider natural philosophy and meteorology, botany, zoölogy, and geology, and only in the second place the discovery of geographical details. I do not intend in what I said to depreciate the merits of my arctic predecessors, whose sacrifices few can appreciate better than I do. In giving utterance for the first time to these opinions, which I have taken time in forming, I complain against myself, and I condemn the greater part of the results of my own arduous labors."

Germany is again contrasted with England in the completeness with which science is separated from religion, a result we should hardly have expected among a people so prone to philosophical speculation. Their scientists pursue their investigations with but very small regard to the bearings they may have upon theological beliefs. The writer whom we have quoted gives an illustration of this in a lecture delivered at the Gratz meeting by Prof. Benedict on the history of crime with regard to ethnology and anthropology. "He touched upon delicate ground, asserting that every action is based less on liberty than on compulsion; that our acts are governed by natural laws, and not by theological opinions; and that punishment may act as a corrective of perverted human nature, but is chiefly the outflow of the desire of society to avenge wrongs inflicted upon it. The best prevention of crime depends upon the increase of our knowledge of those circumstances that necessarily engender it. In England a speech like this would, no doubt, have raised a storm of theological indignation. In Germany the clergy is distinguished by its absence from scientific meetings. The separation of natural science and orthodoxy is complete, and no opposition was therefore offered to these remarks."

The tendency of English science to occupy itself more or less with religious questions has several causes. In the first place, there is a large and cultivated clerical class whose professional duties are nominal, and who devote themselves earnestly to scientific studies. These mingle in the scientific societies and associations, and bring with them the bias of theological doctrine. Much money has, moreover, been expended in England, in the way of prizes, to be given to writers for making scientific books, for the advancement of theological views; and, as shown by the Bridgewater treatises, some of the most eminent and influential scientific men have sanctioned this practice, which has been much imitated by others of inferior ability. Such a course could hardly fail to arouse reaction and stimulate controversy. But, besides these causes, a cause still more efficient has been in operation there, in the rise of a school of psychology, that has brought old and fundamental theological doctrines and dogmas into the arena of scientific scrutiny, so that scientific men, in the performance of their duty as investigators, find themselves brought into collision with the "defenders of the faith."

But, while English science is much complicated with theology, it is but very little affected by politics. On the other hand, the political perturbations of German thought are deeply felt in its scientific assemblages. While English science is laboring to free itself from undue theological influence, German science is struggling for freedom of thought from undue political influences. This was the burden of the opening addresses of the September meeting. The Association was formed upward of half a century ago, and the writer in *Nature* says that politics entered into the intentions of its founder—the celebrated Oken, Professor of Zoölogy at Jena—as well as of many of its original members. "When German unity was nothing but a treasonable aim of persecuted patriots, every meeting of Germans from different states served to spread and to give fresh vigor to this aim, and was in itself a protest against the division into small states of the common country, and against persecutions such as Oken himself has had to suffer. Ay, and even now, when the old wishes have been fulfilled, and no division separates government and nation, remains of the old political undercurrent can still be traced in some of these meetings."

The interest of German men of science in political subjects is, therefore, an incident of the disturbed condition of the people, rather than any tendency to the purely scientific study of political and social problems.

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We have a great amount of declamation on the dignity of mind, but we shall have a rational appreciation of that dignity just in proportion as we understand the laws of mind: what we need, therefore, is a broader and clearer apprehension of mental science. The attention of students of this subject is called to the weighty and suggestive article which opens the present number of The Monthly, on "The Comparative Psychology of Man." It treats of a phase of the subject of great moment, but hitherto only slightly regarded. It will be evident to all readers that the view taken by the writer is one that must be permanently recognized in future if mental phenomena are to be interpreted on strict scientific principles. But the article, moreover, remarkably exemplifies the close interdependence of the higher and more complex sciences. Those who have been slow to comprehend the alleged important bearing that psychology has upon sociology will see that the two subjects are so inextricably involved—the mental organism and the social organism having been developed together by intimate interaction—that neither can be elucidated in a really scientific way without working out its relations to the other. The article affords an excellent illustration of the fruitfulness of investigation from the genetic point of view.

## LITERARY NOTICES.

Currency and Banking. By Bonamy Price, Professor of Political Economy in the University of Oxford. Pp. 176. Price, $1.50. D. Appleton & Co.

The author of this book is not a stranger to the American people. He made a tour of the country a year or two since, and was called upon at various points to express his views on currency and finance, which he did with a bluntness and pungency that made a deep impression upon his hearers, and upon all who read his well-reported addresses. It was felt by many that his views were sound and important, and that it would be an advantage to the country if he would give us a season of lecturing upon the subject. But, as he could not remain, he agreed to do the next best thing, which was, to prepare a little volume, to be published in this country, giving a condensed exposition of his views. This volume is now issued and will be widely read, as well for its vivid and racy controversialism as for its sound and instructive teachings upon the topics discussed. Besides the Appendix, it is divided into three parts: first, "Metallic Currency;" second, "Paper Currency;" and third, "What is a Bank?" Prof. Price insists that there is really very little mystery about this subject that is generally regarded as so mysterious; while he admits that there is more error and absurdity and stupid nonsense put forth regarding it than upon almost any other subject of current speculation. A main cause of this, he states to be, the credulous confidence with which the public listens to the outgivings of men whose authority comes not from any intelligent or scientific understanding of the subject, but from the circumstance that they deal in money and have a great deal of it, and much to do with it. But practical familiarity with business operations, he maintains, is very far from conferring insight into the philosophy of such operations. A blockhead may make money, and make a parade of all the technical terms of finance, but know no more of the principles of the subject than the veriest beggar who hardly sees a dollar from one year's end to another. Yet the public pricks up its long ears to listen to the oracular twaddle of brokers, bankers, merchants, and treasury officials, who only confuse and confound the subject with their discordant utterances. Such books as those of Price and Jevons will do much to clear away the fog that has gathered around monetary questions in this country, and they should be widely circulated and carefully read, especially by young men who would prepare themselves to take a useful part in public affairs.

Elements of Meteorology. Part II., Meteorological Cycles. By John H. Tice. St. Louis, 1875. Pp. 208. Price, $2.50.

We have in Mr. Tice's book another wild and fruitless attempt to explain all phenomena by electricity. As, in former times, unexplained phenomena were ascribed to magic or supernatural power, so in modern days the unscientific look to electricity as the efficient cause of all physical mysteries. The author of this book admits no force but electricity. Mechanics is a nightmare, centrifugal force is electric repulsion, the perturbing force of a planet is only electric attraction, and all the phenomena of our atmosphere arise from electrical causes.

The volume before us is Part II., and from the preface we learn that Part I. has never been published; we are, however, not left in doubt as to its contents. We are told on the first page that in Part I. we can learn "all about the nature and constitution of rain and snow storms; all about cold and hot, wet and dry, seasons; and all about winds, gales, tornadoes, and hurricanes." If Mr. Tice has done half of what he claims, he has done enough to secure immortal fame. Nevertheless, after an examination of Part II., we are seized with a violent longing to be spared from Part I. The special function of Part II. is to establish meteorological cycles and to promulgate the theory of planetary equinoxes, on the strength of which Mr. Tice has made predictions which have gained for him considerable attention. It is unfortunate, however, for his reputation that he ever ventured into print; for no one can give his book the most cursory examination without detecting its unsoundness. Lack of space forbids more than a brief outline of Mr. Tice's theory. To point out all his errors in mathematics, physics, and astronomy, his false assumptions and logical fallacies, would require several pages.

All phenomena are periodic. "The regular recurrence of *identical* physical phenomena is an admitted fact." Were the cycle known, we could tell just when the phenomena of the past would be repeated. Mr. Tice considers the discovery of a meteorological cycle "the most *clamant desideratum* of the age." The discovery (?) of the Great Cycle was Mr. Tice's first step in the science of meteorology. It is exactly 11.86 years. He claims that this is established by the periodic phenomena of sun-spots, magnetic storms, cyclones, earthquakes, auroras, etc., but fails to give us the process of reduction. This period is identical with Jupiter's year, and the inference is that Jupiter is the cause of the cycle, which henceforth is called the Jovial Cycle. The idea of associating Jupiter with the eleven-year periods is not new, but we supposed it had been abandoned.

Mr. Tice's next stage is to prove that the phenomena of sun-spots, cyclones, etc., reach their maxima when Jupiter is at his equinoxes, and, of course, once every 5.93 years. This proof Mr. Tice gives in full with immense satisfaction, quite unconscious of its having not even a presumption in its favor. Finding nothing in his astronomy of Jupiter's equinoxes, he *assumed* that his solstitial points coincided with his points of greatest and least distance from the sun (aphelion and perihelion), as is the case, approximately, with the earth. The same groundless and false assumption is afterward made for the other planets, and such reasoning Mr. Tice calls "deduction from general principles" and "telluric analogy." Again, at its equinoxes the earth is at its greatest distance north and south of the plane of the sun's equator: Mr. Tice infers that the same is true of all other planets.

Mr. Tice calculates the equinoxes of the planets from their aphelia and perihelia, and accounts for the disturbing force of a planetary equinox on the supposition that the planet at its equinox is at its greatest distance from the solar equator, and hence exposed to only one pole of the sun. Thus, when the earth is at its vernal equinox, the north pole of the sun is invisible, and we are exposed to the full influence of its south magnetic pole. Terrific energy is then interchanged, disturbing both the atmosphere of the earth and that of the sun. The disturbances in the latter are communicated to the other members of the solar system. Similar results are produced at the autumnal equinox by the sun's north magnetic pole. When at their equinoxes the other planets undergo a like experience, and indirectly, through the sun, we share in the resultant electrical excitement. Such is the theory, and on such foundations does it rest. Historical records and the reports of the weather bureaus furnish endless confirmations, for every storm finds an equinox to bear the responsibility. In order to include all actual phenomena, the duration of an equinoctial period is put at one-fourth the planet's year, so that each planet spends half its time in creating disturbances throughout the solar system.

Not the least curious feature of the book is the adoption, into the family of planets, of the mythical Vulcan, supposed to have been discovered in 1859, and for a time believed to be a real planet, lying very near the sun. As nothing has been seen of it for the last dozen years, this looks very much like another assumption, of which, indeed, there appears to be no lack throughout the book.

Proceedings of the Seventh Annual Session of the American Philological Association, held at Newport, R. I., July, 1875. Hartford, 1875.

The meeting of the American Philological Association, of which this pamphlet is a record, was held at Newport, R. I., from July 13th to July 15th of this year. It was opened by an eloquent and suggestive address from the President, Dr. I. Hammond Trumbull, who reminded the Association of the urgent need of attentive study of the structure of the languages of our American Indians, a need all the more urgent as they have no written language, and as year by year they are passing away. The vexed question as to a change in the present mode of spelling in English was also considered, and Dr. Trumbull avers that, while scholars agree on the question of the *desirability* of such a change, the main difficulty in the way of reform is the want of agreement among them as to the best way of effecting it. He says, "The objection that reform would obscure etymology is not urged by real etymologists;" and the testimony of Hadley and Max Müller is quoted, sustaining this position.

Again, the objection that words "when decently spelled would lose their 'historic interest' is equally unfounded. The modern orthography is superlatively unhistorical. . . . The only history it can be trusted to teach begins with the publication of Johnson's Dictionary." The important recommendation is made that a list of words be prepared, "exhibiting side by side the present and the reformed spelling," such that prominent scholars in England and America would recognize either form as allowable.

This subject was referred to a committee of five eminent philologists, who will report at the next annual meeting, and have liberty in the mean time to prepare such a list of words and cause them to be printed. This action assumes an additional interest from the fact that the State of Connecticut has already in contemplation such a change of spelling in its official reports and journals.

Important papers were read by Prof. Albert Harkness, Mr. A. C. Merriam, Prof. F. A. March, Prof. Franklin Carter, and others.

Many of these are, of course, of quite a special nature: among those of more general interest may be mentioned Prof. March's paper on "The Immaturity of Shakespeare as shown in Hamlet." In the report of Prof. March's paper in the "Proceedings," his analysis of the play, from this point of view, is brought into nine short propositions which are comprised within the limits of an octavo page. This brevity rather amusingly recalls Goethe's prolix analysis of the same play in "Wilhelm Meister;" it is by no means certain that Prof. March's summary will not help the puzzled reader of Hamlet quite as much as Goethe's chapters.

Another paper of interest was by Mr. C. M. O'Keefe, of Brooklyn, "On the Proper Names in the First Sentence of Cæsar's Commentaries."

Annual Report of the Supervising Surgeon of the Marine Hospital Service of the United States, for the Fiscal Year 1874. By John M. Woodworth, M. D. Washington, 1875. Pp. 256.

This report opens with a brief statement of what the Marine Hospital Service of the United States is; amount of collections and expenditures during the year; number of cases of disease and injury treated; and a comparison of the figures with those of previous years. Defects needing legislation; cost of the service to the government; port inspections and office dues; government hospitals; and preventive medicine in the service, are the subjects of succeeding sections. Then follow seventy pages of statistics classified under two heads: first, financial and economic; second, medical and surgical. Eleven papers under the following titles, and a copious index, occupy the last one hundred and fifty pages of the book: "The Hygiene of the Forecastle;" "American Commerce and the Service;" "Unseaworthy Sailors;" "Sailors and their Diseases in Chelsea Hospital;" "The Service on Cape Cod;" "The Freedman and the Service on the Ohio;" "Diseases of River Men, their Causes and Prevention;" "Preventable Diseases on the Great Lakes;" "Syphilis: the Scourge of the Sailor and the Public Health;" "Yellow Fever at Pensacola in 1874;" "The Yellow Fever Epidemic of 1873." These papers are by different authors, and will be found of interest by medical men.

The Mechanic's Friend. By W. E. A. Axon. New York: Van Nostrand. Pp 339. Price, $1.50.

The articles contained in this volume originally appeared in the *English Mechanic*, a practical magazine of sterling merit. The information may be relied on as trustworthy, and the problems solved are precisely such as arise for solution every day in the workshop of the mechanic or the amateur handicraftsman. We cannot better indicate the character of the work than by naming a few of the heads under which the matter it contains is arranged. Thus we have the heading "Miscellaneous Tools, Instruments, and Processes," which includes hints on the microscope, hydraulic press, drills, screw-propeller, etc.; "Cements, Glues, Varnishes," "Solders," "Metals," "Steam-Engine," "Fire-arms," "Clock-work," "Glass," "House and Garden," "Drawing and Modeling," "Photography," "Musical Instruments," "Electricity and Telegraphing."

The Mechanical Engineer: His Preparation and his Work. By R. H. Thurston, C. E. Pp. 24. New York: Van Nostrand.

This is an address to a graduating class of the Stevens Institute of Technology, by the Professor of Mechanical Engineering. Prof. Thurston, in the first place, recalls to the minds of the young engineers the rare educational advantages they have enjoyed at the Institute: very full instruction in mathematics and physics; in modern languages; the English language and literature; principles of engineering, and the practice of the arts connected therewith. So far, the students have been working at the foundation; the superstructure they must build by their own efforts. The professor exhorts them to be wide-awake, observant, conscientious, true to their clients, progressive, radical in theory but conservative in practice, and diligent in study.

Politics as a Science. By Chas. Reemelin. Cincinnati: R. Clarke & Co., Printers. Pp. 186.

In this work the author well sustains the reputation he has long enjoyed of being a profound thinker. It contains the results of Mr. Reemelin's meditations during many years—meditations reduced to writing from time to time without any definite intention of publishing—upon the laws and phenomena of politics. As reading corrected his views, these detached meditations were amended, and gradually the purpose ripened to gather them together and put them in permanent form.

Melanosiderite: A New Mineral Species from Mineral Hill, Delaware County, Pennsylvania; and on Two New Varieties of Vermiculites, with a Revision of other Members of this Group. By Josiah P. Cooke, Jr. From "Proceedings of the American Academy of Sciences." Pp. 12.

The first of these papers is a brief description of the physical and chemical characters of a new mineral which, according to the author, is closely related to the sesquihydrates of iron. It contains about seventy-five per cent. of sesquioxide of iron, seven per cent. of silica, and thirteen per cent. of water, the remainder being alumina.

The second paper is a full account of the physical properties and chemical constitution of two new varieties of vermiculite, a mineral having a granular, scaly structure, and composed mainly of silica, alumina, magnesia, iron, and water. Its name is derived from the circumstance that, when heated, its scales open out into worm-like threads.

On a Fœtal Manatee and Cetacean, with Remarks upon the Affinities and Ancestry of the Sirenia. By Prof. Burt G. Wilder. Reprinted from the *American Journal of Science and Arts.* Pp. 10. Illustrated.

This is a preliminary paper describing, with measurements, the external parts of a fœtal manatee, a little less than three inches long; and a fœtal cetacean but a trifle longer, and supposed to be the embryo of a porpoise or dolphin. Then follow some remarks on the affinities of the sirenia, in which the author, after referring to the present state of opinion on the subject, gives reasons for viewing them as near relations of the ungulates.

Examination of Gases from the Meteorite of February 12, 1875. By A. W. Wright. Pp. 6.

Prof. Wright analyzed some fragments of the great Iowa meteorite of 1875, and the results of his investigation are given in the pamphlet before us. He finds the spectrum of the gases contained in the meteorite to closely resemble that of several of the comets. Other facts are cited to show that a comet is simply a meteorite of considerable magnitude, or a swarm of many of lesser size.

A Report on Trichinosis, as observed in Dearborn County, Indiana, in 1874. By George Sutton, M. D. Aurora, Indiana. Pp. 23.

This is a remarkably clear and interesting history of an outbreak of trichina disease that was clearly traced to the eating of smoked but uncooked sausage. The disease was fatal in several cases, but the larger proportion of those attacked recovered. The author describes the symptoms of the disease, and the several modes of treatment that were adopted. The occurrence led to an extended examination of the pork produced in several counties in Southern Indiana, when it was found that from three to sixteen per cent. of the hogs that came under observation contained trichinæ. Though full of important information for the doctors and the public, this paper is, for pork-eaters, any thing but pleasant reading.

Preventive Medicine. By C. C. F. Gay, M. D. Pp. 12.

The author of this address defends the paradox that disease is the *normal* condition, while health is the *abnormal* condition of our race. If this is the case, then prophylaxy and sanitation must be up-hill work indeed. Still to this work Dr. Gay does not hesitate to address himself, and his pamphlet contains many timely observations on various insanitary conditions of modern life.

Health Fragments; or, Steps toward a True Life. By George H. Everett, M. D., and Susan Everett, M. D. New York: Charles P. Somerby. Pp. 306. Illustrated. Price, $2.

This book contains a few good things, that have been said a hundred times before, and that are here scattered through a large amount of nonsense which might better have been left unsaid.

Mineral Deposits in Essex County, Massachusetts, especially in Newbury and Newburyport; with Map. By Chas. J. Brockway. Newburyport, 1875. Price, 50 cents.

This is a pamphlet of sixty pages, containing a popular account of the discovery, opening, and mode of working, of the new silver and lead mines in the locality named.

Aërial Locomotion; Pettigrew *vs.* Marey. By Prof. Coughtrie. London, 1875. Pp. 20.

On the first page of this pamphlet the author says his object is to show that, notwithstanding certain apparent differences, Pettigrew and Marey essentially agree in their views on the subject of flight. But the real object, as it appears from the remaining pages, is to prove by citations from both authors that Pettigrew anticipated Marey in most of his results, the latter, indeed, having claimed as original a great deal for which he was clearly indebted to Dr. Pettigrew. It is the old fight over again concerning priority of discovery, and in this case, according to our present lights, Pettigrew appears to have the best of the battle.

Half-Hour Recreations in Popular Science. Boston: Estes & Lauriat. Price per number, 25 cents.

Number 13 of this series contains Tyndall's paper on "The Transmission of Sound by the Atmosphere," and an account of "Gigantic Cuttle-Fishes," by W. Saville Kent. In this paper the author recites the records of early observations of these monsters, the stories about which were considered doubtful until the recent discoveries off the coast of Newfoundland. The bulk of the article is a history of these later discoveries.

Number 14 is on "The Glacial Epoch of our Globe," by Alexander Brown. This is an interesting popular statement of how the theory of a glacial epoch arose, and of the investigations and theories relating to the constitution and movements of glaciers of celebrated observers. The number is illustrated.

Number 15 gives Balfour Stewart's address on "The Sun and the Earth;" a paper on "Force electrically exhibited," by J. W. Phelps; and two short articles entitled respectively "Weighing the Earth in a Coal-Pit," and The "Influence of Violet Light on the Growth of Animals and Plants."

Pseudomorphs of Chlorite, after Garnet. By R. Pumpelly. Pp. 4.

Of interest to mineralogists exclusively. The paper is republished from the *American Journal of Science.* It is accompanied with two colored lithographs.

Causes of Irregularities in the Development of the Teeth. By N. W. Kingsley, D. D. S. Pp. 42.

This pamphlet contains a paper on the above subject, read before the Odontological Society of New York. Irregularity of teeth is shown to arise from three causes: 1. During the life of the individual, from cerebral disturbance while the teeth were forming; 2. Or before the individual life commenced, from like causes transmitted; or, 3. From mixing inharmonious types, large teeth with small jaws.

On the Cotton-Worm of the Southern States. By Aug. R. Grote. Pp. 6.

In this paper, reprinted from the proceedings of the Hartford meeting of the American Association for the Advancement of Science, Prof. Grote summarizes the results of five seasous' observation of the cotton-worm in the States of Georgia and Alabama. Where the moth first came from, its powers of flight, breeding habits, and the measures to be taken agaiust its ravages, are among the interesting questions discussed.

The *American Engineer*, published monthly at Baltimore, begins its third volume in enlarged form. Though primarily this journal addresses iuventors aud mechanics, it will be perused with interest by the general reader, who will find in its pages much useful scientific and industrial information. $1.00 per annum.

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PUBLICATIONS RECEIVED

Condition of Affairs in Alaska. By H. W. Elliott. Washington: Government Printing-Office. Pp. 277.

Our Wasted Resources. By W. Hargreaves, M. D. New York: National Temperance Society. Pp. 201. Price, $1.25.

Dissertations and Discussions. Vol. V. By J. Stuart Mill. New York: Holt & Co. Pp. 294. Price, $2.50.

Soluble Glass. By Dr. L. Feuchtwanger. Pp. 168.

Report of the Commissioners of Education, 1874. Pp. 936.

Graphical Statics. By A. J. Du Bois, C. E. New York: Van Nostrand. Pp. 79.

Camp-Life in Florida. By Charles Hallock. New York: Forest aud Stream Co Pp. 348.

Travel in Southwestern Africa. By C. J. Audersou. New York: Putuams. Pp. 329. Price, $2.00.

Strength of Beams. By W. Allan. New York: Van Nostrand. Pp. 114. Price, 50 cents.

Report of Prison Association of New York. 1874. Pp. 192.

State Medicine and Insanity. By Dr. N. Alleu. Pp. 31.

Sewerage. By W. H. Corfield. New York: Van Nostrand. Pp. 128. Price, 50 cents.

Manufacture of Pottery among Savages. By C. F. Hartt. Rio de Janeiro: *South American Mail* print. Pp. 70.

Prospecter's Manual. By W. J. Schofield. Boston: Schofield & Co. Pp. 96. Price, 50 cents.

American Journal of Microscopy. New York: Handicraft Publishing Company. Pp. 12. Price, 50 cents per anuum.

Check-list of Noctuidæ. By A. R. Grote. Buffalo: Reinecke & Zesch, printers. Pp. 28.

Difference of Thermal Energy transmitted from Different Parts of Solar Surface. By J. Ericssou. Pp. 10.

Report of Directors of the New York Meteorological Observatory, 1873. Pp. 34.

Currency. By G. B. Satterlee. Pp. 17.

Report of Directors of the California Institution for Deaf and Dumb and the Bliud. Pp. 55.

Prohibitiou does prohibit. By J. N. Stearns. Pp. 48.

Odontornithes. By O. C. Marsh. Pp. 7.

Auæsthetics in Labor. By S. S. Todd, M. D. Pp. 25.

The Great Salvation. By J. W. Chadwick. Pp. 23.

## MISCELLANY.

**The Frailty of Modern Art.**—The old masters made their own colors. The material which entered into their pigments came to them unadulterated, and the excellence of the paint depended on the brain mixed in it. Hence, their paintings to-day, though lacking somewhat freshness of color, have a mellowness which age can only give to pigments of the highest excellence. Modern pictures will not ripen, their colors fade, and the mellowness of the old masters is unattainable. Holman Hunt, of England, has called the attention of lovers of the fine arts to this deplorable fact. And the reasons are given. The artist's colors are no longer made by himself. Their manufacture is a business from whose secrets he is shut out. Artist's colors are subject to fearful adulteration. Even the oils cannot be genuine, as things go. The materials of which they are made go to the maker in a sophisticated state. Linseed and poppy-seed are adulterated before they reach the oil-maker's hands. So too, is it generally with the crude material for the pigments. A high-priced vermilion from an eminent dealer, upon analysis, yielded twelve per cent. of red lead. So the artist, who puts his whole life and soul into a painting that should be "a joy forever," has this immortality of art quenched by the use of dishonest paint.

**Oscillations of Lakes.**—The "seiches" of the lake of Geneva have for several years, as we learn from *Nature*, been under investigation by Forel, of Lausanne. The term "seiche" is applied locally to certain oscillatory movements occasionally seen on the surface of the lake. The phenomenon had been investigated by previous observers, among them Saussure and Vaucher, who attributed it to variations in atmospheric pressure; in this, Forel agrees with them. The same phenomenon occurs in other Swiss lakes, and Forel believes it will be found in all large bodies of water. He recognizes in the "seiche" probably the most considerable and the grandest oscillatory movement which can be studied on the surface of the globe. His investigations have led him to the conclusion that the "seiche" on the Swiss lakes is an oscillatory undulation, having a true rhythm, and that the phenomenon is not occasional, but constant, though varying in degree. The duration of a "seiche" is a function of the length and depth of the section of the lake, along which it oscillates; this duration increases directly with the length, and inversely with the depth of the lake. The instrument he has devised for the investigation of the phenomenon he calls a plémyramètre ("tide-measurer").

**Contents of a Kitchen-Midden.**—Prof. Cope lately exhibited to the Academy of Natural Sciences of Philadelphia a collection of animal remains, fragments of pottery, flint arrow-heads, etc., taken from an Indian kitchen-midden in Charles County, Md. The animal remains included the bones of seventeen species of vertebrata and two of shells. Of the vertebrates four were mammals, two birds, four reptiles, and seven fishes. The mammals were the Virginia deer, raccoon, gray squirrel, and opossum. Most of the deer-bones had been split into pieces lengthwise for the purpose of extracting the marrow. The birds were represented by a number of parts of the turkey, and the tarsometa-tarsus of some natatorial bird of the size of a widgeon. The reptiles were all turtles, and included the snapper, the box-tortoise, and two emydes. The fishes represented were the sturgeon and the gar, there were also numerous bones of Siluroid fishes of at least two species. The mollusks were *Unio purpureus* and *Mesodon albolabris*.

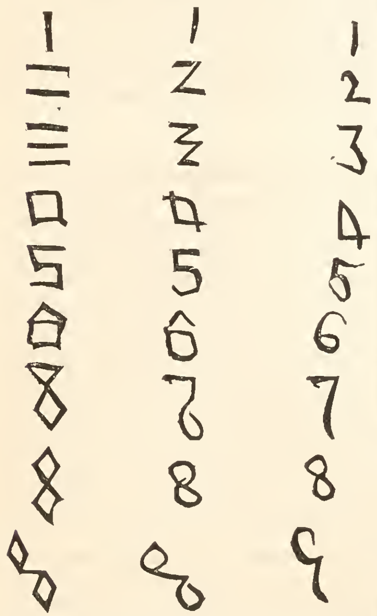
**Habits of Blind Crawfish from Mammoth Cave.**—In November, 1874, Prof. F. W. Putnam collected a number of blind crawfish (*Cambarus pellucidus*) in the Mammoth Cave, which he kept alive for several months afterward in Massachusetts. The habits of these animals and the reproduction in them of lost parts are the subject of a communication by Prof. Putnam, published in the "Proceedings of the Boston Society of Natural History." The animals eat but very little in captivity. When food is dropped into the jar in which they are kept, they dart backward, then extend the antennæ, and stand as if on the alert. The animal continues in this attitude for several minutes, and then cautiously crawls about the jar with antennæ extended. On approaching the piece of meat, and before touching it, the animal gives a powerful backward jump and remains quiet for a while. It often repeats this three or four times before touching the food, and when it does touch it the result is another backward jump. When it has become satisfied that there is no danger, it takes the morsel in its claws and conveys it to its mouth. "I have twice," says the author, "seen the meat dropped as it was passed along the base of the antennæ, as if the sense of smell, or more delicate organs of touch seated at that point, were again the cause of alarming the animal. When the jaws once begin to work, the piece of meat, or bread, if very small, is devoured, but if too large, only a few bites are taken, and the food is dropped and not touched again."

A detailed account is given of one of the specimens, in order to show the mode of reproduction of lost members. This specimen, a female, was captured November 13th, being then perfect in all respects, except the right, large claw, which was as yet rudimentary. Total length of the animal from tip of large claw to end of tail, not quite two and a half inches. From November 14th to 24th, the crawfish lost in battle most of her antennæ, the third, fourth, and fifth legs from the left side, the fifth from the right side, and the two end-joints of the third leg on the right side; January 28th or 29th she cast her shell and came forth with a soft white covering, which was nearly two weeks in hardening. All the legs which were perfect before were now of the same size, but in addition the great claw of the right side was developed to about one-half or two-thirds the size of its fellow, and was apparently of as much use. The two missing joints of the third leg on the right side were also developed, though not quite to their full proportions. The fifth leg on the right side, and the third, fourth, and fifth of the left side, were reproduced, but in a very small and rudimentary manner. The antennæ were about two-thirds their full size. On April 20th the shell was again cast; the crawfish had now all the legs and claws nearly perfect. The great claw of the right side was very nearly as large as that of the left. The tip of the third leg of the same side was perfect, and all the legs that before were rudimentary were now developed apparently to their full proportionate size, with the exception of the last on the right side. Antennæ about full length.

From these observations, it will be seen that the parts are not reproduced in perfection on one shedding of the shell, but that each time the shell is cast they are more nearly perfect than before.

**Sound and Fog Signals.**—Among the papers read at the Philadelphia meeting of the American Academy of Sciences, was one by Prof. Henry on "Sound and Fog Signals," of which we present an abstract. The author stated the results of experiments made last summer, under the direction of the Lighthouse Board, at Block Island, and at Little Jail Island, at the east end of Long Island Sound. One set of experiments was made to investigate the cause of an echo apparently heard from the ocean: the results were not such as to solve the problem, though they favored the hypothesis that the echo was due rather to a reflection from the waves than from the air. Another set of experiments was directed to investigating the effect of elevation on the hearing of sound; the result was to show that a sound traveling against the wind is heard farther away on an elevation than at the sea-level. In five cases, sound was heard five times farther with the wind than against it, the wind's velocity being about five miles per hour. The effects of sound traveling with the wind, against it, at right angles to it, etc., were shown in diagrams representing *curves of audition*. In still air these curves are nearly circular; with wind uniform in velocity throughout the whole space the curves are approximately elliptical. The curves differed according to the different conditions. It appeared to be demonstrated that sound is heard farthest with a moderate wind, and that with a strong wind it is heard a less distance in every direction than in still air, and perhaps to a less distance than with a wind of moderate velocity. These experiments will be resumed next summer.

**Origin of the Numerals.**—Having never met with any explanation of the origin of the numerals, or rather of the figures symbolizing them, perhaps I am right in supposing that nothing satisfactory is known of it. In that case the following may be interesting to your readers: The first column contains the original figures, each con-



taining as many lines as the number which it is intended to represent. The other columns show the transitions likely to result from quick writing.—W. Donisthorpe *in Nature.*

**Location of Sensory Centres in the Brain.**—At the recent meeting of the British Medical Association, Dr. Brunton read a paper communicated by Dr. Ferrier, entitled "Abstract of Experiments on the Brains of Monkeys, with special reference to the Localization of Sensory Centres in the Convolutions." The experiments, which were conducted by trephining and the destruction of the sensory centres by means of a red-hot wire, led to the following results, as stated by the *Lancet:* These centres are bilateral, so that when, for instance, one of the centres of touch was destroyed, there was loss of tactile sensibility in the corresponding half of the body. Stimulation of the centre of hearing caused the animal to prick up its ears as if it heard something, while destruction of the whole of this centre rendered the creature totally deaf. Destruction of the centre of vision corresponding to one eye only, rendered the animal temporarily blind in that eye, the function, after twenty-four hours, being carried on by the opposite centre. In the discussion which followed, Dr. Nairne pointed out that other observers had arrived at conclusions different from those of Ferrier, and that the brain of a monkey could not be taken as exactly similar to that of a man; but Dr. Brunton thought the mistake made by German and other investigators who differed from Ferrier was, that they took the brains of animals lower even than the monkey to correspond with that of man. Dr. Dupuy said that he had found, when the centres of motion on one side of the brain were removed, that paralysis followed for a short time throughout the corresponding part of the body, but that, when the centres were removed from both sides of the brain, there was no paralysis at all.

**Health of Children in Utah.**—In a report made by Surgeon E. P. Vollum to the Surgeon-General on "Some Diseases of Utah," it is stated that the adult population of that Territory is as robust as any within the limits of the United States. The children furnish two-thirds of all the deaths, most of which occur under five years of age. In Salt Lake City, as appears from the register kept by the undertakers, the male deaths exceed the female in number about 50 per cent., but Surgeon Vollum could not get the relative proportion. The polygamous children are as healthy as the monogamous, and the proportion of deaths about the same, the difference being rather in favor of the former, who are generally, in the city especially, situated more comfortably as to residence, food, air, and clothing, their parents being in easier circumstances than those in monogamy. It is perhaps still too early to form an opinion as to the influence of polygamy on the health, or constitutional or mental character of the Anglo-Saxon race in Utah; but Surgeon Vollum has been unable to detect any difference in favor either of monogamy or polygamy. So far as he can learn, polygamy in Utah furnishes no idiocy, insanity, rickets, tubercles, struma, or debasing constitutional condition of any kind.

**Vehicles of Infection.**—A number of cases of the transmission of contagious diseases by means of clothing, articles of furniture, and other objects that had been in contact with persons stricken by such diseases, are brought together by a writer in *Chambers's Journal*, in order to show the great importance of thoroughly disinfecting such vehicles of infection, before making use of them again. The author, Mr. William Chambers, in the first place quotes Sir James Simpson's remedy for hospital-infection, namely, building such establishments of cast-iron, and casting them anew when contaminated. A servant-girl in Morayshire died of scarlet fever. Her clothing was sent back to her parents, but *en route* the box lay over for a few days at a railway-station. On reaching its destination, the contents of the box were dispersed among friends and neighbors. The children of the station-master, who had played around the box, and every recipient of the infected clothing, were stricken with the fever. Again, the clothing of a soldier who had died of cholera was sent home to his friends. While the garments were "in the wash," a man was employed on the roof of the cottage, repairing the thatch. He inhaled the poisonous fumes of the washing, and died of cholera. Scarlet fever of a malignant type appeared in a family at Carlisle, and two of the children died. In this case, the carrier of the infection was a retriever-pup, which had been reared in a house where scarlatina was present. It is stated in a pamphlet by Dr. McCall Anderson, of Glasgow, that a peculiar disease was introduced into a family in that town under the following circumstances: Some mice, caught in a trap, were seen to have on the head and front legs crusts of a sombre yellow tint, of circular form, and more or less elevated above the level of the neighboring healthy parts. A depression was noticed in the centre of each crust, and the parts where these had fallen off were ulcerated, and the skin appeared to be destroyed throughout the whole thickness. These mice were given to a cat, which soon exhibited, above the eye, a crust similar to those on the mice. Later still, two young children of the family who played with the cat were successively affected with the same disease, yellow crusts making their appearance on several parts of the body, on the shoulder, face, and thigh. Other instances are cited by Dr. Anderson, where mice, affected in the same way, had transmitted the disease to the human subject, both indirectly through cats, and directly through the mice themselves having been handled by children.

**Practical Education.**—A correspondent of the *Moniteur Industriel Belge* communicates to that journal a description of a school of practical instruction, situated in one of the suburbs of Paris. The writer exhibits to us a system of education in which the future occupations of the pupils are kept steadily in view, and where every step of progress in study marks an advance in real knowledge. A few instances will best show the method of instruction. Suppose a lesson in botany is to be given, and that the special subject is some textile plant. The pupil sees, in the botanic garden attached to the school, a few stalks of hemp growing. The botanic characters of the plant are explained to him; he is told how it grows, and what are the conditions favorable to its growth; then he is shown how it is treated in order to obtain the fibre, how the latter is spun, woven, etc. In giving instruction on minerals, a like course is followed. For instance, the subject is iron-ore: various kinds of ore are exhibited; the processes are explained, by means of models and designs, of the reduction of iron and its manufacture. So in mechanics: models of machinery are shown and explained; better still, the pupil is taken to the workshops where he sees various kinds of machines in operation. His understanding of things is tested by questions, and by being required to draw the objects he has been looking at, and to explain their working. Topography and geography are taught in the same common-sense way, the pupil being led to map out an ever-widening area. He begins with the plan of the school, then gives its relative position in the commune, in the canton, in the arrondissement, and so on. The great principle of instruction in this school is "to make knowledge concrete, practical."

**Revivals and Religious Insanity.**—In a paper by G. H. Savage, M.D., of the Bethlehem Hospital for the Insane, London, on "Religious Insanity and Religious Revivals," the lists of cases admitted to the hospital during the four months April to August, in the three years 1875, 1874, and 1873, are compared. The result dces not show any increase of insanity traceable to the recent religious excitement in England. Indeed, the author sees no reason for regarding religious insanity as a peculiar, well-defined species of mental disease. According to him, it is simply an accident of education, temperament, or sex, whether eertain subjective feelings develop themselves into a morbid religious idea, or into an illusion of being persecuted and annoyed by others. "Many persons," he adds, "verging on insanity—in fact, in the melancholy stage of the disease—seek religious consolation, and, notwithstanding this, go mad; they would probably have gone mad in any case, and the most that can be said against the service is that it precipitated the attack." But to return to the figures. In 1875, from April to August, there were admitted to Bethlehem 42 male patients, and of these 9 suffered from religious insanity. During the same time 55 women were admitted, of whom 8 had religious delusions. That was 21.4 per cent. of the men, and 14.5 per cent. of the women. During 1874, in the same period, 30 male admissions gave 6 religious cases, and 47 female cases gave 16—that is, 16.6 and 34 per cent. respectively. In 1873, 28 male admissions gave 4 religious cases, or 14.2 per cent.; 28 female admissions gave 8 religious cases, or 28.4 per cent.

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## NOTES.

We have received from Prof. W. S. Barnard the following correction of a statement in his article on "Opossums and their Young," published in the December Monthly: "In your December number I stated that the delivery of young opossums had never been witnessed. To the contrary see observations of Mr. J. G. Shute, in the 'Proceedings of the Essex Institute,' vol. iii., page 288, to which my attention has just been called. The female curves her body until the sexual orifice is opposite the pouch, which opens by muscular contraction to receive the young, without any assistance from the paws or lips."

The largest telescope ever yet attempted is now in course of construction in Dublin by Mr. Grubb. It is intended for the new Observatory of Vienna. The object-glass will have an aperture of over twenty-six inches, and the focal length is to be about thirty-two feet.

In the *American Journal of Science and Arts* for November Prof. Marsh has a short illustrated paper describing the remains of several fossil birds obtained from the Cretaceous of Kansas, and possessing teeth.

We learn from the *Scientific American* that the excavations at Hell-Gate were completed about the end of July. The work now in progress consists in the boring of holes for the charges of nitro-glycerine. This was to have been completed before the end of the year 1875, and then two or three months more would be occupied in inserting the charges.

A curious race of sheep, living on an island in Englishman's Bay, coast of Maine, are described in *Forest and Stream*. They are nearly as wild as deer. Their principal winter food is sea-weed, chiefly dulse; they also eat the branches of nearly all the trees which grow on the island.

In very early times the pine appears to have been the principal forest-tree of Denmark. At present the beech occupies this position, and the pine is no longer indigenous in the country. Next after the beech comes the birch, then the alder, the aspen, the hazel, etc. An examination of the vegetable *débris* of the bogs of Denmark shows that the pine was followed immediately by the sessile-fruited variety of the oak, and this in turn by the beech.

In illustration of the influence of nutrition on the habits of plants, Mr. Meehan, of Philadelphia, cites the case of two species of *Euphorbia*, which, though usually prostrate, he found assuming an erect growth when their nutrition was interfered with by a small fungoid parasite. A similar fact was observed in connection with the common purslane, one of the most prostrate of all procumbent plants, which, under similar conditions, also became erect.

Dr. Nicolas von Konkoly finds in the *train* of meteors the spectrum-lines of sodium, magnesium, carbon, strontium, and possibly lithium, while the nucleus invariably gives a continuous spectrum, in which the yellow, the green, or the red predominates, according to the color, blue being very rare, and violet never seen.

At the trial of the 81-ton gun, at Woolwich Arsenal, a 1,250-pound ball was fired with a charge of 170 pounds of powder. This shot penetrated 45 feet of sand, and the recoil of the gun was 23½ feet. A second shot was fired with a charge of 190 pounds. The penetration-distance was now over 50 feet, and the recoil 32 feet. It is intended gradually to increase the charge to 300 pounds.

A State Archæological Association has been formed in Ohio to promote investigation of the mounds and earthworks of the State, to collect facts, descriptions, relics, and other evidences of the prehistoric races, and to awaken an interest in the general subject of archæology. The library and cabinet of the Association will be established in the State-House, at Columbus, provided the State furnish suitable accommodations free of cost. The meetings will be held annually in the various cities of Ohio, and a yearly bulletin will be published. The first annual meeting will be held at Newark, Licking County, on Tuesday, September 5, 1876.

A quarter of a million of young salmon, according to a writer in *Forest and Stream*, have been placed in the Truckee River, which flows into Lake Tahoe, Nevada, and they are doing well.

A vein of nickel has been discovered in New Caledonia, extending across the entire island, from east to west. There are also in New Caledonia copper-mines of great richness. The gold-mines, of which much was expected a few years ago, have so far yielded insignificant results.

The death-rate of some English towns is very high. Thus, while the death-rate for England and Wales generally is 22.2 per 1,000, in Bristol it is 26.9, in Leeds, 28.7, in Manchester, 32.1, and in Liverpool, 35.9. Of children under five years of age, 39 per 1,000 die annually in country districts, while in towns the ratio is 103 per 1,000.

A commission has been appointed by the British Government, to investigate the subject of the spontaneous combustion of coal on shipboard. Persons having any facts on the subject of the spontaneous combustion of coal, under any circumstances, are requested to communicate the same to H. S. Poole, Charlottetown, Nova Scotia, Inspector of Mines.

Microscopic examination of the muscular tissue of a wild-boar lately shot in the forests of Saxony showed it to be full of trichinæ. This is the first case in which this parasite has been found in the wild-boar, it having been the general belief that only domesticated swine were affected.

By substituting atomized water or spray for steam in sulphuric-acid manufacture, Sprengel not only effects a saving of fuel, but also saves 6½ per cent. of pyrites and 15 per cent. of nitre.

An adequate punishment for those human brutes who vent their despicable passions in murderous assaults on women and children is suggested by the authors of "The Unseen Universe." "It is probable," they write, "that, before many years have passed, electricity will be called upon by an enlightened legislature to produce absolutely indescribable torture, thrilling through every fibre of such miscreants."

A process for brightening iron is described as follows in a German periodical: The articles to be brightened are, when taken from the forge, placed in dilute sulphuric acid (1 to 20), and then washed with water and dried with sawdust. They are then dipped for a second or so in nitrous acid, washed carefully, and rubbed clean. Iron thus treated acquires a bright surface, having a white glance.

They are trying to introduce humble-bees into New Zealand, for the purpose of aiding in the fertilization of the common clover. This office the common bee is unable to discharge, its proboscis being too short to reach down to the pollen of the flower.

A university, to be founded at Tomsk, Siberia, by the Russian Government, will at first consist of only two Faculties, law and medicine. Siberia at present is very ill supplied with doctors, there being only 55 for a population of 6,000,000, inhabiting a territory as large as all Europe.

Hofmann's process for preparing vanilla from the wood of the pine has been patented, and will be generally applied in paper-mills which use wood-pulp for the purposes of their manufacture.

It is stated in the *Lancet* that female medical missionaries are now laboring very successfully in various parts of India. The Maharajah of Vezianagram has engaged an American lady to open a dispensary for women at Benares, and Sir Salar Jung has done the same thing in Hyderabad.

Bath bricks are made from the deposits of the river Parrett, at Bridgewater, Somersetshire. Nowhere else is a similar deposit found, so that Bridgewater supplies the world. The annual import into the United States is about 240,000 bricks.

The State of Minnesota produced last year 28,000,000 bushels of wheat, 15,000,000 of oats, and 12,000,000 of Indian-corn.

THOMAS STERRY HUNT, LL. D., F. R. S.

THE

POPULAR SCIENCE MONTHLY.

FEBRUARY, 1876.

# THE WARFARE OF SCIENCE.

By ANDREW D. WHITE, LL.D.,

PRESIDENT OF CORNELL UNIVERSITY.

## I.

I PURPOSE to present an outline of the great, sacred struggle for the liberty of science—a struggle which has lasted for so many centuries, and which yet continues. A hard contest it has been; a war waged longer, with battles fiercer, with sieges more persistent, with strategy more shrewd than in any of the comparatively petty warfares of Cæsar or Napoleon or Moltke.

I shall ask you to go with me through some of the most protracted sieges, and over some of the hardest-fought battle-fields of this war. We will look well at the combatants; we will listen to the battle-cries; we will note the strategy of leaders, the cut and thrust of champions, the weight of missiles, the temper of weapons.

My thesis, which, by an historical study of this warfare, I expect to develop, is the following: *In all modern history, interference with science in the supposed interest of religion, no matter how conscientious such interference may have been, has resulted in the direst evils both to religion and to science, and invariably. And, on the other hand, all untrammeled scientific investigation, no matter how dangerous to religion some of its stages may have seemed, for the time, to be, has invariably resulted in the highest good of religion and of science.* I say "invariably." I mean exactly that. It is a rule to which history shows not one exception

It would seem, logically, that this statement cannot be gainsaid. God's truths must agree, whether discovered by looking within upon the soul, or without upon the world. A truth written upon the human heart to-day, in its full play of emotions or passions, cannot be

[1] In its earlier form this address was given as a Phi Beta Kappa oration at Brown University, and as a lecture at New York, Boston, New Haven, Ann Arbor, and elsewhere.

at any real variance even with a truth written upon a fossil whose poor life ebbed forth millions of years ago.

This being so, it would also seem a truth irrefragable, that the search of each of these kinds of truth must be followed out on its own lines, by its own methods, to its own results, without any interference from investigators on other lines, or by other methods. And it would also seem logical to work on in absolute confidence that whatever, at any moment, may seem to be the relative positions of the two different bands of workers, they must at last come together, for Truth is one.

But logic is not history. History is full of interferences which have cost the earth dear. Strangest of all, some of the direst of them have been made by the best of men, actuated by the purest motives, and seeking the noblest results. These interferences, and the struggle against them, make up the warfare of science.

One statement more, to clear the ground. You will not understand me at all to say that religion has done nothing for science. It has done much for it. The work of Christianity, despite the clamps which men have riveted about it, has been mighty indeed. Through these two thousand years, it has undermined servitude, mitigated tyranny, given hope to the hopeless, comfort to the afflicted, light to the blind, bread to the starving, joy to the dying, and this work continues. And its work for science, too, has been great. It has fostered science often. Nay, it has nourished that feeling of self-sacrifice for human good, which has nerved some of the bravest men for these battles.

Unfortunately, some good men started centuries ago with the idea that purely scientific investigation is unsafe—that theology must intervene. So began this great modern war.

The first typical battle-field to which I would refer is that of Geography—the simplest elementary doctrine of the earth's shape and surface.

Among the legacies of thought left by the ancient world to the modern, were certain ideas of the rotundity of the earth. These ideas were vague; they were mixed with absurdities; but they were *germ ideas*, and, after the barbarian storm which ushered in the modern world had begun to clear away, these germ ideas began to bud and bloom in the minds of a few thinking men, and these men hazarded the suggestion that the earth is round—is a globe.[1]

The greatest and most earnest men of the time took fright at once. To them, the idea of the earth's rotundity seemed fraught with dan-

[1] Most fruitful among these were those given by Plato in the "Timæus." *See*, also, Grote on Plato's doctrine of the rotundity of the earth. Also Sir G. C. Lewis's "Astronomy of the Ancients," London, 1862, chap. iii., sec. i. and note. Cicero's mention of the antipodes and reference to the passage in the "Timæus" are even more remarkable than the original, in that they much more clearly foreshadow the modern doctrine. *See* "Academic Questions," ii., xxix. Also, "Tusc. Quest.," i., xxviii., and v., xxiv.

gers to Scripture: by which, of course, they meant *their interpretation* of Scripture.

Among the first who took up arms against the new thinkers was Eusebius. He endeavored to turn off these ideas by bringing science into contempt. He endeavored to make the innovators understand that he and the fathers of the Church despised all such inquiries. Speaking of the innovations in physical science, he said: "It is not through ignorance of the things admired by them, but through contempt of their useless labor, that we think little of these matters, turning our souls to better things."[1]

Lactantius asserted the ideas of those studying astronomy to be "mad and senseless."[2]

But the attempt to "flank" the little phalanx of thinkers did not succeed, of course. Even such men as Lactantius and Eusebius cannot pooh-pooh down a new scientific idea. The little band of thinkers went on, and the doctrine of the rotundity of the earth naturally led to the consideration of the tenants of the earth's surface, and another germ idea was[3] warmed into life—the idea of the existence of the antipodes, the idea of the existence of countries and men on the hemisphere opposite to ours.

At this the war spirit waxed hot. Those great and good men determined to fight. To all of them such doctrines seemed dangerous; to most of them they seemed damnable. St. Basil and St. Ambrose[4] were tolerant enough to allow that a man might be saved who believed the earth to be round, and inhabited on its opposite sides; but the great majority of the Fathers of the Church utterly denied the possibility of salvation to such misbelievers.

Lactantius asks ". . . Is there any one so senseless as to believe that there are men whose footsteps are higher than their heads?—that the crops and trees grow downward?—that the rains and snow and

[1] *See* Eusebius, "Præp. Ev.," xv., 61.

[2] *See* Lactantius, "Inst.," l., iii., chap. 3. Also, citations in Whewell, "Hist. Induct. Sciences," Lond., 1857, vol. i., p. 194. To understand the embarrassment thus caused to scientific men at a later period, *see* "Letter of Agricola to Joachimus Vadianus" in 1514. Agricola asks Vadianus to give his views regarding the antipodes, saying that he himself does not know what to do, between the Fathers on one side and learned men of modern times on the other. On the other hand, for the embarrassment caused to the Church by this mistaken zeal of the Fathers, *see* Kepler's references and Fromund's replies; also De Morgan, "Paradoxes," p. 58. Kepler appears to have taken great delight in throwing the views of Lactantius into the teeth of his adversaries.

[3] "Another germ idea," etc. *See* Plato, "Timæus," 62 C., Jowett's translation, N. Y. ed. Also "Phædo," pp. 449, *et seq.* Also Cicero, "Academic Quest.," and "Tusc. Disput.," *ubi supra.* For citations and summaries, *see* Whewell, "Hist. Induct. Sciences," vol. i., p. 189, and St. Martin, "Hist. de la Géog.," Paris, 1873, p. 96. Also Leopardi, "Saggio sopra gli errori popolari degli antichi," Firenze, 1851, chap. xii., p. 184, *et seq.*

[4] For opinion of Basil, Ambrose and others, *see* Lecky, "Hist. of Rationalism in Europe," New York, 1872, vol. i., p. 279, note. Also Letronne, in *Revue des Deux Mondes*, March, 1834.

hail fall upward toward the earth? . . . But if you inquire from those who defend these marvelous fictions, why all things do not fall into that lower part of the heaven, they reply that such is the nature of things, that heavy bodies are borne toward the middle, like the spokes of a wheel; while light bodies, such as clouds, smoke, and fire, tend from the centre toward the heavens on all sides. Now, I am at loss what to say of those who, when they have once erred, steadily persevere in their folly, and defend one vain thing by another."

Augustine seems inclined to yield a little in regard to the rotundity of the earth, but he fights the idea that men exist on the other side of the earth, saying that "Scripture speaks of no such descendants of Adam."

But this did not avail to check the idea. What may be called the flank movement, as represented by Eusebius, had failed. The direct battle given by Lactantius, Augustine, and others, had failed. In the sixth century, therefore, the opponents of the new ideas built a great fortress and retired into that. It was well built and well braced. It was nothing less than a complete theory of the world, based upon the literal interpretation of texts of Scripture, and its author was Cosmas Indicopleustes.[1]

According to Cosmas, the earth is a parallelogram, flat, and surrounded by four great seas. At the outer edges of these seas rise immense walls closing in the whole structure. These walls support the vault of the heavens, whose edges are cemented to the walls; walls and vault shut in the earth and all the heavenly bodies. The whole of this theologic, scientific fortress was built most carefully, and, as was then thought, most scripturally.

Starting with the expression, Το *ἅγιον κοσμικόν*, applied in the ninth chapter of Hebrews to the tabernacle in the desert, he insists, with other interpreters of his time, that it gives a key to the whole construction of the world. The universe is, therefore, made on the plan of the Jewish Tabernacle—box-like and oblong.

Coming to details, he quotes those grand words of Isaiah,[2] "It is he that sitteth upon the circle of the earth, . . . that stretcheth out the heavens like a curtain, and spreadeth them out like a tent to dwell in," and the passage in Job,[3] which speaks of the "pillars of heaven." He turns all that splendid and precious poetry into a prosaic statement, and gathers therefrom, as he thinks, treasures for science.

This vast box is then divided into two compartments, one above the other. In the first of these, men live and stars move; and it ex-

[1] For Lactantius, *see* "Instit.," iii., 24, translation in Ante-Nicene Library; also, citations in Whewell, i., 196, and in St. Martin, "Histoire de la Géographie," pp. 216, 217. For St. Augustine's opinion, *see* the "Civ. D.," xvi., 9, where this great Father of the Church shows that the existence of the antipodes "*nulla ratione credendum est.*" Also, citations in Buckle's "Posthumous Works," vol. ii., p. 645.

[2] Isaiah xl. 22.

[3] Job xxvi. 11.

tends up to the first solid vault or firmament, where live the angels, a main part of whose business it is to push and pull the sun and planets to and fro. Next he takes the text, "Let there be a firmament in the midst of the waters, and let it divide the waters from the waters," and other texts from Genesis.[1] To these he adds the texts from the Psalms, "Praise him ye heaven of heavens, and ye waters that be above the heavens,"[2] casts that outburst of poetry into his crucible with the other texts, and, after subjecting them to sundry peculiar processes, brings out the theory that over this first vault is a vast cistern containing the waters. He then takes the expression in Genesis regarding the "windows of heaven,"[3] and establishes a doctrine regarding the regulation of the rain, which is afterward supplemented by the doctrine that the angels not only push and pull the heavenly bodies, to light the earth, but also open and close the windows of heaven to water it.

To find the character of the surface of the earth, Cosmas studies the table of shew-bread in the Tabernacle. The dimensions of that table prove to him that the earth is flat and twice as long as broad. The four corners of the table symbolize the four seasons.

To account for the movement of the sun, Cosmas suggests that at the north of the earth is a great mountain, and that, at night, the sun is carried behind this. But some of the commentators ventured to express a doubt here. They thought that the sun was pushed into a great pit at night, and was pulled out in the morning.

Nothing can be more touching in its simplicity than Cosmas's closing of his great argument. He bursts forth in raptures, declaring that Moses, the prophets, evangelists, and apostles, agree to the truth of his doctrine.[4]

Such was the fortress built against human science in the sixth century, by Cosmas; and it stood. The innovators attacked it in vain. The greatest minds in the Church devoted themselves to buttressing it with new texts, and throwing out new outworks of theologic reasoning. It stood firm for two hundred years, when a bishop—Virgilius of Salzburg—asserts his belief in the existence of the antipodes.

It happened that there then stood in Germany, in the first years of the eighth century, one of the greatest and noblest of men—St. Boniface. His learning was of the best then known; in labors he was a worthy successor to the apostles; his genius for Christian work made

[1] Genesis i. 6. [2] Psalm cxlviii. 4. [3] Genesis vii. 11.

[4] *See* Montfaucon, "Collectio Nova Patrum," Paris, 1706, vol. ii., p. 188; also, pp. 298, 299. The text is illustrated with engravings showing walls and solid vault (firmament), with the whole apparatus of "fountains of the great deep," "windows of heaven," angels, and the mountain behind which the sun is drawn. For an imperfect reduction of one of them, *see* article "Maps," in Knight's "Dictionary of Mechanics," New York, 1875. For still another theory, very droll, and thought out on similar principles, *see* Mungo Park, cited in De Morgan, "Paradoxes," 309. For Cosmas's joyful summing up, *see* Montfaucon, "Collectio Nova Patrum," vol. ii., p. 255.

him, unwillingly, Primate of Germany; his devotion afterward led him, willingly, to martyrdom. There sat, too, at that time, on the papal throne, a great Christian statesman—Pope Zachary. Boniface immediately declares against the revival of such a terrible heresy as the existence of the antipodes. He declares that it amounts to the declaration that there are men on the earth beyond the reach of the means of salvation; he attacks Virgilius; he calls on Zachary for aid; effective measures are taken, and we hear no more of Virgilius or his doctrine.

Six hundred years pass away, and in the fourteenth century two men publicly assert the doctrine. The first of these, Peter of Abano, escapes punishment by natural death; the second, known as Cecco d'Ascoli, a man of seventy years, is burned alive. Nor was that all the punishment: that great painter, Orcagna, whose terrible works you may see on the walls of the Campo Santo at Pisa, immortalized Cecco by representing him in the flames of hell.[1]

Still the idea lived and moved, and a hundred years later we find the theologian Tostatus protesting against the doctrine of the antipodes as "unsafe." He has invented a new missile—the following syllogism: "The apostles were commanded to go into all the world, and to preach the gospel to every creature. They did not go to any such part of the world as the antipodes, they did not preach to any creatures there: *ergo*, no antipodes exist." This is just before the time of Columbus.

Columbus is the next warrior. The world has heard of his battles: how the Bishop of Ceuta worsted him in Portugal; how at the Junta of Salamanca the theologians overwhelmed him with quotations from the Psalms, from St. Paul, and from St. Augustine.[2]

But in 1519 Science gains a crushing victory. Magalhaens makes his famous voyages. He has proved the earth to be round; for his great expedition has circumnavigated it. He proves the doctrine of the antipodes, for he sees the men of the antipodes.[3] But even this

[1] Virgil of Salzburg. *See* Neander's "History of the Christian Church," Torrey's translation, vol. iii., p. 63. Since Bayle, there has been much loose writing about Virgil's case. *See* Whewell, p. 197; but for best choice of authorities and most careful winnowing out of conclusions, *see* De Morgan, pp. 24–26. For very full notes as to pagan and Christian advocates of doctrine of rotundity of the earth and of antipodes, and for extract from Zachary's letter, *see* Migne, "Patrologia," vol. vi., p. 426, and vol. xli., p. 487. For Peter of Abano, or Apono, as he is often called, *see* Tiraboschi; also Ginguené, vol. ii., p. 293. Also Naudé, "Histoire des grands hommes accusés de Magie." For Cecco d'Ascoli, *see* Montucla, "Histoire des Mathématiques," i., 528; also, Daunou, "Études Historiques," vol. vi., p. 320. Concerning Orcagna's representation of Cecco in flames of hell, *see* Renan, "Averroès et l'Averroisme," Paris, 1867, p. 328.

[2] For Columbus before the Junta of Salamanca, *see* Irving's "Columbus," Murray's, edition, vol. ii., pp. 405–410. Figuier, "Savants du Moyen Age," etc., vol. ii., p. 394, *et seq.* Also Humboldt, "Histoire de la Géographie du Nouveau Continent."

[3] For effect of Magalhaens's voyages, and the reluctance to yield to proof, *see* Henri Martin, "Histoire de France," vol. xiv., p. 395; St. Martin's "Histoire de la Géog.,"

does not end the war. Many earnest and good men oppose the doctrine for two hundred years longer. Then the French astronomers make their measurements of degrees in equatorial and polar regions and add to other proofs that of the lengthened pendulum. When this was done, when the deductions of science were seen to be established by the simple test of measurement, beautifully, perfectly, then and then only this war of twelve centuries ended.[1]

And now what was the result of this war? The efforts of Eusebius and Lactantius to deaden scientific thought; the efforts of Augustine to combat it; the efforts of Cosmas to stop it by dogmatism; the efforts of Boniface, and Zachary, and others to stop it by force, conscientious as they all were, had resulted in what? Simply in forcing into many noble minds this most unfortunate conviction, that Science and Religion are enemies; simply in driving away from religion hosts of the best men in all those centuries. The result was wholly bad. No optimism can change that verdict.

On the other hand, what was gained by the warriors of science for religion? Simply, a far more ennobling conception of the world, and a far truer conception of Him who made and who sustains it.

Which is the more consistent with a great, true religion—the cosmography of Cosmas, or that of Isaac Newton? Which presents the nobler food for religious thought—the diatribes of Lactantius, or the astronomical discourses of Thomas Chalmers?

The next great battle was fought on a question relating to the *position of the earth among the heavenly bodies.* On one side, the great body of conscientious religious men planted themselves firmly on the geocentric doctrine—the doctrine that the earth is the centre, and that the sun and planets revolve about it. The doctrine was old, and of the highest respectability.[2] The very name, Ptolemaic theory, carried weight. It had been elaborated until it accounted well for the phenomena. Exact textual interpreters of Scripture cherished it, for it agreed with the letter of the sacred text.[3]

Still the germs of the heliocentric theory[4] had been planted long before, and well planted; it had seemed ready even to bloom forth

p. 369; Peschel, "Geschichte des Zeitalters der Entdeckungen," concluding chapters; and for an admirable summary, Draper, "Hist. Int. Dev. of Europe," pp. 451–453.

[1] For general statement as to supplementary proof by measurement of degrees, and by pendulum, *see* Somerville, "Phys. Geog.," chapter i., § 6, note. Also Humboldt, "Cosmos," vol. ii., p. 736, and v., pp. 16, 32. Also, Montucla, iv., 138.

[2] "Respectability of Geocentric Theory, Plato's Authority for it," etc., *see* Grote's "Plato," vol. iii., p. 257. Also, Sir G. C. Lewis, "Astronomy of the Ancients," chap. iii., sec. i., for a very thoughtful statement of Plato's view, and differing from ancient statements. For plausible elaboration of it, *see* Fromundus, "Anti-Aristarchus," Antwerp, 1631. Also Melanchthon "Initia Doctrinæ Physicæ."

[3] For supposed agreement of Scripture with Ptolemaic theory, *see* Fromundus, *passim*, Melanchthon, and a host of other writers.

[4] For "Germs of Heliocentric Theory planted long before," etc., *see* Sir G. C. Lewis; also, Draper, "Intellectual Development of Europe," p. 512. For germs among thinkers

from the mind of Cardinal de Cusa; but the chill of dogmatism was still over the earth, and up to the beginning of the sixteenth century there had come to this great truth neither bloom nor fruitage.[1]

Quietly, however, the soil was receiving enrichment, and the air warmth. The processes of mathematics were constantly improved, the heavenly bodies were steadily though silently observed, and at length appeared, afar off from the centres of thought, on the borders of Poland, a plain, simple-minded scholar, who first fairly uttered to the world the truth, now so commonplace, then so astounding, that the sun and planets do not revolve about the earth, but that the earth and planets revolve about the sun, and that man was Nicholas Kopernik.[2]

Kopernik had been a professor at Rome, but, as this truth grew within him, he seemed to feel that at Rome he was no longer safe.[3]

of India, *see* Whewell, vol. i., p. 277. Also, Whitney, "Oriental and Linguistic Studies," New York, 1874. "Essay on the Lunar Zodiac," p. 345.

[1] For general statement of De Cusa's work, *see* Draper, "Intellectual Development of Europe," p. 512. For skillful use of De Cusa's view in order to mitigate censure upon the Church for its treatment of Copernicus's discovery, *see* an article in the *Catholic World*, for January, 1869. For a very exact statement, in a spirit of judicial fairness, *see* Whewell, "History of the Inductive Sciences," p. 275 and pp. 379, 380. In the latter, Whewell cites the exact words of De Cusa in the "De Docta Ignorantia," and sums up in these words: "This train of thought might be a preparation for the reception of the Copernican system; but it is very different from the doctrine that the sun is the centre of the planetary system." In the previous passage, Whewell says that De Cusa "propounded the doctrine of the motion of the earth, more, however, as a paradox than as a reality. We cannot consider this as any distinct anticipation of a profound and consistent view of the truth."

[2] For improvement of mathematical processes, *see* Draper, "Intellectual Development of Europe," 513. In looking at this and other admirable summaries, one feels that Prof. Tyndall was not altogether right in lamenting, in his farewell address at New York, that Dr. Draper has devoted so much of his time to historical studies.

[3] Copernicus's danger at Rome. The *Catholic World* for January, 1869, cites a recent speech of the Archbishop of Mechlin before the University of Louvain, to the effect that Copernicus defended his theory, at Rome, in 1500, before two thousand scholars; also, that another professor taught the system in 1528, and was made Apostolic Notary by Clement VIII. All this, even if the doctrines taught were identical with those of Copernicus, as finally developed, which idea Whewell seems utterly to disprove, avails nothing against the overwhelming testimony that Copernicus felt himself in danger—testimony which the after-history of the Copernican theory renders invincible. The very title of Fromundus's book, already cited, published within a few miles of the archbishop's own cathedral, and sanctioned expressly by the theological Faculty of that same University of Louvain in 1630, utterly refutes the archbishop's idea that the Church was inclined to treat Copernicus kindly. The title is as follows:

"Anti-Aristarchus | Sive | Orbis-Terræ | Immobilis | In quo decretum S. Congregationis S. R. E. | Cardinalium | IↃC. XVI adversus Pytha | gorico-Copernicanos editum defenditur | Antwerpiæ MDCXXXI."

L'Epinois, "Galilée," Paris, 1867, lays stress, p. 14, on the broaching of the doctrine by De Cusa, in 1435, and by Widmanstadt, in 1533, and their kind treatment by Eugenius IV. and Clement VII., but this is absolutely worthless in denying the papal policy afterward. Lange, "Geschichte des Materialismus," vol. i., pp. 217, 218, while

To publish this thought was dangerous indeed, and for more than thirty years it lay slumbering in the minds of Kopernik and the friends to whom he had privately intrusted it.

At last he prepares his great work on the "Revolution of the Heavenly Bodies," and dedicates it to the pope himself. He next seeks a place of publication. He dares not send it to Rome, for there are the rulers of the older Church ready to seize it. He dares not send it to Wittenberg, for there are the leaders of Protestantism no less hostile. He therefore intrusts it to Osiander, of Nuremberg.[1]

But, at the last moment, the courage of Osiander failed him. He dared not launch the new thought boldly. He writes a groveling preface; endeavors to excuse Kopernik for his novel idea. He inserts the apologetic lie that Kopernik propounds the doctrine of the movement of the earth, not as a *fact*, but as an *hypothesis*. He declares that it is lawful for an astronomer to indulge his *imagination*, and that this is what Kopernik has done.

Thus was the greatest and most ennobling, perhaps, of scientific truths—a truth not less ennobling to religion than to science—forced, in coming into the world, to sneak and crawl.[2]

On the 24th of May, 1543, the newly-printed book first arrived at the house of Kopernik. It was put into his hands; but he was on his death-bed. A few hours later he was beyond the reach of those mistaken, conscientious men, whose consciences would have blotted his reputation, and perhaps have destroyed his life.

Yet not wholly beyond their reach. Even death could not be trusted to shield him. There seems to have been fear of vengeance upon his corpse, for on his tombstone was placed no record of his life-long labors, no mention of his great discovery. There were graven upon it affecting words, which may be thus simply trans-

admitting that De Cusa and Widmanstadt sustained this idea and received honors from their respective popes, shows that, when the Church gave it serious consideration, it was condemned. There is nothing in this view unreasonable. It would be a parallel case to that of Leo X., at first inclined toward Luther and the others, in their "squabbles with the begging friars," and afterward forced to oppose them.

[1] For dangers at Wittenberg, *see* Lange, "Geschichte des Materialismus," vol. i., p. 217.

[2] Osiander, in a letter to Copernicus, dated April 20, 1541, had endeavored to reconcile him to such a procedure, and ends by saying, "Sic enim placidiores reddideris peripateticos et theologos quos contradicturos metuis." *See* Apologia Tychonis in "Kepleri Opera Omnia," Frisch's edition, vol. i., p. 246. Kepler holds Osiander entirely responsible for this preface. Bertrand, in his "Fondateurs de l'Astronomie Moderne," gives its text, and thinks it possible that Copernicus may have yielded "in pure condescension toward his disciple." But this idea is utterly at variance with expressions in Copernicus's own dedicatory letter to the pope, which follows the preface. For a good summary of the argument, *see* Figuier, "Savants de la Renaissance," pp. 378, 379. *See* also, citation from Gassendi's life of Copernicus, in Flammarion, "Vie de Copernic," p. 124. Mr. John Fiske, accurate as he usually is, in his recent "Outlines of Cosmic Philosophy," appears to have fallen into the error of supposing that Copernicus, and not Osiander, is responsible for the preface.

lated: "I ask not the grace accorded to Paul, not that given to Peter; give me only the favor which thou didst show to the thief on the cross." Not till thirty years after did a friend dare write on his tombstone a memorial of his discovery.[1]

The book was taken in hand at once by the proper authorities. It was solemnly condemned: to read it was to risk damnation; and the world accepted the decree.[2]

Doubtless many will at once exclaim against the Roman Catholic Church for this. Justice compels me to say that the founders of Protestantism were no less zealous against the new scientific doctrine. Said Martin Luther: "People gave ear to an upstart astrologer, who strove to show that the earth revolves, not the heavens or the firmament, the sun and the moon. Whoever wishes to appear clever must devise some new system which of all systems is, of course, the very best. This fool wishes to reverse the entire science of astronomy. But Sacred Scripture tells us that Joshua commanded the sun to stand still, and not the earth."

Melanchthon, mild as he was, was not behind Luther in condemning Kopernik. In his treatise, "Initia Doctrinæ Physicæ," he says: "The eyes are witnesses that the heavens revolve in the space of twenty-four hours. But certain men, either from the love of novelty, or to make a display of ingenuity, have concluded that the earth moves; and they maintain that neither the eighth sphere nor the sun revolves. . . . Now, it is a want of honesty and decency to assert such notions publicly, and the example is pernicious. It is the part of a good mind to accept the truth as revealed by God, and to acquiesce in it." Melanchthon then cites passages from the Psalms and from Ecclesiastes which he declares assert positively and clearly that the earth stands fast, and that the sun moves around it, and adds eight other proofs of his proposition that "the earth can be nowhere, if not in the centre of the universe."[3]

[1] Figuier, "Savants de la Renaissance," p. 380. Also, Flammarion, "Vie de Copernic," p. 190.

[2] The "proper authorities" in this case were the "Congregation of the Index," or cardinals having charge of the "Index Librorum Prohibitorum." Recent desperate attempts to fasten the responsibility on them as individuals seem ridiculous in view of the simple fact that their work is sanctioned by the highest Church authority, and required to be universally accepted by the Church. Three of four editions of the "Index" in my own possession declare on their title-pages that they are issued by order of the pontiff of the period, and each is prefaced by a special papal bull or letter. See specially Index of 1664, issued under order of Alexander VII., and that of 1761, under Benedict XIV. Copernicus's work was prohibited in the Index "*donec corrigatur*." Kepler said that it ought to be worded "*donec explicetur*." *See* Bertrand, "Fondateurs de l'Astronomie Moderne," p. 57. De Morgan, pp. 57–60, gives the corrections required by the Index of 1620. Their main aim seems to be to reduce Copernicus to the groveling level of Osiander, making of his discovery a mere hypothesis; but occasionally they require a virtual giving up of the whole Copernican doctrine, e. g., "correction" insisted upon for cap. 8, p. 6.

[3] *See* Luther's "Table Talk." Also, Melanchthon's "Initia Doctrinæ Physicæ." This

And Protestant people are not a whit behind Catholic in following out these teachings. The people of Elbing made themselves merry over a farce in which Kopernik was the main object of ridicule. The people of Nuremberg, a great Protestant centre, caused a medal to be struck, with inscriptions ridiculing the philosopher and his theory.[1]

Then was tried one piece of strategy very common formerly in battles between theologians themselves. It consists in loud shoutings that the doctrine attacked is old, outworn, and already refuted—that various distinguished gentlemen have proved it false—that it is not a living truth, but a detected lie—that, if the world listens to it, that is simply because the world is ignorant. This strategy was brought to bear on Copernicus. It was shown that his doctrine was simply a revival of the Pythagorean notion, which had been thoroughly exploded. Fromundus, in his title-page and throughout his book, delights in referring to the doctrine of the revolution of the planets around the sun, as "that Pythagorean notion." This mode of warfare was imitated by the lesser opponents, and produced, for some time, considerable effect.[2]

But the new truth could neither be laughed down nor forced down. Many minds had received it; only one tongue dared utter it. This new warrior was that strange mortal, Giordano Bruno. He was hunted from land to land, until, at last, he turns on his pursuers with fearful invectives. For this he is imprisoned six years, then burned alive and his ashes scattered to the winds. Still the new truth lived on; it could not be killed. Within ten years after the martyrdom of Bruno,[3] after a world of troubles and persecutions, the

treatise is cited by the *Catholic World*, September, 1870. The correct title is as given above. It will be found in the "Corpus Reformatorum," ed. Bretschneider: Halle, 1846. (For the above passage *see* vol. xiii., pp. 216, 217.) Also, Lange, "Geschichte des Materialismus," vol. i., p. 217. Also, Prowe, "Ueber die Abhängigkeit des Copernicus," Thorn, 1865, p. 4. Also, note, pp. 5 and 6, where text is given in full.

[1] For treatment of Copernican ideas by the people, *see Catholic World*, as above. Fromundus, cited above, heads his sixth chapter as follows, "Scriptura Sacra Oppugnat Copernicanos," and cites from the Psalms the passage speaking of the sun which "cometh forth as a bridegroom from his chamber;" and also from Ecclesiastes, "Terra in Aeternum Stat." "Anti-Aristarchus," p. 29. Some of his titles also show his style in philosophical argument, e. g., "The wind would constantly blow from the east; we should, with great difficulty, hear sounds against such a wind" (chapter xi.); "Buildings, and the earth itself, would fly off with such a rapid motion" (chapter x.). For another of Fromundus's arguments, showing, both from theology and mathematics (with suitably-mixed theology), that the earth must be in the centre of the universe, *see* Quetelet, "Histoire des Sciences Mathématiques et Physiques," p. 170, Bruxelles, 1864.

[2] *See* title-page of Fromundus's work cited in note at bottom of p. 392; also, Melanchthon, *ubi supra*.

[3] *See* Bartholmès, "Vie de Jordano Bruno," Paris, 1846, vol. i., pp. 121 and pp. 212, *et seq.* Also Berti, "Vita di Giordano Bruno," Firenze, 1868, chapter xvi. Also Whewell, i., 294, 295. That Whewell is somewhat hasty in attributing Bruno's punishment entirely to the "Spaccio della Bestia Trionfante" will be evident, in spite of Montcula, to any one who reads the account of the persecution in Bartholmès or Berti; and, even if

truth of the doctrine of Kopernik was established by the telescope of Galileo.[1]

Herein was fulfilled one of the most touching of prophecies. Years before, the enemies of Kopernik had said to him, "If your doctrines were true, Venus would show phases like the moon." Kopernik answered: "You are right. I know not what to say; but God is good, and will in time find an answer to this objection."[2] The God-given answer came when the rude telescope of Galileo showed the phases of Venus.

On this new champion, Galileo, the attack was tremendous. The supporters of what was called "sound learning" declared his discoveries deceptions, and his announcements blasphemy. Semi-scientific professors, endeavoring to curry favor with the Church, attacked him with sham science; earnest preachers attacked him with perverted Scripture![3]

The principal weapons in the combat are worth examining. They are very easily examined. You may pick them up on any of the battle-fields of science; but on that field they were used with more effect than on almost any other. These weapons are two epithets: "Infidel" and "Atheist."

The battle-fields of science are thickly strewn with these. They have been used against almost every man who has ever done anything new for his fellow-men. The list of those who have been denounced as infidel and atheist includes almost all great men of science—general scholars, inventors, philanthropists. The deepest Christian life, the most noble Christian character have not availed to shield combatants. Christians like Isaac Newton and Pascal and John Locke and John Milton, and even Howard and Fénelon, have had these weapons hurled against them. Of all proofs of the existence of a God, those of Descartes have been wrought most thoroughly into the minds of modern men; and yet the Protestant theologians of Holland sought to bring him to torture and to death by the charge of atheism.[4]

Whewell be right, the "Spaccio" would never have been written, but for Bruno's indignation at ecclesiastical oppression. *See* Tiraboschi, vol. xi., p. 435.

[1] Delambre, "Histoire de l'Astronomie moderne," discours préliminaire, p. xiv. Also Laplace, "Système du Monde," vol. i., p. 326, and, for more careful statement, "Kepleri Opera Omnia," edit. Frisch, tom. ii., p. 464.

[2] Cantu, "Histoire Universelle," vol. xv., p 473.

[3] A very curious example of this sham science is seen in the argument, frequently used at the time, that, if the earth really moved, a stone falling from a height would fall back of the point immediately below its point of starting. This is used by Fromundus with great effect. It appears never to have occurred to him to test the matter by dropping a stone from the topmast of a ship. But the most beautiful thing of all is that Benzenburg has experimentally demonstrated just such an aberration in falling bodies as is mathematically required by the diurnal motion of the earth. *See* Jevons, "Principles of Science," vol. i., p. 453, and ii., pp. 310, 311.

[4] For curious exemplification of the way in which these weapons have been hurled, *see* lists of persons charged with "infidelity" and "atheism," in "Le Dictionnaire des Athées." Paris, An. viii. Also Lecky, "History of Rationalism," vol. ii., p. 50.

These can hardly be classed with civilized weapons. They are burning arrows. They set fire to great masses of popular prejudices; smoke rises to obscure the real questions, fire bursts forth at times to destroy the attacked party. They are poisoned weapons. They go to the hearts of loving women, they alienate dear children. They injure the man after life is ended, for they leave poisoned wounds in the hearts of those who loved him best—fears for his eternal happiness—dread of the divine displeasure.

Of course, in these days, these weapons, though often effective in disturbing good men, and in scaring good women, are somewhat blunted. Indeed, they not unfrequently injure assailants more than assailed; so it was not in the days of Galileo. These weapons were then in all their sharpness and venom.

The first champion who appears against him is Bellarmin, one of the greatest of theologians, and one of the poorest of scientists. He was earnest, sincere, learned, but made the fearful mistake for the world, of applying to science, direct, literal interpretation of Scripture.[1]

The weapons which men of Bellarmin's stamp used were theological. They held up before the world the dreadful consequences which must result to Christian theology were the doctrine to prevail that the heavenly bodies revolve about the sun, and not about the earth. Their most tremendous theologic engine against Galileo was the idea that his pretended discovery vitiated the whole Christian plan of salvation. Father Le Gazrée declared that it "cast suspicion on the doctrine of the Incarnation." Others declared that it "upset the whole basis of theology; that if the earth is a planet, and one among several planets, it cannot be that any such great things have been done especially for it, as the Christian doctrine teaches. If there are other planets, since God makes nothing in vain, they must be inhabited; but how can these inhabitants be descended from Adam? How can they trace back their origin to Noah's ark? How can they have been redeemed by the Saviour?"[2]

Nor was this argument confined to the theologians of the Roman Church; Melanchthon, Protestant as he was, had already used it in his attacks upon the ideas of Copernicus and his school.[3]

In addition to this prodigious engine of war, there was kept up a terrific fire of smaller artillery in the shape of texts and scriptural extracts. Some samples of these weapons may be interesting.

When Galileo had discovered the four satellites of Jupiter,[4] the

[1] For Bellarmin's view *see* Quinet, "Jesuits," vol. ii., p. 189. For other objectors and objections, *see* Libri, "Histoire des Sciences Mathématiques en Italie," vol. iv., pp. 233, 234; also, "Private Life of Galileo," compiled from his correspondence and that of his eldest daughter, Boston, 1870 (an excellent little book).

[2] *See* Trouessart, cited in Flammarion, "Mondes Imaginaires et Réels," sixième édition, pp. 315, 316.

[3] "Initia Doctrinæ Physicæ," pp. 220, 221.

[4] *See* Delambre as to the discovery of the satellites of Jupiter being the turning-point

whole thing was denounced as impossible and impious. It was argued that the Bible clearly showed by all applicable types, that there could be only seven planets; that this was proved by the seven golden candlesticks of the Apocalypse, by the seven-branched candlestick of the Tabernacle, and by the seven churches of Asia.[1]

In a letter to his friend Renieri, Galileo gives a sketch of the dealings of the Inquisition with him. He says: "The Father Commissary, Lancio, was zealous to have me make amends for the scandal I had caused in sustaining the idea of the movement of the earth. To all my mathematical and other reasons he responded nothing but the words of Scripture, '*Terra autem in æternum stat.*'"[2]

It was declared that the doctrine was proved false by the standing still of the sun for Joshua; by the declarations that "the foundations of the earth are fixed so firm that they cannot be moved," and that the sun "runneth about from one end of heaven to the other."[3]

The Dominican father, Caccini, preached a sermon from the text, "Ye men of Galilee, why stand ye gazing up into heaven?" and this wretched pun was the first of a series of sharper weapons, for before Caccini finishes he insists that "geometry is of the devil," and that "mathematicians should be banished as the authors of all heresies."[4]

For the final assault, the park of heavy artillery was at last wheeled into place. You see it on all the scientific battle-fields. It consists of general denunciation, and Father Melchior Inchofer, of the Jesuits, brought his artillery to bear well on Galileo with this declaration: that the opinion of the earth's motion is, of all heresies, the most abominable, the most pernicious, the most scandalous; that the immobility of the earth is thrice sacred; that argument against the immortality of the soul, the Creator, the incarnation, etc., should be tolerated sooner than an argument to prove that the earth moves.[5]

In vain did Galileo try to prove the existence of satellites by showing them to the doubters through his telescope. They either declared it impious to look, or, if they did see them, denounced them as illusions from the devil. Good Father Clavius declared that "to see satellites of Jupiter, men had to make an instrument which would create them."[6]

with the heliocentric doctrine. As to its effects on Bacon, *see* Jevons, "Principles of Science," vol. ii., p. 298.

[1] For argument drawn from the candlestick and seven churches, *see* Delambre.

[2] For Galileo's letter to Renieri, *see* Cantu, "Hist. Universelle," Paris, 1855, xv., p. 477, note.

[3] Cantu, "Histoire Universelle," vol. xv., p. 478.

[4] For Caccini's attack, *see* Delambre, "Hist. de l'Astron.," disc. prélim., p. xxii., also Libri, "Hist. des Sciences Math.," vol. iv., p. 232.

[5] *See* Inchofer's "Tractatus Syllepticus," cited in Galileo's letter to Deodati, July 28, 1634.

[6] Libri, vol. iv., p. 211. De Morgan, "Paradoxes," p. 26, for account of Father Clavius. It is interesting to know that Clavius, in his last years, acknowledged that "the whole system of the heavens is broken down, and must be mended."

In vain did Galileo try to protect himself by his famous letter to the duchess, in which he insisted that theological reasoning should not be applied to science. The rest of the story the world knows by heart; none of the recent attempts have succeeded in mystifying it. The whole world will remember forever how Galileo was subjected certainly to indignity and imprisonment equivalent to physical torture;[1] how he was at last forced to pronounce publicly, and on his knees, his recantation as follows: "I, Galileo, being in my seventieth year, being a prisoner and on my knees, and before your eminences, having before my eyes the Holy Gospel, which I touch with my hands, abjure, curse, and detest, the error and heresy of the movement of the earth."[2]

He was vanquished indeed, for he had been forced, in the face of all coming ages, to perjure himself. His books were condemned, his friends not allowed to erect a monument over his bones. To all appearance his work was overthrown.

Do not understand me here as casting blame on the Roman Church as such. It must, in fairness, be said that some of its best men tried to stop this great mistake; even the pope himself would have been glad to stop it; but the current was too strong.[3] The whole of the civilized world was at fault, Protestant as well as Catholic, and not any particular part of it. It was not the fault of religion, it was the fault of the short-sighted views which narrow-minded, loud-voiced men are ever prone to mix in with religion, and to insist *is* religion.[4]

Were there time, I would refer at length to some of the modern mystifications of the history of Galileo. One of the latest seems to have for its groundwork the theory that Galileo was condemned for a breach of good taste and etiquette. But those who make this defense make the matter infinitely worse for those who committed the great

[1] It is not probable that torture in the ordinary sense was administered to Galileo. *See* Th. Martin, "Vie de Galilée," for a fair summing up of the case.

[2] For text of the abjuration, *see* "Private Life of Galileo," Appendix. As to the time when the decree of condemnation was repealed, various authorities differ. Artaud, p. 307, cited in an apologetic article in *Dublin Review*, September, 1865, says that Galileo's famous dialogue was published in 1744, at Padua, entire, and with the usual approbations. The same article also declares that in 1818 the ecclesiastical decrees were repealed by Pius VII., in full Consistory. Whewell says that Galileo's writings, after some opposition, were expunged from the "Index Expurgatorius," in 1818. Cantu, an authority rather favorable to the Church, says that Copernicus's work remained on the "Index" as late as 1835. Cantu, "Histoire Universelle," vol., xv., p. 483.

[3] For Baronius's remark *see* De Morgan, p. 26. Also Whewell, vol. i., p. 394.

[4] For an exceedingly striking statement, by a Roman Catholic historian of genius, as to popular demand for persecution, and the pressure of the lower strata, in ecclesiastical organizations, for cruel measures, *see* Balmès, "Le Protestantisme comparé au Catholicisme," etc., 4th ed., Paris, 1855, vol. ii. Archbishop Spaulding has something of the same sort in his Miscellanies. L'Epinois, "Galilée," p. 22, *et seq.*, stretches this as far as possible, to save the reputation of the Church in the Galileo matter.

wrong. They deprive it of its only palliation, mistaken conscientiousness.[1]

Nor was this the worst loss to the earth.

There was then in Europe one of the greatest thinkers ever given to mankind. Mistaken though many of his theories were, they were fruitful in truths. The man was Réné Descartes. The scientific warriors had stirred new life in him, and he was working over and summing up in his mighty mind all the researches of his time. The result must make an epoch in the history of man. His aim was to combine all knowledge and thought into a "Treatise on the World." His earnestness he proved by the eleven years which he gave to the study of anatomy alone. Petty persecution he had met often, but the fate of Galileo robbed him of all hope, of all energy. The battle seemed lost. He gave up his great plan forever.[2]

But champions pressed on. Campanella, full of vagaries as he was, wrote his "Apologia pro Galileo," though for that and other heresies, religious and political, he seven times underwent torture.[3]

And Kepler comes. He leads science on to greater victories. He throws out the minor errors of Kopernik. He thinks and speaks as

[1] *See Dublin Review*, as above. Whewell, vol. i., 393. Citation from Marini: "Galileo was punished for trifling with the authorities to which he refused to submit, and was punished for obstinate contumacy, not heresy." The sufficient answer to all this is that the words of the inflexible sentence designating the condemned books are: "*Libri omnes qui affirmant telluris motum.*" *See* Bertrand, p. 59. It has also been urged that "Galileo was punished not for his opinion, but for basing it on Scripture." The answer to this may be found in the Roman Index of 1704, in which are noted for condemnation "*Libri omnes docentes mobilitatem terræ et inmobilitatem solis.*" For the way in which, when it was found convenient in argument, Church apologists insisted that it *was* "the Supreme Chief of the Church, by a pontifical decree, and not certain cardinals," who condemned Galileo and his doctrine, *see* Father Gazrée's letter to Gassendi in Flammarion, "Pluralité des Mondes," p. 427. For the way in which, when necessary, Church apologists asserted the very contrary of this, declaring that "it was issued in a doctrinal decree of the Congregation of the Index, and *not* as the Holy Father's teaching," *see Dublin Review*, September, 1865. And for the most astounding attempt of all, to take the blame off the shoulders of both pope and cardinals, and place it upon the Almighty, see the following words of the article above cited: "But it may well be doubted whether the Church did retard the progress of scientific truth. What retarded it was the circumstance that God has thought fit to express many texts of Scripture in words which have every appearance of denying the earth's motion. But it is God who did this, not the Church; and, moreover, since he thought fit so to act as to retard the progress of scientific truth, it would be little to her discredit even if it were true that she had followed his example."—*Dublin Review*, September, 1865, p. 419. For the best summary of the various attempts, and for replies to them in a spirit of judicial fairness, *see* Th. Martin, "Vie de Galilée." This is probably the best book ever written on the Galileo question. The bibliography at the close is very valuable.

[2] Humboldt, "Cosmos," London, 1851, vol. iii., p. 21. Also Lange, "Geschichte des Materialismus," vol. i., p. 222, where the letters of Descartes are given, showing his despair, and the giving up of his best thoughts and works to preserve peace with the Church. Also Jolly, "Hist. du Mouvement Intellectuel au XVI[e] Siècle," vol. i., p. 390.

[3] Libri, pp. 149, *et seq.*

one inspired. His battle is severe. He is sometimes abused, sometimes ridiculed, sometimes imprisoned. Protestants in Styria and at Tübingen, Catholics at Rome press upon him,[1] but Newton, Huyghens and the other great leaders follow, and to science remains the victory.

And yet the war did not wholly end. During the seventeenth century, in all France, no one dared openly teach the Copernican theory, and Cassini, the great astronomer, never declared it.[2] In 1672, Father Riccioli, a Jesuit, declared that there were precisely forty-nine arguments for the Copernican theory and seventy-seven against it; so that there remained twenty-eight reasons for preferring the orthodox theory.[3] Toward the end of the seventeenth century also, even Bossuet, the "eagle of Meaux," among the loftiest of religious thinkers, declared for the Ptolemaic theory as the Scriptural theory,[4] and in 1746 Boscovich, the great mathematician of the Jesuits, used these words: "As for me, full of respect for the Holy Scriptures and the decree of the Holy Inquisition, I regard the earth as immovable; nevertheless, for simplicity in explanation, I will argue as if the earth moves, for it is proved that of the two hypotheses the appearances favor that idea."[5]

The Protestantism of England was no better. In 1772 sailed the famous English expedition for scientific discovery under Cook. The greatest by far of all the scientific authorities chosen to accompany it was Dr. Priestley. Sir Joseph Banks had especially invited him; but the clergy of Oxford and Cambridge intervened. Priestley was considered unsound in his views of the Trinity; it was declared that this would vitiate his astronomical observations; he was rejected and the expedition crippled.[6]

Nor has the opposition failed even in our own time. On the 5th of May, 1826, a great multitude assembled at Thorn to celebrate the three hundredth anniversary of Kopernik, and to unveil Thorwaldsen's statue of him.

Kopernik had lived a pious, Christian life. He was well known

[1] Fromundus, speaking of Kepler's explanation, says: "Vix teneo ebullientem risum." It is almost equal to the *New York Church Journal*, speaking of John Stuart Mill as "that small sciolist," and of the preface to Dr. Draper's recent work as "chippering." How a journal generally so fair in its treatment of such subjects can condescend to use such weapons is one of the wonders of modern journalism. For Protestant persecution of Kepler, *see* vol. i., p. 392.

[2] For Cassini's position, *see* Henri Martin, "Hist. de France," vol. xiii., p. 175.

[3] Daunou, "Études Historiques," vol. ii., p. 439.

[4] Bossuet, *see* Bertrand, p. 41.

[5] Boscovich. This was in 1746, but in 1785 Boscovich seemed to feel his position in view of history, and apologized abjectly. Bertrand, pp. 60, 61. *See* also Whewell's notice of Le Sueur and Jacquier's introduction to their edition of Newton's "Principia." For the most recent proofs of the Copernican theory, by discoveries of Bunsen, Bischoff, Benzenburg, and others, *see* Jevons, "Principles of Science."

[6] *See* Weld, "History of the Royal Society," vol. ii., p. 56, for the facts and the admirable letter of Priestley upon this rejection.

for unostentatious Christian charity. With his religious belief no fault had ever been found. He was a canon of the church of Frauenberg, and over his grave had been written the most touching of Christian epitaphs.

Naturally, then, the people expected a religious service. All was understood to be arranged for it. The procession marched to the church and waited. The hour passed, no priest appeared; none could be induced to appear. Kopernik, simple, charitable, pious, one of the noblest gifts of God to the service of religion as well as science, was still held to be a reprobate. Seven years after that, his book was still standing on the "Index of Books prohibited to Christians." [1]

Nor has this warfare against dead champions of science been carried on only by the older Church.

On the 10th of May, 1859, was buried Alexander von Humboldt. His labors were among the greatest glories of the century, and his funeral one of the most imposing that Berlin had ever seen: among those who honored themselves by their presence was the prince regent—the present emperor. But of the clergy it was observed that none were present save the officiating clergyman and a few regarded as unorthodox.[2]

Nor have attempts to renew the battle been wanting in these latter days. The attempt in the Church of England, in 1864, to fetter Science—which was brought to ridicule by Herschel, Bowring, and De Morgan; the Lutheran assemblage at Berlin, in 1868, to protest against "science falsely so called," in the midst of which stood Pastor Knak denouncing the Copernican theory; the "Syllabus," the greatest mistake of the Roman Church, are all examples of this.[3]

And now, what has been won by either party in this long and terrible war? The party which would subordinate the methods and aims of science to those of theology, though in general obedient to deep convictions, had given to Christianity a series of the worst blows it had ever received. They had made large numbers of the best men in Europe hate it. Why did Ricetto and Bruno and Vanini, when the crucifix was presented to them in their hours of martyrdom, turn from that blessed image with loathing? [4] Simply because Christianity had been made to them identical with the most horrible oppression of the mind.

Worse than that, the well-meaning defenders of the faith had

[1] Bertrand, "Fondateurs de l'Astron. Mod.," p. 61. Flammarion, "Vie de Copernic," chap. ix.

[2] Bruhns and Lassell, "Life of Humboldt," London, 1873, vol. ii., p. 411.

[3] For the very amusing details of the English attempt, and of the way in which it was met, *see* De Morgan, "Paradoxes," p. 42. For Pastor Knak and his associates, *see Revue des Deux Mondes*, 1868.

[4] For a striking account, gathered from eye-witnesses, of this frightful scene at the execution of Bruno, *see* letter of Scioppius in appendix to vol. iv. of Libri, "Hist. des Mathématiques."

wrought into the very fibre of the European heart that most unfortunate of all ideas, the idea that there is a necessary antagonism between science and religion. Like the landsman who lashes himself to the anchor of the sinking ship, they had attached the great fundamental doctrines of Christianity, by the strongest cords of logic which they could spin, to these mistaken ideas in science, and the advance of knowledge had wellnigh engulfed them.

On the other hand, what had science done for religion? Simply this: Kopernik, escaping persecution only by death; Giordano Bruno, burned alive as a monster of impiety; Galileo, imprisoned and humiliated as the worst of misbelievers; Kepler, hunted alike by Protestant and Catholic, had given to religion great new foundations, great new, ennobling conceptions, a great new revelation of the might of God.

Under the old system we have that princely astronomer, Alfonso of Castile, seeing the poverty of the Ptolemaic system, yet knowing no other, startling Europe with the blasphemy that if he had been present at creation he could have suggested a better ordering of the heavenly bodies. Under the new system you have Kepler, filled with a religious spirit, exclaiming, "I do think the thoughts of God."[1] The difference in religious spirit between these two men marks the conquest made in this, even by science, for religion. But we cannot leave the subject of astronomy without noticing the most recent warfare. Especially interesting is it because at one period the battle seemed utterly lost, and then was won beautifully, thoroughly, by a legitimate advance in scientific knowledge. I speak of the Nebular Hypothesis.

The sacred writings of the Jews which we have inherited speak clearly of the creation of the heavenly bodies by direct intervention, and for the convenience of the earth. This was the view of the Fathers of the Church, and was transmitted through the great doctors in theology.

More than that, it was crystallized in art. So have I seen, over the portal of the Cathedral of Freiburg, a representation of the Almighty making and placing numbers of wafer-like suns, moons, and stars; and at the centre of all, platter-like and largest of all, the earth.[2] The lines on the Creator's face show that he is obliged to contrive; the lines of his muscles show that he is obliged to toil. Naturally, then, did sculptors and painters of the mediæval and early modern period represent the Almighty as weary after labor, and enjoying dignified repose.

These ideas, more or less gross in their accompaniments, passed into the popular creed of the modern period.

[1] As a pendant to this ejaculation of Kepler may be cited those wondrous words of Linnæus: "Deum omnipotentem a tergo transeuntem vidi et obstupui."

[2] For papal bulls representing the earth as a flat disk, *see* Daunou, "Études Historiques," vol. ii., p. 421.

But about the close of the last century, Bruno having guessed the fundamental fact of the nebular hypothesis, and Kant having reasoned out its foundation idea, Laplace developed it, showing the reason for supposing that our own solar system, in its sun, planets, satellites, with their various motions, distances, and magnitudes, is a natural result of the diminishing heat of a nebulous mass—a result obeying natural laws.

There was an outcry at once against the "atheism" of the scheme. The war raged fiercely. Laplace claimed that there were in the heavens many nebulous patches yet in the gaseous form, and pointed them out. He showed by laws of physics and mathematical demonstration that his hypothesis accounted in a most striking manner for the great body of facts, and, despite clamor, was gaining ground, when the improved telescopes resolved some of the patches of nebulous matter into multitudes of stars.

The opponents of the nebular hypothesis were overjoyed. They sang pæans to astronomy, because, as they said, it had proved the truth of Scripture.

They had jumped to the conclusion that all nebulæ must be alike—that if some are made up of systems of stars all must be so made up; that none can be masses of attenuated gaseous matter, because some are not.

Science, for a time, halted. The accepted doctrine became this—that the only reason why all the nebulæ are not resolved into distinct stars is, because our telescopes are not sufficiently powerful.

But in time came that wonderful discovery of the spectroscope and spectrum analysis, and this was supplemented by Fraunhofer's discovery that the spectrum of an ignited gaseous body is discontinuous, with interrupting lines; and this, in 1846, by Draper's discovery that the spectrum of an ignited solid is continuous, with no interrupting lines. And now the spectroscope was turned upon the nebulæ and about one-third of them were found to be gaseous.

Again the nebular hypothesis comes forth stronger than ever. The beautiful experiment of Plateau on the rotation of a fluid globe comes in to strengthen if not to confirm it. But what was likely to be lost in this? Simply a poor conception of the universe. What to be gained? A far more worthy idea of that vast power which works in the universe, in all things by law, and in none by caprice.[1]

[1] For Bruno's conjecture (in 1591), *see* Jevons, vol. ii., p. 299. For Kant's part in the nebular hypothesis, *see* Lange, "Geschichte des Materialismus," vol. i., p. 266. For value of Plateau's beautiful experiment very cautiously estimated, *see* W. Stanley Jevons, "Principles of Science," London, 1874, vol. ii., p. 36. Also Elisée Réclus, "The Earth," translated by Woodward, vol. i., pp. 14–18, for an estimate still more careful. For a general account of discoveries of nature of nebulæ by spectroscope, *see* Draper, "Conflict between Religion and Science." For a careful discussion regarding the spectra of solid, liquid, and gaseous bodies, *see* Schellen, "Spectrum Analysis," pp. 100, *et seq.* For a very thorough discussion of the bearings of discoveries made by spectrum analysis upon the

The great series of battles to which I next turn with you were fought on those fields occupied by such sciences as chemistry and natural philosophy.

Even before those sciences were out of their childhood, while yet they were tottering mainly toward childish objects and by childish steps, the champions of that same old mistaken conception of rigid scriptural interpretation began the war. The catalogue of chemists and physicists persecuted or thwarted would fill volumes; from them I will select just three as representative men.

First of these I take Albert of Bollstadt, better known in the middle ages as Albert the Great. In the thirteenth century he stands forth as the greatest scholar in Germany. Fettered though he was by the absurd methods of his time, led astray as he was by the scholastic spirit, he has conceived ideas of better methods and aims. His eye pierces the mists of scholasticism, he sees the light and draws the world toward it. He stands among the great pioneers of modern physical and natural science. He gives foundations to botany and chemistry, and Humboldt finds in his works the germ of the comprehensive science of physical geography.[1]

The conscience of the time, acting as it supposed in defense of religion, brought out a missile which it hurled with deadly effect. You see those mediæval scientific battle-fields strewn with such: it was the charge of sorcery, of unlawful compact with the devil.

This missile was effective. You find it used against every great investigator of Nature in those times and for centuries after. The list of great men charged with magic, as given by Naudé, is astounding. It includes every man of real mark, and the most thoughtful of the popes, Sylvester II. (Gerbert), stands in the midst of them. It seemed to be the received idea that, as soon as a man conceived a love to study the works of God, his first step must be a league with the devil.[2]

This missile was hurled against Albert. He was condemned by the great founder of the Dominican order himself. But more terrible weapons than this missile were added to it, to make it effective. Many an obscure chemist paid a terrible penalty for wishing to be wiser than his time; but I pass to the greater martyrs.

I name, next, Roger Bacon. His life and work seem until recent-

nebular hypothesis, ibid., pp. 532–537. For a presentation of the difficulties yet unsolved, *see* article by Plummer, in London *Popular Science Review* for January, 1875. For excellent short summary of recent observations and thought on this subject, *see* T. Sterry Hunt, "Address at the Priestley Centennial," pp. 7, 8. For an interesting modification of this hypothesis, *see* Proctor's recent writings.

[1] "Il était aussi très-habile dans les arts mécaniques, ce que le fit soupçonner d'être sorcier."—Sprengel, "Histoire de la Médecine," vol. ii., p. 389.

[2] For the charge of magic against scholars and others, *see* Naudé, "Apologie pour les grands hommes accusés de Magie," *passim*. Also, Maury, "Hist. de la Magie," troisième édit., pp. 214, 215. Also Cuvier, "Hist. des Sciences Naturelles," vol. i., p. 396.

ly to have been generally misunderstood. He has been ranked as a superstitious alchemist who stumbled upon some inventions; but more recent investigation has revealed him to be one of the great masters in human progress.

The advance of sound historical judgment seems likely to reverse the positions of the two who bear the name of Bacon. Bacon of the chancellorship and the "Novum Organon" seems to wane. Bacon of the prison-cell and the "Opus Majus" seems to grow brighter.[1]

Roger Bacon's work, as it is now revealed to us, was wonderful. He wrought with power in philosophy and in all sciences, and his knowledge was sound and exact. By him, more than by any other man of the middle ages, was the world put on the most fruitful paths of science—the paths which have led to the most precious inventions. Clocks, lenses, burning specula, telescopes, were given by him to the world, directly or indirectly. In his writings are found formulæ for extracting phosphorus, manganese, and bismuth. It is even claimed that he investigated the power of steam. He seems to have very nearly reached also some of the principal doctrines of modern chemistry. His theory of investigation was even greater than these vast results. In an age when metaphysical subtilizing was alone thought to give the title of scholar, he insisted on *real* reasoning and the aid of natural science by mathematics. In an age when experimenting was sure to cost a man his reputation and was likely to cost him his life, he insisted on experiment and braved all its risks. Few greater men have lived. As we read the sketch given by Whewell of Bacon's process of reasoning regarding the refraction of light, he seems fairly inspired.

On this man came the brunt of the battle. The most conscientious men of his time thought it their duty to fight him, and they did it too well. It was not that he disbelieved in Christianity, *that* was never charged against him. His orthodoxy was perfect. He was attacked and condemned, in the words of his opponents, "*propter quasdam novitates suspectas*."

He was attacked, first of all, with that goodly old missile, which, with the epithets "infidel" and "atheist," has decided the fate of so many battles—the charge of magic and compact with Satan.

He defended himself with a most unfortunate weapon—a weapon which exploded in his hands and injured him more than the enemy, for he argued against the idea of compacts with Satan, and showed that much which is ascribed to demons results from natural means. This added fuel to the flame. To limit the power of Satan was deemed hardly less impious than to limit the power of God.

The most powerful protectors availed him little. His friend Guy

[1] For a very contemptuous statement of Lord Bacon's claim to his position as a philosopher, *see* Lange, "Geschichte des Materialismus," Leipsic, 1874, vol. i., p. 219. *See* also Jevons, "Principles of Science," London, 1874, vol. ii., p. 298.

Foulkes having been made pope, Bacon was for a time shielded, but the fury of the enemy was too strong. In an unpublished letter, Blackstone declares that when, on one occasion, Bacon was about to perform a few experiments for some friends, all Oxford was in an uproar. It was believed that Satan was let loose. Everywhere were priests, fellows, and students rushing about, their garments streaming in the wind, and everywhere resounded the cry, "Down with the conjurer!" and this cry "Down with the conjurer" resounded from cell to cell and hall to hall.[1]

But the attack took a shape far more terrible. The two great religious orders, Franciscan and Dominican, vied with each other in fighting the new thought in chemistry and philosophy. St. Dominic, sincere as he was, solemnly condemned research by experiment and observation. The general of the Franciscan order took similar grounds.

In 1243 the Dominicans solemnly interdicted every member of their order from the study of medicine and natural philosophy; and, in 1287, this interdiction was extended to the study of chemistry.[2]

Another weapon began to be used upon the battle-fields of that time with much effect. The Arabs had made noble discoveries in science. Averroes had, among many, divided the honors with St. Thomas Aquinas. These facts gave the new missile. It was the epithet "Mahometan." This, too, was flung with effect at Bacon.[3]

Bacon was at last conquered. He was imprisoned for fourteen years. At the age of eighty years he was released from prison, but death alone took him beyond the reach of his enemies. How deeply the struggle had racked his mind may be gathered from that last afflicting declaration of his: "Would that I had not given myself so much trouble for the love of science!"

Sad is it to think of what this great man might have given to the world had the world not refused the gift. He held the key of treasures which would have freed mankind from ages of error and misery. With his discoveries as a basis, with his method as a guide, what might not the world have gained! Nor was the wrong done to that age alone. It was done to this age also. The nineteenth century was robbed at the same time with the thirteenth. But for that inter-

[1] Whewell, vol. i., pp. 367, 368. Draper, p. 438. Saisset, "Descartes et ses Précurseurs," deuxième édition, pp. 397, *et seq.* Nourrisson, "Progrès de la pensée humaine," pp. 271, 272. Sprengel, "Histoire de la Médecine," Paris, 1865, vol. ii., p. 397. Cuvier, "Histoire des Sciences Naturelles," vol. i., p. 417. As to Bacon's orthodoxy, *see* Saisset, pp. 53, 55. For special examination of causes of Bacon's condemnation, *see* Waddington, cited by Saisset, p. 14. On Bacon as a sorcerer, *see* Featherstonaugh's article in *North American Review.* For a good example of the danger of denying full power of Satan, even in much more recent times, and in a Protestant country, *see* account of treatment of Bekker's "Monde Enchanté" by the theologians of Holland, in Nisard, "Histoire des Livres Populaires," vol. i., pp. 172, 173.

[2] Henri Martin, "Hist. de France," vol. iv., p. 283.

[3] On Bacon as a "Mahometan," *see* Saisset, p. 17

ference with science, this nineteenth century would, without doubt, be enjoying discoveries which will not be reached before the twentieth century. Thousands of precious lives shall be lost in this century, tens of thousands shall suffer discomfort, privation, sickness, poverty, ignorance, for lack of discoveries and methods which, but for this mistaken religious fight against Bacon and his compeers, would now be blessing the earth.

In 1868 and 1869, sixty thousand children died in England and in Wales of scarlet fever; probably nearly as many died in this country. Had not Bacon been hindered we should have had in our hands, by this time, the means to save two-thirds of these victims, and the same is true of typhoid, typhus, and that great class of diseases of whose physical causes Science is just beginning to get an inkling. Put together all the efforts of all the atheists who have ever lived, and they have not done so much harm to Christianity and the world as has been done by the narrow-minded, conscientious men who persecuted Roger Bacon.[1]

Roger Bacon was vanquished. For ages the champions of science were crippled; but the "good fight" was carried on. The Church itself furnishes heroes of science. Antonio de Dominis relinquishes his archbishopric of Spalatro, investigates the phenomena of light, and dies in the clutches of the Inquisition.[2]

Pierre de la Ramée stands up against Aristotelianism at Paris. A royal edict, sought by the Church, stopped his teaching, and the massacre of St. Bartholomew ended his life.

Somewhat later, John Baptist Porta began his investigations. Despite many absurdities, his work was most fruitful. His book on meteorology was the first in which sound ideas were broached. His researches in optics gave the world the camera obscura, and, possibly, the telescope. He encountered the same old policy of conscientious men. The society founded by him for physical research, "I Secreti," was broken up, and he was summoned to Rome and censured.[3]

In 1624, some young chemists of Paris having taught the experimental method, and cut loose from Aristotle, the Faculty of Theology besets the Parliament of Paris, and the Parliament prohibits this new chemical teaching under penalty of death.[4]

The war went on in Italy. In 1657 occurred the first sitting of

[1] For proofs that the world is steadily working toward great discoveries as to the cause and prevention of zymotic diseases and of their propagation, *see* Beale's "Disease Germs," Baldwin Latham's "Sanitary Engineering," Michel Lévy, "Traité d'Hygiène Publique et Privée," Paris, 1869. And for very thorough summaries, *see* President Barnard's paper read before Sanitary Congress in New York, 1874, and Dr. J. C. Dalton's "Anniversary Discourse, on the Origin and Propagation of Disease," New York, 1874.

[2] Antonio de Dominis, *see* Montucla, "Hist. des Mathématiques," vol. i., p. 705. Humboldt, "Cosmos." Libri, vol. iv., pp. 145, *et seq.*

[3] Sprengel, "Hist. de la Médecine, iii., p. 239. Also Musset-Parthay.

[4] Henri Martin, "Histoire de France," vol. xii., pp. 14, 15.

the *Accademia del Cimento*, at Florence, under the presidency of Prince Leopold dei Medici. This Academy promised great things for science. It was open to all talent. Its only fundamental law was "the repudiation of any favorite system or sect of philosophy, and the obligation to investigate Nature by the pure light of experiment."

The new Academy entered into scientific investigations with energy. Borelli in mathematics, Redi in natural history, and many others, pushed on the boundaries of knowledge. Heat, light, magnetism, electricity, projectiles, digestion, the incompressibility of water, were studied by the right method and with results that enriched the world.

The Academy was a fortress of science, and siege was soon laid to it. The votaries of scholastic learning denounced it as irreligious. Quarrels were fomented. Leopold was bribed with a cardinal's hat and drawn away to Rome; and, after ten years of beleaguering, the fortress fell: Borelli was left a beggar; Oliva killed himself in despair.[1]

From the dismissal of the scientific professors from the University of Salamanca by Ferdinand VII. of Spain, in the beginning of this century, down to sundry dealings with scientific men in our own land and time, we see the same war continued.

Joseph de Maistre, uttering his hatred of physical sciences, declaring that man has paid too dearly for them, asserting that they must be subjected to theology, likening them to fire—good when confined but fearful when scattered about—this brilliant thinker has been the centre of a great opposing camp in our own time—an army of good men who cannot relinquish the idea that the Bible is a text-book of science.

[*To be continued.*]

## NATURAL HISTORY OF THE KANGAROO.

By ST. GEORGE MIVART, F.R.S.

THE kangaroos have now become familiar objects to all who visit our Zoölogical Gardens, or who are familiar with any considerable zoölogical museum.

Their general external form, when seen in the attitude they habitually assume when grazing (with their front limbs touching the ground),

[1] Napier, "Florentine History," vol. v., p. 485. Tiraboschi, "Storia della Litteratura." Henri Martin, "Histoire de France." Jevons, "Principles of Science," vol. ii., pp. 36–40. Libri, in his "Essai sur Galilée," p. 37, says that Oliva was summoned to Rome and so tortured by the Inquisition that, to escape further cruelty, he ended his life by throwing himself from a window. For closing, by church authority, of the Academy, "I Secreti," instituted for scientific investigation at an earlier period, *see* reference to Porta in this article. On Porta, *see* Sprengel, "Histoire de la Médecine," vol. iii., p. 239.

may have recalled to mind, more or less, the appearance presented by some hornless deer. Their chief mode of locomotion (that jumping action necessitated by the great length of the hind-limbs) must be familiar to all who have observed them living, and also, very probably, the singular mode in which the young are carried in a pouch of skin in the front of the belly of the mother.

But "What is a kangaroo?" The question will raise in the minds of those who are not naturalists the image of some familiar circum-

Fig. 1.—Kangaroo (*Macropus*).

stances like those just referred to. But such image will afford no real answer to the question. To arrive at *such* an answer it is necessary to estimate correctly in what relation the kangaroo stands to other animals—its place in the scale of animated beings—as also its relations to space and time; that is, its distribution over the earth's surface to-day, in connection with that of other animals more or less like it, and its relation to the past life of this planet, in connection with similar relations of animals also more or less like it. In other words, to understand what a kangaroo is, we must understand its zoölogical, geographical, and geological conditions. And my task in this paper is to make these conditions as clear as I can, and so to enable the reader to really answer the question, "What is a kangaroo?"

But before proceeding to these matters, let us look at our kangaroo a little closer, and learn something of its structure, habits, and history, so as to have some clear conceptions of the kangaroo considered by itself, before considering its relations with the universe (animate and inanimate) about it.

The kangaroo (Fig. 1) is a quadruped, with very long hind-limbs and a long and rather thick tail. Its head possesses rather a long muzzle, somewhat like that of a deer, with a pair of rather long ears. Each fore-paw has five toes, urnished with claws. Each hind-limb has but two large and conspicuous toes, the inner one of which is much the larger, and bears a very long and strong claw (Fig. 2). On the inner

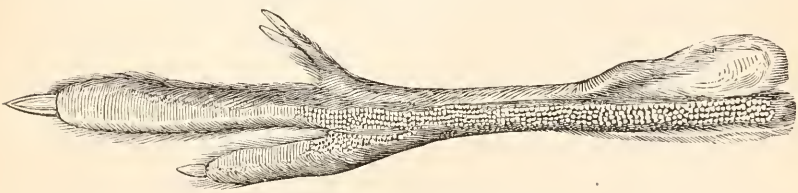

Fig. 2.—Foot of Kangaroo.

side of this is what appears to be a very minute toe, furnished with two small claws. An examination of the bones of the foot shows us, however, that it really consists of two very slender toes united together in a common fold of skin. These toes answer to the second and third toes of our own foot, and there is no representative of our great-toe—not even that part of it which is inclosed in the substance of our foot, called the *inner metatarsal bone*. Two other points are specially noteworthy in the skeleton. The first of these is that the pelvis (or bony girdle to which the hind-limbs are articulated, and by which they are connected with the back-bone) has two elongated bones extending upward from its superior margin in front (Fig. 4, *a*). These are called marsupial bones, and lie within the flesh of the front of the animal's belly. The other point is that the lower, hinder portion of each side of the lower jaw (which portion is technically called the "*angle*") is bent inward, or "inflected," and not continued directly backward in the same plane as the rest of the lower jaw.

A certain muscle, called the cremaster muscle, is attached to each marsupial bone, and thence stretches itself over the inner or deep surface of the adjacent mammary gland or "breast," which is situated low down, and not in the breast at all.

The kangaroo's teeth consist of three on each side in the front of the mouth, and one on each side below. These eight teeth are what are called incisors. At the back of the mouth there are five grinding-teeth on each side above and five below, and between the upper grinders and incisors another pointed tooth, called a canine, may or may not be interposed. Such a set of teeth is indicated by the following formula, where I stands for incisors, C for canines, and M for grinding-teeth or "molars." The number above each line indicates the teeth of each denomination which exist on one side of the upper jaw, and the lower number those of the lower jaw:

$$I\ \frac{3}{1}\quad C\ \frac{0}{0}\ \text{or}\ \frac{1}{0}\quad M\ \frac{5}{5} = \frac{9}{6}\ \text{or}\ \frac{8}{6}$$

The total number of incisor teeth of *both* sides of each jaw may therefore be expressed thus: I $\frac{6}{2}$.

Such is the general structure of an adult kangaroo. At birth it is strangely different from what it ultimately becomes.

It is customary to speak of the human infant as exceptionally helpless at birth and after it, but it is at once capable of vigorous sucking, and very early learns to seek the nipple. The great kangaroo, standing some six feet high, is at birth scarcely more than an inch long, with delicate naked skin, and looking like part of an earthworm. But, in such feeble and imperfectly developed condition, the young kangaroo cannot actively suck. The mother therefore places it upon one of her long and slender nipples (the end of which is somewhat swollen), this nipple entering its mouth, and the little creature remaining attached to it. The mother then, by means of the cremaster muscle (before spoken of), squeezes her own milk gland, and so injects milk into the young, which would thus be infallibly choked but for a noticeable peculiarity of its structure, admirably adapted to the circumstances of the case.

In almost all beasts, and in man also, the air-passage or windpipe (which admits air to and from the lungs) opens into the floor of the mouth, behind the tongue and *in front* of the opening of the gullet. Each particle of food, then, as it passes to the gullet, passes over the entrance to the windpipe, but is prevented from falling into it (and so causing death by choking) by the action of a small cartilaginous shield (the *epiglottis*). This shield, which ordinarily stands up in front of the opening into the windpipe, bends back and comes over that opening just when food is passing, and so, at the right moment, almost always prevents food from "going the wrong way." But, in the young kangaroo, the milk being introduced, not by any voluntary act of the young kangaroo itself, but by the injecting action of its mother, it is evident that, did such a state of things obtain in it as has been just described, the result would be speedily fatal. Did no special provision exist, the young one must infallibly be choked by the intrusion of milk into the windpipe. But there is a special provision for the young kangaroo; the upper part of the windpipe (or larynx), instead of lying as in us, and as in most beasts, widely separated from the hinder opening of the nostrils, is much raised (Fig. 3, *a*). It is in fact so elongated in the young kangaroo that it rises right up into the hinder end of the nasal passage, which embraces it. In this way there is free entrance for air from the nostrils into the windpipe by a

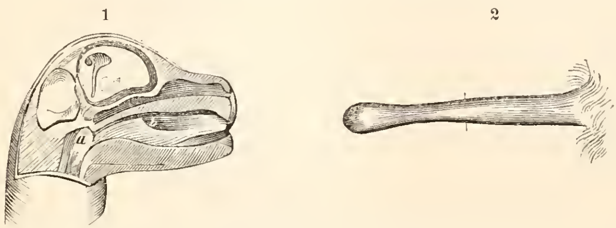


FIG. 3.—1. DISSECTED HEAD OF YOUNG KANGAROO.—*a*, Elongated Larynx; *b*, Cavity of Mouth. 2. Nipple of Mother.

passage shut off from the cavity of the mouth. All the time the milk can freely pass to the back of the mouth and gullet along each side of this elongated larynx, and thus breathing and milk-injection can go on simultaneously, without risk or inconvenience.

The kangaroo browses on the herbage and bushes of more or less open country, and, when feeding, commonly applies its front-limbs to the ground. It readily, however, raises itself on its hind-limbs and strong tail (as on a tripod) when any sound, sight, or smell, alarms its natural timidity (Fig. 1).

Mr. Gould tells us that the natives (where it is found) sometimes hunt these animals by forming a great circle around them, gradually converging upon them, and so frightening them by yells that they become an easy prey to their clubs.

As to its civilized hunters, the same author tells us that kangaroos are hunted by dogs which run entirely by sight, and partake of the nature of the greyhound and deerhound, and, from their great strength and fleetness, are so well adapted for the duties to which they are trained, that the escape of the kangaroo, when it occurs, is owing to peculiar and favorable circumstances; as, for example, the oppressive heat of the day, or the nature of the ground; the former incapacitating the dogs for a severe chase, and the hard ridges, which the kangaroo invariably endeavors to gain, giving him great advantage over his pursuers. On such ground the females in particular will frequently outstrip the fleetest greyhound; while, on the contrary, heavy old males, on soft ground, are easily taken. Many of these fine kangaroo-dogs are kept at the stock-stations of the interior, for the sole purpose of running the kangaroo and the emu, the latter being killed solely for the supply of oil which it yields, and the former for mere sport or for food for the dogs. Although I have killed the largest males with a single dog, it is not generally advisable to attempt this, as they possess great power, and frequently rip up the dogs, and sometimes even cut

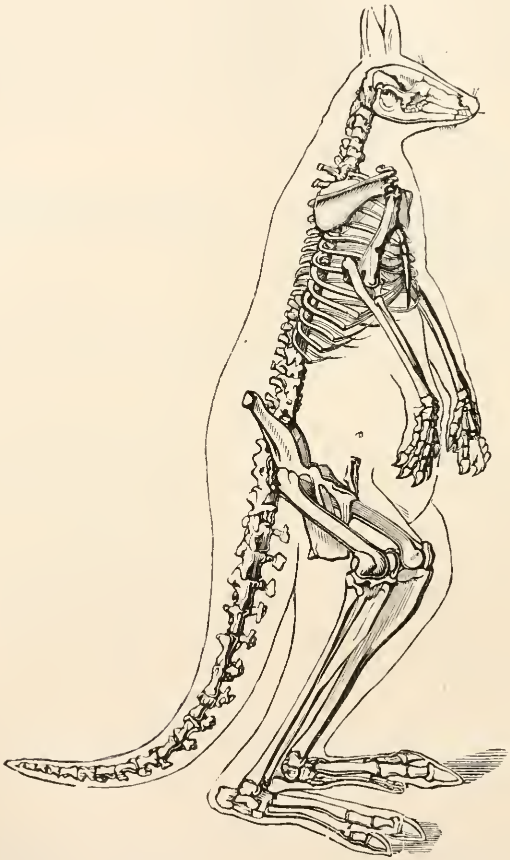


Fig. 4.—Skeleton of the Kangaroo.—*a*, Marsupial Bones.

them to the heart with a single stroke of the hind-leg. Three or four dogs are more generally laid on; one of superior fleetness to "pull" the kangaroo, while the others rush in upon it and kill it. It sometimes adopts a singular mode of defending itself, by clasping its short, powerful fore-limbs around its antagonist, then hopping away with it to the nearest water-hole, and there keeping it beneath the water until drowned.

The kangaroo is said to be able to clear even more than fifteen feet at one bound.

Rapidity of locomotion is especially necessary for a large animal inhabiting a country subject to such severe and widely-extending droughts as in Australia. The herbivorous animals which people the plains of Southern Africa—the antelopes—are also capable of very rapid locomotion. In the antelopes, however, as in all hoofed beasts, all the four limbs (front as well as hind) are exclusively used for locomotion. But in kangaroos we have animals requiring to use their front pair of limbs for the purposes of more or less delicate manipulation with respect to the economy of the "pouch." Accordingly, for such creatures to be able to inhabit such a country, the hind pair of limbs must by themselves be fitted alone to answer the purpose of both the front and hind limbs of deer and antelopes. It would seem, then, that the peculiar structure of the kangaroo's limbs is of the greatest utility to it; the front pair serving as prehensile manipulating organs, while the hind pair are, by themselves alone, able to carry the animal great distances with rapidity, and so to traverse wide arid plains in pursuit of rare and distant water. The harmony between structure, habit, and climate, was long ago pointed out by Prof. Owen.

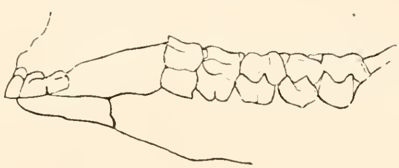

Fig. 5.—Teeth of Kangaroo.

The kangaroo breeds freely in this country, producing one at a birth. We have young ones every year in our Zoölogical Gardens. A large number of them are reared to maturity, and altogether our kangaroos thrive and do well. One born in our gardens was lately in the habit of still entering the pouch of its mother, although itself bearing a very young one within its own pouch. These animals have been already more or less acclimatized in England. I have myself seen them in grounds at Glastonbury Abbey. Some were so kept in the open by Lord Hill, and some by the Duke of Marlborough. A very fine herd is now at liberty in a park near Tours, in France.

It is a little more than one hundred and five years since the kangaroo was first distinctly seen by English observers. At the recommendation and request of the Royal Society, Captain (then Lieutenant) Cook set sail in May, 1768, in the ship Endeavor, on a voyage of exploration, and for the observation of the transit of Venus of the year 1769, which transit the travelers observed, from the Society Islands, on June 3d of that year. In the spring of the following year the ship started from New Zealand to the eastern coast of New Holland, visiting, among other places, a spot which, on account of the number of plants found there by Mr. (afterward Sir Joseph) Banks, received the name of Botany Bay. Afterward, when detained in Endeavor River (about 15° south latitude) by the need of repairing a hole made in the vessel by a rock (part of which, fortunately, itself stuck in the hole it made), Captain Cook tells us that on Friday, June 22, 1770, "some of the people were sent on the other side of the water, to shoot pigeons for the sick, who at their return reported that they had seen an animal, as large as a greyhound, of a slender make, a mouse-color, and extremely swift." On the next day, he tells us: "This day almost everybody had seen the animal which the pigeon-shooters had brought an account of the day before; and one of the seamen, who had been rambling in the woods, told us on his return that he verily believed he had seen the devil. We naturally inquired in what form he had appeared, and his answer was, says John, 'As large as a one-gallon keg, and very like it; he had horns and wings, yet he crept so slowly through the grass that, if I had not been *afeared*, I might have touched him.' This formidable apparition we afterward, however, discovered to have been a bat (A FLYING FOX). . . . Early the next day," Captain Cook continues, "as I was walking in the morning, at a little distance from the ship, I saw myself one of the animals which had been described; it was of a light mouse-color, and in size and shape very much resembling a greyhound; it had a long tail also, which it carried like a greyhound; and I should have taken it for a wild-dog if, instead of running, it had not leaped like a hare or deer." Mr. Banks also had an imperfect view of this animal, and was of opinion that its species was hitherto unknown. The work exhibits an excellent figure of the animal. Again, on Sunday, July 8th, being still in Endeavor River, Captain Cook tells us that some of the crew "set out, with the first dawn, in search of game, and in a walk of many miles they saw four animals of the same kind, two of which Mr. Banks's greyhound fairly chased; but they threw him out at a great distance, by leaping over the long, thick grass, which prevented his running. This animal was observed not to run upon four legs, but to bound or leap forward upon two, like the jerboa." Finally, on Saturday, July 14th, "Mr. Gore, who went out with his gun, had the good fortune to kill one of these animals which had been so much the subject of our speculation;" adding, "This animal is called by the natives *kanguroo*. The next day (Sunday, July 15th) our kanguroo was dressed for dinner, and proved most excellent meat."

Such is the earliest notice of this creature's observation by Englishmen; but Cornelius de Bruins, a Dutch traveler, saw,[1] as early as 1711, specimens of a species (now named after him, *Macropus Brunii*),

[1] *See* Cornelis de Bruins, "Reizen over Moskovie, door Persie en Indie." Amsterdam, 1714, p. 374, Fig. 213

which he called *Filander*, and which were kept in captivity in a garden at Batavia. A very fair representation of the animal is given—one showing the aperture of the pouch. This species was, moreover, described both by Pallas[1] and by Schreber.[2]

It is not improbable, however, that kangaroos were seen by the earlier explorers of the western coast of Australia; and it may be that it is one of these animals which was referred to by Dampier, when he tells us that on August 12, 1699, "two or three of my seamen saw creatures not unlike wolves, but so lean that they looked like mere skeletons."

Having now learned something of the structure, habits, and history of the kangaroo, we may proceed to consider its zoölogical, geographical, and geological relations, in order to arrive at the best answer we may to our initial question, "What is a kangaroo?"

First, as to its zoölogical relations: and here it is necessary to recall to mind certain leading facts of zoölogical classification, in order that we may be better able to see with what creatures the kangaroo is, in various degrees, allied.

The whole animal population of the globe is spoken of under the fanciful term, the "animal kingdom," in contrast with the world of plants, or "vegetable kingdom."

The animal kingdom is divided into certain great groups, each of which is called a sub-kingdom; and one, the highest of these sub-kingdoms (that to which we ourselves belong), bears the name *vertebrata*, and it includes all beasts, birds, reptiles, and fishes; and the name refers to the series of bone called *vertebræ*, of which the backbone or spinal column (and all *vertebrata have* a spinal column) is generally made up.

Each sub-kingdom is made up of subordinate groups, termed classes; and thus the vertebrate sub-kingdom is made up of the *class* of beasts or *Mammalia* (so called because they suckle their young), the class of birds, and other classes.

Each class is made up of subordinate groups, termed *orders;* each order is further subdivided into *families;* each family is made up of *genera;* while every genus comprises one, few, or many species.

In considering the zoölogical relations of the kangaroo, we have then to consider the relations borne by its genera to the other genera of its family, the relations borne by its family to the other families of its order, and finally the relations borne by its order to the other orders of its class (the *Mammalia*)—that class which includes within it all other beasts whatever, and also man.

In the first place, it may be observed, there are many species of kangaroos, arranged in some four genera; but the true kangaroos form a genus, *Macropus*, which is very nearly allied to the three other

[1] Pallas, "Act. Acad. Sc. Petrop.," 1777, part ii., p. 299, tab. 4, Figs. 4 and 5.

[2] Schreber, "Sangth.," iii., p. 551, pl. 153, 1778.

genera. 2. *Dorcopsis*, with a very large first back tooth. 3. The *tree kangaroos* (*Dendrolagus*), which frequent the more horizontal branches of trees, have the fore-limbs but little shorter than the hind-limbs, and inhabit New Guinea; 4. The *rat-kangaroos* (*Hypsiprymnus*), which have the first upper grinding-tooth large, compressed, and with vertical grooves.

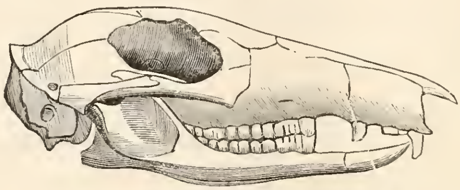

FIG. 6.—SKULL OF A RAT-KANGAROO (*Hypsiprymnus*).

These four genera together constitute the kangaroo's FAMILY, the *Macropodidæ*, the species of which all inhabit Australia and the islands adjacent, but are found nowhere else in the world.

The species agree in having—

1. The second and third toes slender and united in a common fold of skin.

2. The hind-limbs longer than the fore-limbs.

3. No inner *metatarsal* bone.

4. All the toes of each fore-foot provided with claws.

5. Total number of incisors only $\frac{6}{2}$.

These five characters are common to the group, and do not co-exist in any other animals. They form, therefore, the distinguishing CHARACTERS of the kangaroo's family. This family, *Macropodidæ*, is one of the six other families which, together with it, make up that much larger group, the kangaroo's ORDER. As was just said, to understand what a kangaroo is, we must know "what are the relations borne by his *family* to the other families of its order;" and accordingly it is needful for our purpose to take at least a cursory view of those other families.

There is a small animal, called a *bandicoot* (Fig. 7), which, in external appearance, differs very plainly from the kangaróo, but resembles it in having the hind-limbs longer than the fore-limbs, and also in the form of its hind-feet, which present a kangaroo structure, but not carried out to such an extreme degree as in the kangaroo, and therefore approximating more to the normal type of foot, there being a rudimentary inner toe and a less preponderant fourth toe; the second and third toes, however, are still very small, and bound together by skin down to the nails. In the fore-foot, on the contrary, there is a deficiency, the outer toes being nailless or wanting. The cutting-teeth are more numerous, these being I $\frac{10}{8}$.

This little creature is an example of others, forming the family

*Peramelidæ*—a family made up of creatures none of which much exceed the hare in size, and which, instead of feeding on vegetable substances (as do the kangaroos), eat insects, for which food they are well adapted by the sharp points and ridges which may be seen on their back teeth.

FIG. 7.—LONG-NOSED BANDICOOT (*Perameles*).

One member of this family, *Chæropus* (Fig. 8), is very exceptional in the structure of its hind-feet, which out-kangaroo the kangaroo in the

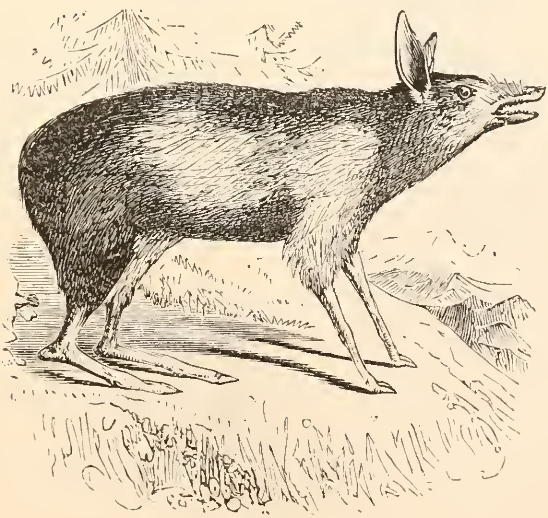

FIG. 8.—CHÆROPUS.

minuteness of all the toes but the fourth, upon which alone the creature walks, while its front-feet are each reduced to two functional digits.

No other known beast besides walks upon a single toe in each hind-foot, save the horse family (horses, asses, and zebras), and they walk upon a different one, namely, that which answers to our middle-toe, while *Chæropus* walks on the next outer one or fourth. No known beast besides *Chæropus* walks upon two toes in each foot, save hoofed creatures, such as the ruminants and their allies; but in them it is the third and fourth toes that are used, while in *Chæropus* it is the second and third toes.

Another animal, called a phalanger (of the genus *Phalangista*), is a type of a third family of the kangaroo's order, the *Phalangistidæ*, a family made up of creatures which live in trees and are nocturnal in their habits, feeding upon fruits and leaves. Here we find the limbs of nearly equal length. Once more we have I $\frac{3}{2}$, and we still have the second and third toes united in a common fold of skin; but the innermost toe (that answering to *our* great-toe) is not only largely developed, but is like that of the apes, directed outward, and capable of being opposed to the other toes, as our thumb can be opposed to our fingers.

Fig. 9.—The Koala (*Phascolarctus*).

Some of these creatures have prehensile tails. Others have the skin of the flanks enlarged so as to serve them as a parachute in their leaps, whence they are called "flying opossums," just as squirrels, similarly provided, are called "flying" squirrels.

There are two very aberrant members of this family. One, the koala, Fig. 9 (*Phascolarctus*), called the native bear or native sloth, is devoid of any tail.

The other, *Tarsipes*, but little bigger than a mouse, has a long and pointed muzzle, and its teeth are reduced to minute pointed processes, few in number, $\frac{6-6}{5-5}$, situated far apart in each jaw.

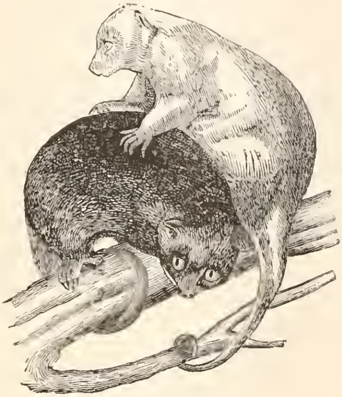

FIG. 10.—CUSCUS ORIENTALIS.

The genus *Cuscus*, closely allied to *Phalangista*, is found in New Guinea and the adjacent islands to Timor (Fig. 10).

FIG. 11.—THE WOMBAT (*Phascolomys*).

Another animal, the wombat, Fig. 11 (*Phascolomys*), forms by itself a distinct family, *Phascolomyidæ*. It is a burrowing nocturnal animal, about the size of a badger, with rudimentary tail and peculiar feet and teeth.

We still find the second and third toes bound together, limbs of equal length, and all the five toes of the fore-foot with claws (as in the last family), but the great-toe is represented by a small tubercle, while the cutting teeth are $\frac{2}{2}$, growing from persistent pulp through life, as in rats, squirrels, and Guinea-pigs (Fig. 12).

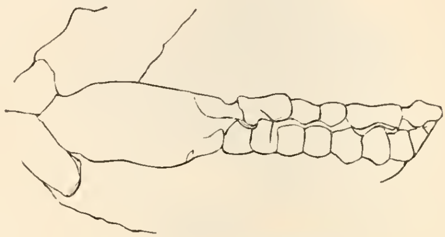

Fig. 12.—Teeth of the Wombat.

We may now pass to a very different family of animals belonging to the kangaroo's order. We pass, namely, to the *Dasyuridæ*, or family of the native cat, wolf, and devil, so named from their predatory or fierce nature. They have well-developed eye-teeth (or canines), and back teeth with sharp cutting blades, or bristling with prickly points. The second and third toes are no longer bound together; and while there are five toes with claws to each fore-foot, the great-toe is either absent altogether or small. The cutting teeth, Fig. 13, are $\frac{8}{6}$,

Fig. 13.—Teeth of Dasyurus.

and the tail is long and clothed with hair throughout. Some of these animals are elegantly colored and marked, and all live on animal food. This form (belonging to the typical genus *Dasyurus*, which gives its name to the family) may be taken as a type; but two others merit notice.

The first of these is *Myrmecobius*, Fig. 14, from Western Australia, remarkable for its number of back teeth, $\frac{8-8}{9-9}$, and for certain geographical and zoölogical relations, to be shortly referred to. With respect to this creature, Mr. Gilbert has told us:

"I have seen a good deal of this beautiful little animal. It appears very much like a squirrel when running on the ground, which it does in successive leaps, with its tail a little elevated, every now and then raising its body, and resting on its hind-feet. When alarmed, it generally takes to a dead tree lying on the ground, and before entering

FIG. 14.—MYRMECOBIUS.

the hollow invariably raises itself on its hind-feet, to ascertain the reality of approaching danger. In this kind of retreat it is easily captured, and when caught is so harmless and tame as scarcely to make any resistance, and never attempts to bite. When it has no chance of escaping from its place of refuge, it utters a sort of half-smothered grunt, apparently produced by a succession of hard breathings."

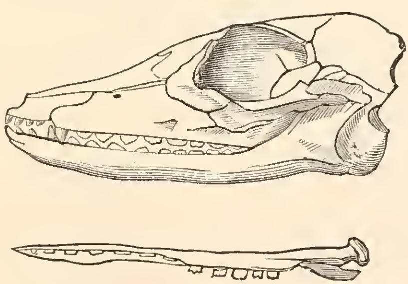

FIG. 15.—SKULL OF MYRMECOBIUS.

The other member of the family *Dasyuridæ*, to which I call the reader's attention, is a very different animal from the *Myrmecobius*. I refer to the largest of the predatory members of the kangaroo's order; namely, to the Tasmanian wolf. It is about the size of the animal after which it is named, and it is marked across the loins with tiger-like, black bands (Fig. 16). It is only found in the island of Tasmania, and will probably very soon become altogether extinct, on account of its destructiveness to the sheep of the colonists. Its teeth have considerable resemblance to those of the dog, and it differs from all other members of the kangaroo's order, in that *mere cartilages* represent those marsupial bones which every other member of the order unquestionably possesses.

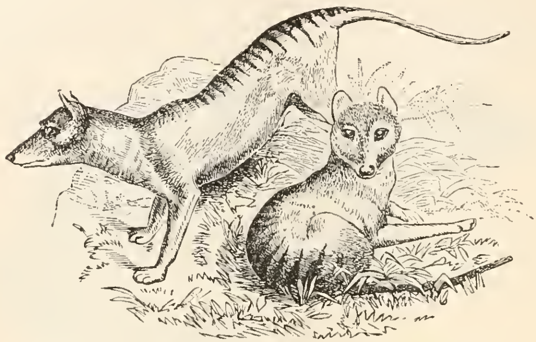

FIG. 16.—TASMANIAN WOLF (*Thalacinus Cynocephalus*).

The last family of the kangaroo's order consists of the true opossum, which (unlike all the animals we have as yet passed in review) inhabits not the Australian region, but America only.

These creatures vary in size from that of the cat to that of the rat.

They are called *Didelphidæ*, and agree with the *Dasyuridæ* in having well-developed canine teeth and cutting back teeth (Fig. 17); in

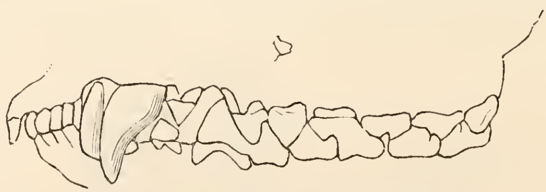

FIG. 17.—TEETH OF OPOSSUM (*Didelphys*).

having the second and third toes free, and five toes to the fore-foot. But they differ in that—

1. Cutting-teeth $\frac{10}{8}$ (more than in any other animal).
2. A large opposable great-toe.
3. A tail, naked (like that of the rat) and prehensile.

One of them is aquatic in its habits and web-footed. Such are the very varied forms which compose the six families which together make up the kangaroo's order, and such are the relations borne by the kangaroo's family to the other families of the kangaroo's order.

But, to obtain a clear conception of the kangaroo, we must not rest content with a knowledge of its order considered by itself. But we must endeavor to learn the relation of its order to the other orders of that highest class of animals to which the kangaroo and we ourselves both belong, namely, the class *Mammalia*, which class, with the other classes, birds, reptiles, and fishes together, makes up the back-boned or *vertebrate* primary division of the whole animal kingdom.

What, then, is the relation of the kangaroo's order—the MARSUPIALIA—to the other orders of the class Mammalia?

Now, these orders are:

1. The order which contains man and apes.

2. That of the bats.

3. That of the mole, shrew, hedgehog, and their allies—all *insectivorous.*

4. That of the dog, cat, weasel, and bear—all *carnivorous.*

5. That of the gnawing animals, such as the rat, squirrel, jerboa, and guinea-pig—all with cutting-teeth $\frac{2}{2}$, with permanent pulps. They are called Rodents.

6. The order containing the sloths.

7. That of the grazing, hoofed quadrupeds—deer, antelopes, and their allies.

Besides three orders of aquatic beasts (seals, whales, and the manatee order), with which we need not be now further concerned.

FIG. 18.—THE YAPOCK (*Chironectes*).

Now, in the first place, very noticeable is the much greater diversity of structure found in the kangaroo's order than in any other order of mammals. While each of the *latter* is of one predominate type of structure and habit, we have found in the marsupials the greatest diversity in both.

Some marsupials are, we have seen, arboreal, some are burrowing, some flit through the air, while others range over and graze upon grassy plains. Some feed on vegetable food only, others are as exclusively insectivorous or carnivorous, and their teeth vary much in number and structure. Certain of my readers may wonder that such diverse forms should be thus grouped together, apart from the other mammals. At first sight it might seem more natural to place together *flying opossums* with *flying squirrels;* the *native sloth* with the *true sloth;* the *dog* and *cat-like opossums* with the *true dogs* and *cats;* and, lastly, the *insectivorous marsupials* with the *other insectivora.*

As to the kangaroos themselves, they might be considered as approximating in one respect to the Ruminants, in another to the Rodents.

We have seen that even in Captain Cook's time its resemblance to the jerboa forced itself into notice. And, indeed, in this jerboa (and its first cousin, the *alactaga*) we have the same or even a relatively greater length of hind-limb and tail, and we have the same jumping mode of progression.

Again, in the little jumping insectivorous mammal, the shrew (*Macroscelides*), we meet with excessively long hind-limbs and a jumping habit. More than this: if we examine its teeth, we find both in the upper cutting teeth and in the back teeth great resemblance to those of the kangaroo. And yet there is no real affinity between the kangaroo and such creatures, any more than there is between a non-marsupial truly carnivorous beast and a marsupial carnivore. Indeed, both myself and my readers are far more like the jerboa or weasel than either of the latter is like to any marsupial animal.

The fact is, that all these so varied marsupial forms of life possess in common certain highly-important characters, by which they differ from all other mammals. These characters, however, mainly relate to the structure of their reproductive organs, and could not be here detailed without a long preliminary anatomical explanation; but, as to the great importance of these characters, naturalists are agreed.

Among the characters which serve to distinguish the marsupials, there are two to which I have already called attention in describing the kangaroo; namely, the marsupial bones and the inflected angle of the lower jaw.

Every mammal which has marsupial bones has the angle of its jaw inflected, or else has no angle to its jaw at all; while every animal which has both marsupial bones and an inflected jaw-angle possesses also those special characters of the reproductive system which distinguish the marsupials from all other mammals.

Thus it is clear we have at least two great groups of mammals. One of them—the non-marsupials—contains man; the apes; bats; hedgehog-like beasts (shrews, moles, etc.); cats, dogs, bears, etc.; hoofed beasts; edentates; rodents, and also the aquatic mammals. And this great group, containing so many orders, is named MONODELPHIA.

The other great groups consist of all the marsupials, and no others. It consists, therefore, of the single order, *Marsupialia*, and is called DIDELPHIA.

Another group of mammals is made up of two genera only—the duck-billed platypus, or *Ornithorhynchus*, and the *Echidna*, two most interesting forms, but which cannot be further noticed here. They form, by themselves, a theme amply sufficient for an article, or even half a dozen articles.

As to its zoölogical relations, then, we may say that *the kangaroo is a peculiarly modified form of a most varied order of mammals* (*the* MARSUPIALS), *which differ from all ordinary beasts* (and at the same time differ from man) *by very important anatomical and physiological characters, the sign of the presence of which is the coexistence of marsupial bones with an inflected angle of the lower jaw.*

We may now proceed to the next subject of inquiry, and consider the space relations (that is, the geographical distribution) of the kangaroo, its family, and order. I have already incidentally mentioned some countries where marsupials are found, but all of those were more or less remote. To find living, in a state of nature, any member of the kangaroo's order, we must at least cross the Atlantic.

When America was discovered by the Spaniards, among the animals found there, and afterward brought over to Europe, were *opossums*, properly so called—marsupials, of the family *Didelphidæ*, which extend over the American Continent, from the United States to the far South. These creatures were the first to make known to Europeans [1] that habit of sheltering the young in a pouch which exists in the kangaroo, and which habit has given the name *Marsupialia* to the whole order. But, though this habit was duly noted, it is not strange that (being the only pouched forms then known) the value of the peculiarity should have been under-estimated. It is not strange that they should have been regarded as merely a new kind of ordinary flesh-eating beasts, since in the more obvious characters of teeth and general form they largely resembled such beasts. Accordingly even the great Cuvier, in the first edition of his "Règne Animal," made them a mere subdivision of his great order of flesh-eating mammals.

But, to find any other member of the kangaroo's order (besides the *Didelphidæ*), in a state of nature, we must go much farther than merely across the Atlantic; namely, to Australia or the islands adjacent to it, including that enormous and unexplored island, New Guinea, which has recently attracted public attention through the published travels of a modern Baron Munchausen.

To return, however, to our subject. To find marsupials at all, we

[1] The following are some among the earlier notices of these animals: "Histoire d'un Voyage fait en la Terre du Brésil," par Jean de Léry, Paris, 1578, p. 156. Hernande's "Hist. Mex.," p. 330, 1626. "Histoire Naturelle des Antilles," Rotterdam, 1658. "Anatomy of an Opossum," Tyson, Phil. Trans., 1698.

have, as we have seen, to go to the New World. To find nearer allies of the kangaroo, we must go to the *newest* world, Australia; *newest* because, if America merited the title of *new* from its new natural productions as well as its new discovery, Australia may well claim the superlative epithet on both accounts. We have found an indication, in the name Botany Bay, of the interest excited in the mind of Sir Joseph Banks by the new plants as well as by the new animals of Australia. And, indeed, its plants and animals do differ far more from those of the New World (America) than do those of America from those of the Old World.

Marsupials, in fact, are separated off from the rest of their class —from the great bulk of mammals—the *Monodelphia*—no less by their geographical limits than by their peculiarities of anatomical structure.

And these geographical limits are at the same time the limits of many groups of animals and plants, so that we have an animal population (or fauna) and a vegetable population (or flora) which are characteristic of what is called the Australian region—the Australian *region*, because the Australian forms of life are spread not only over Australia and Tasmania, but over New Guinea and the Moluccas, extending as far northwest as the island of *Lombok*, while marsupials themselves extend to *Timor*.

In India, the Malay Peninsula, and the great islands of the Indian Archipelago, we have another and a very different fauna and flora— those, namely, of the Indian region, and Indian forms of life extend downward southeast as far as the island of Bali. Now, Bali is separated from Lombok by a strait of but fifteen miles in width. But that little channel is the boundary-line between these two great regions— the Australian and the Indian. The great Indian fauna advances to its western margin, while the Australian fauna stops short at its eastern margin.

The zoölogical line of demarkation which passes through these straits is called "Wallace's line," because its discovery is due to the labors of that illustrious naturalist, that courageous, persevering explorer, and most trustworthy observer, Alfred Wallace, a perusal of whose works I cordially recommend to my readers, since the charm of their style is as remarkable as is the sterling value of their contents. Mr. Wallace pointed out that not only as regards beasts (with which we are concerned to-day), but that also as regards birds, these regions are sharply limited. "Australia has," he says, "no woodpeckers, no pheasants—families which exist in every other part of the world; but instead of them it has the mound-making brush-turkeys, the honeysuckers, the cockatoos, and the brush-tongued lories, which are found nowhere else upon the globe."

All these striking peculiarities are found also in those islands which form the Australian division of the archipelago, while in those islands which belong to its Indian division these Australian birds have no place.

On passing from the island of Bali to that of Lombok, we cross the division between the two. "In Bali," he tells us, "we have barbets, fruit-thrushes, and woodpeckers, while in Lombok these are seen no more; but we have abundance of cockatoos, honeysuckers, and brush-turkeys, which are equally unknown in Bali, or any island farther west."

As to our second point, then—the geographical relations of the kangaroo—we may say that the *kangaroo is one of an order of animals confined to the Australian region and America*, *the great bulk of which order*, *including the kangaroo's own family*, MACROPODIDÆ, *is strictly confined to the Australian region.* We may further add that in the Australian region ordinary beasts (*Monodelphia*) are entirely absent, save some bats and a rat or two, and the wild-dog or dingo, which was probably introduced there by man himself.

There only remains, then, for us to inquire, lastly, what relations with past time may be found to exist on the part of the kangaroo's order or of the kangaroo itself. Now, in fact, these relations are of considerable interest. I have spoken of Australia as, what in one sense it certainly is, the *newest world*, and yet *the oldest world* would, in truth, be an apter title for the Australian region.

In these days we hear much of "survivals," as the two buttons behind our frock-coats are "survivals" of the extinct sword-belt they once supported, and the "Oh, yes! oh, yes! oh, yes!" of the town-crier is a "survival" of the former legal and courtly predominance of the French language among us. Well, in Australia we have to-day a magnificent case of zoölogical survival on the largest scale. There, as has already been said, we find living the little *Myrmecobius*, which represents before our eyes a creature living in the flesh to-day, which is like other creatures which once lived here in England, and which have left their relics in the Stonesfield oolite, the deposition of which is separated from our own age by an abyss of past time not to be expressed by thousands of years, but only to be indicated in geological language as the Mesozoic period—the middle of the secondary rocks.

But Australia presents us with a yet more interesting case of "survival." Certain fish-teeth had from time to time been found in deposits of oolitic and triassic date, and the unknown creature to which they once belonged had received the name of *Ceratodus*. Only five years ago this animal, supposed to have been extinct for untold ages, was found still living in Queensland, where it goes by the name of "flat-head." It is a fish of somewhat amphibious habits, as at night it leaves the brackish streams it inhabits, and wanders among the reeds and rushes of the adjacent flats. The anatomy of this animal has been carefully described for us by Dr. Günther.

We have, then, in Australia what may be termed a triassic land, still showing us in life to-day the more or less modified representations of forms which elsewhere have long since passed away from among us, leaving but rare and scattered fragments—relics "sealed within the iron hills."

No member of the Australian families of the kangaroo's order has left its relics in European strata more recent than the secondary rocks. But the American family, *Didelphidæ*, is represented in the earliest Tertiary period by the remains of an American form (a true opossum) having been found by Cuvier in the quarries of Montmartre. He first discovered a lower jaw, and, from its inflected angle, concluded that it belonged to a marsupial animal, and that therefore marsupial bones were hidden in the matrix. Accordingly he predicted that such bones would be found; and, proceeding to remove the enveloping deposit with the greatest care, he laid bare before the admiring eyes of the bystanders the proof of the correctness of his prediction. It is noteworthy, however, that, had this fossil been that of an animal like the Tasmanian wolf, he would have been disappointed, as, though marsupial, it has, as has been already said, not marsupial *bones*, but *cartilages.*

But relics of creatures more closely allied to the kangaroo existed in times ancient historically, though, geologically speaking, very recent. Just as in the recent deposits of South America we find the bones of huge beasts, first cousins to the sloths and armadilloes which live there now, so in Australia there lived beasts having the more essential structural characters of the kangaroo, yet of the bulk of the rhinoceros. Their bones and teeth have been found in the tertiary deposits of Australia. They have been described by Prof. Owen, and are now to be seen preserved in the British Museum and that of the Royal College of Surgeons. It may be that other fossil forms of the middle mesozoic or even of triassic times may, so some believe, have belonged to creatures of the kangaroo's family; but at least there is no doubt that such existed in times of post-tertiary date.

As to our third point—the geological relations of the kangaroo—we may say, then, that "*the kangaroo is one of an order of animals which ranged over the Northern Hemisphere in triassic and oolitic times, one exceptional family lingering in Europe to the Eocene period, and in America to the present day. That the kangaroo itself is a form certainly become fossil in its own region, where, in times geologically recent, creatures allied to it, but of vastly greater bulk, frequented the Australian plains.*"

We may now, then, proceed to answer finally the question, "*What is a kangaroo?*" We may do so because the meaning of the technical terms in which the answer must necessarily be expressed (if not of undue length) has been now explained, as far as space has allowed.

We may say, then, that "*the kangaroo is a didelphous* (*or marsupial*) *mammal, of the family* MACROPODIDÆ; *an inhabitant of the*

*Australian region, and connected, as respects its order, with triassic times, and possibly even as regards its family also, though certainly (as regards the latter) with the time of the post-tertiary geological deposits.*"

We have seen what are didelphous and what are monadelphous mammals; what are the respective values of the terms "order," "family," and "genus," and also in what respect the kangaroo differs from the other families of the marsupial order. We have also become acquainted with the distribution of organic life now and with the inter-relations of different geological strata, as far as those phenomena of space and of time concern our immediate subject.

By becoming acquainted with these matters, and by no other way, is it possible to give an intelligent answer to the question, "*What is a kangaroo?*"—*Popular Science Review.*

## LIFE IN GREENLAND.

THE Danish settlements in Greenland date from the year 1721, when a colony was established at Godthaab, in latitude 64° north. The country had been visited and colonies settled there as early as the tenth century by Icelanders; but these Icelandic colonies were utterly destroyed, probably by the pestilence known as the "black-death" in the fourteenth century, or early in the fifteenth. The present Danish settlements are all situated on the west coast, and contain about 10,000 inhabitants, all Esquimaux with the exception of a few hundred, who are Danes. The region of Disco Bay may be regarded as the type of the entire western coast of Greenland. The aspects of Nature and the conditions of human life, as presented in this region, are graphically portrayed by Dr. Robert Brown, F. R. G. S., in the *Geographical Magazine*, and in the following pages we purpose to epitomize, for the benefit of our readers, the account given by this very competent observer. Dr. Brown, we would add, is probably the highest living authority on all scientific questions connected with Greenland; he has written a number of memoirs upon the geology, meteorology, etc., of the country, which are held in the very highest esteem by men of science.

Disco Bay is situated between the parallels of about 68° and 70° north latitude. On the west lies Disco Island, and on the east Greenland. Nowhere are the cliffs high, and the southern shore is in general flat and uninteresting. About Christianshaab (latitude 69°), and farther to the north, the shores are backed by bare rocky hills of about 1,000 or 1,200 feet—rounded knolls of gneiss, ice-shaven and worn. Between these higher grounds run birch and willow-covered mossy valleys, bright with running streams and waterfalls during the brief arctic summer. Everywhere are indubitable signs that the extensive *mer de glace*, which is believed to cover the whole interior of Greenland, once covered at least the greater part of what is now the uncovered or "fast-land" of the Danes. The ice is again beginning to encroach on the land, and everywhere in this vicinity there are proofs of a gradual subsidence of the ground.

From the fossil remains of numerous land-plants and a few insects found in the Miocene beds of Disco Island, it appears that in comparatively recent times a luxuriant vegetation, somewhat similar in character to that of California or the Southern United States, flourished in these arctic wastes. Luxuriant evergreen-oaks, magnolias, and sequoias, grew where now is found only the dwarf-willow, creeping along the ground with a stem not over half an inch in diameter. Among the fossil trees of Greenland, Prof. Heer has discovered three distinct species of sequoia, nine of oak, four of which were evergreen, like the Italian oak, two beeches, a chestnut, two planes, and a walnut. "Besides these," writes Prof. Heer, "American species, such as the magnolias, sassafrasses, and liquidambars, were represented there; and the characters of the ebony-tree are to be distinguished in two of the species. The hazel, the sumach, the buckthorn, and the holly, the guelder-rose, and the white, probably formed the thickets at the borders of the woods; while the vine, the ivy, and the sarsaparilla, climbed over the trees of the virgin forest, and adorned them with garlands. In the shadow of the wood grew a profusion of ferns, which covered the soil with their elegant fronds. The insects which gave animation to these solitudes are not all lost. The impressions of these which have reached us show that *Chrysomelas* and *Castilidæ* enjoyed themselves in the sun, and large *Trogsitæ* pierced the bark of the trees, while charming *Cicadellæ* leaped about among the herbage." In all, about 167 species of Miocene plants have been discovered in Greenland.

The coal found on Disco Island is, like all tertiary lignites, of poor quality, but yet, when mixed with English coal, it forms a good fuel for household and even for steaming purposes. It is mined to a small extent for the use of the settlements around the bay. Soapstone is found in some places in the primitive rocks, on the southern shores of Disco Bay; it was at one time extensively employed by the Esquimaux for making various domestic utensils, but is now much less used, owing to the introduction of vessels of iron, copper, and tin. There is no other economic mineral, cryolite being only found in one locality, Arsut Fiord, in South Greenland.

In the winter the cold is extreme in the region of Disco Bay, and the ground is generally thickly covered with snow from September till May or early June. During this period the whole sea is covered with ice, and the Danes and Esquimaux visit from settlement to settlement in sledges drawn by dogs. During the summer, under the four months of continual daylight, the snow soon melts over the lower lands, and the heat is often extreme. Mosquitoes are troublesome, and, there being no shelter from the rays of the sun reflected from the snow, ice, and bare rocks, traveling is frequently attended with great discomfort. The day may be bright and sunny in the morning, and in the evening snow, sleet, and all the concomitants of spring or winter. During the short summer season vegetation springs up apace and soon comes to maturity. In September the weather is uncertain and the nights are very dark and cold.

The trade of Danish Greenland is a strict crown monopoly, and is administered by government officials solely for the benefit of the natives. The principle adopted is to buy the natives' blubber, skins, ivory, etc., at a low price and to sell to them articles of European manufacture which are necessary to their comfort at an equally low figure; coffee and other luxuries are sold at a good profit. The surplus is credited to each district, and expended for the public good, by the little local parliaments (Partisoks) of the districts, the members of which (partisæts) are elected by universal suffrage. The settlements are known as colonies, and each is presided over by a "colonibestyrer" (*best man in the colony*). The other notables of the colony are the colonibestyrer's assistant, the cooper, the carpenter, and, if the settlement is large, the Lutheran parson, and the schoolmaster—the latter generally an educated native. The most exciting event in the settlements is the arrival of the annual ship from Copenhagen. Pianos are not unknown in the houses of the Danish officials, and the Tauchnitz edition of the best English authors is to be found in the "governor's" house.

The Danish Government treat the natives with the most paternal care. No spirits are allowed to be sold to them, schools are provided, and altogether the rule of the little northern kingdom is productive of very good results. Theft is practically unknown in Danish Greenland.

The vegetation around Disco Bay is, during the brief summer, rather luxuriant; the rocks are bright with mosses, and gayly-colored flowers peep out from the crannies. In the Upernivik district the birch is said to grow high enough in localities to cover the reindeer. Such giant shrubs are looked upon with pride by the natives. They take visitors to see them, and point to these extraordinary specimens of vegetation with an air as of "See this and die!"

Hunting and fishing form the sole occupation of those natives who are not in the government service. The white bear is almost extinct in this region; farther north they are more numerous. The arctic fox is common. The native dog is threatened with extermination by a peculiar disease which first appeared in Greenland a few years ago. The cat has become domesticated. The mouse and rat are regularly introduced every summer with the European ships, but rarely survive the winter. The arctic hare is common. The reindeer is now so rare in the vicinity of Disco Bay that few natives care to go hunting it. The seals are the main staple of the Esquimaux hunt. Large numbers are killed, both in summer and winter, but chiefly on the ice-fields during the latter season. The right-whale is now only a rare visitor. The white whale and the narwhal are often killed.

All the more common arctic birds visit Disco Bay in the summer, but, with the exception of the ptarmigan and some of the raptorial birds, they migrate during the winter. There are no reptiles in Greenland, but the salt-water fishes are numerous. Shark-fishing forms a considerable branch of industry. The kalleraglek, or small halibut, is caught in Disco Bay; among the Danes it forms a favorite dish, when sliced and dried. About six species of *Salmo* are found in Greenland. Both the trout and the salmon are excellent, though they have a thick layer of fat beneath the skin. The marine invertebrata are numerous. Insect-life is poor; a few butterflies are seen during the summer months; some *Coleoptera*, a few *Diptera*, *Hymenoptera*, etc., go to make up the limited insect fauna of the region of Disco Bay.

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# SCIENCE AND RELIGION.[1]

By Rev. CHARLES F. DEEMS, D. D.

THIS recent cry of the "Conflict of Religion and Science" is fallacious, and mischievous to the interests of both science and religion; and would be most mournful if we did not believe that, in the very nature of things, it must be ephemeral. Its genesis is to be traced to the weak foolishness of some professors of religion, and to the weak wickedness of some professors of science. No man of powerful and healthy mind, who is devout, ever has the slightest apprehension that any advancement of science can shake the foundations of that faith which is necessary to salvation. No man of powerful and healthy mind, engaged in observing, recording, and classifying facts, and in searching among them for those identities and differences which point to principles and indicate laws, ever feels that he suffers any embarrassment or limitations in his studies by the most reverent love he can have for God as his Father, or the most tender sympathy he can have for man as his brother, or that hatred for sin which produces penitence, or that constant leaning of his heart on God which

[1] Extract from the opening address at the inauguration of Vanderbilt University, by Charles F. Deems, D. D., pastor of the Church of the Strangers, New York, October 4, 1875.

produces spiritual-mindedness, or that hope of a state of immortal holiness which has been the ideal of humanity in all ages.

All this dust about "the conflict" has been flung up by men of insufficient faith, who doubted the basis of their faith; or by men of insufficient science, who have mistaken theology or the Church for religion; or by unreasonable and wicked men, who have sought to pervert the teachings of science so as to silence the voice of conscience in themselves, or put God out of their thoughts, so that a sense of his eternal recognition of the eternal difference between right and wrong might not overawe their spirits in the indulgence of the lust of the flesh, the lust of the eye, and the pride of life. It may be profitable to discriminate these; and, if badges and flags have become mixed in this fray, it may be well to readjust our ensigns, so that foes shall strike at only foes.

It is, first of all, necessary to settle distinctly what science is, as well as what it is not; and also, what religion is, as well as what it is not.

We can all afford to agree upon the definition rendered by the only man who has been found in twenty-two centuries to add anything important to the imperial science of logic. Sir William Hamilton defines science as "a complement of cognitions, having in point of form the character of logical perfection, and in point of matter the character of real truth." Under the focal heat of a definition like this, much that claims to be science will be consumed. It is the fashion to intimate, if not to assert, that it is much more easy to become scientific than to become religious; that in one case a man is dealing with the real, in the other with the ideal; in the one case with the comprehensible, in the other with the incomprehensible; in the one case with that which is certain and exact, and in the other case with that which at best is only probable and indefinite.

There can be no doubt, among thoughtful men, of the great value of both science and religion. A thinker who is worth listening to is always misunderstood if it be supposed that he means to disparage either. An attempt to determine the limits of religion is no disparagement thereof, because all the most religious men who are accustomed to think are engaged in striving to settle those limits, in order that they may have advantage of the whole territory of religion on the one hand, and on the other may not take that as belonging to religion which belongs to something else.

Now, if Sir William Hamilton's definition is to be taken, we shall perceive that he represents science in its quality, in its quantity, and in its form. Cognition of something is necessary for science. Then, (1) the knowledge of things known must be true; (2) that knowledge must be full, and (3) it must be accurate; it must be in such form as to be most readily and successfully used by the logical understanding for purposes of thought.

This sets aside very much that has been called science, and, as it seems, perhaps nearly all that which has been the material used by those who have raised the most smoke over this "conflict" question.

"Guesses at truth" are valuable only as the pecking at a plastered wall, to find where a wooden beam runs, is useful; but a guess is not knowledge. A working hypothesis were not to be despised, although the student of science might feel quite sure in advance that when he had learned the truth in this department he would throw the hypothesis away. A working hypothesis, like a scaffold, is useful; but a scaffold is not a wall. Art is not science. Art deals with the appearances, science with the realities, of things. Art deals with the external, science with the internal, of a thing; art with the phenomenon, science with the *noumenon*. It must be the "*real* truth" which we know, and know truly.

Weak men on both sides have done much harm—the weak religionists by assuming, and the weak scientists by claiming, for guesses and hypotheses, the high character and full value of real truth. The guesses of both have collided in the air, and a real battle seemed impending; but it was only "guesses" which exploded—bubbles, not bombs; and it is never to be forgotten that a professor of religion has just as much right to guess as a professor of science, and the latter no more right than the former, although he may have more skill.

No man can abandon a real truth without degradation to his intellectual and moral nature; but Galileo, Kepler, and Newton, in their studies from time to time, employed and discarded theory after theory, until they reached that which was capable of demonstration. It was only that which took its place as science. In the case of Kepler, it is known what great labor he spent in attempting to represent the orbit of Mars by combinations of uniform circular motion. His working hypothesis was the old doctrine of epicyclic curves. But his great labor was not fruitless, as has been carelessly asserted. The theory was false, and therefore not a part of real science; but, working on it, he discovered that the orbit of Mars is an ellipse, and this led him to the first of his three great laws of planetary motion, and enabled him almost immediately to discover the second. Here was a great intellect employing as a working hypothesis a theory which has always been false, and now is demonstrably false. It was not science.

Now if, while scientific men are employing working hypotheses merely as such, men representing religion fly at them as if they were holding those hypotheses as science, or if men representing science do set forth these hypotheses as if they were real knowledge of truth, and proceed to defend them as such, then much harm is done in all directions.

In the first instance, the religious man shows an impatience which is irreligious. "He that believeth doth not make haste." It is unfair to criticise any man while he is doing. Let him do what he will do; then criticise *the deed.* The artist has laid one pigment on his palette, and he is criticised before it is known what others he intends to mix with it, to procure what shade, to produce what effect. Wait until all the paint is on the canvas, and the artist has washed his brushes and drawn the curtain from his picture; then criticise *the picture.*

This impatient and weak criticism on the part of religious men is injurious to scientific progress, as well as to the progress of religion. For the latter, it makes the reputation of unfairness; for the former, it does one of two bad things: it obstructs free discussion among students of science, or pushes them into a foolish defiance of religion. Men must co-work with those of their own sphere of intellectual labors. They must publish guesses, conjectures, hypotheses, theories. Whatever comes into any mind must be examined by many minds. It may be true, it may be false; there must be no prejudgment. Now if, because our scientific men are discussing a new view, our religious men fly among them and disturb them by crying "Heresy!" "Infidelity!" "Atheism!" those students must take time to repel the charges, and thus their work be hurt. If let alone, they may soon abandon their false theory. Certainly, if a proposition in science be false, the students of science are the men likeliest to detect the falsehood, however unlikely they may be to discover the truth that is in religion. Nothing more quickly destroys an error than to attempt to establish it scientifically.

The premature cries of the religious against the scientific have also the effect of keeping a scientific error longer alive. Through sheer obstinacy the assailed will often hold a bad position, which, if not attacked, had been long ago abandoned. And we must have noticed that Nature seems quite as able to make scientific men obstinate as grace to do this same work for the saints.

No man should be charged with being an atheist who does not, in distinct terms, announce himself to be such; and in that case the world will believe him to be too pitiful a person to be worth assailing with hard words. But as you may drive a man away from you by representing him as your enemy, so a scientific man may be driven from the Christian faith, if convinced that the Christian faith stands in the way of free investigation and free discussion; or, he may hold on to the faith because he has brains enough to see that one may be most highly scientific and most humbly devout at the same time; but by persecution he may be compelled to withdraw from open communion with "those who profess and call themselves Christians." Then both parties lose—what neither can well afford to lose—the respect and help which each could give the other. When the son of a religious teacher turns to the works of a man whom he has heard that father denounce, and finds in any one page of those books more high religious thought than in a hundred of his father's commonplace discourses, a sad state of feeling is produced, and many mistakes are likely to follow.

Sir William Hamilton's definition of science has for *genus* "a complement of cognitions," and for *differentia* "logical perfection of form," and "real truth of matter." The definition is a demand for a certain fullness. We can only conjecture, in the case of any particular science, how much knowledge such a man as Sir William Hamilton would regard as a "complement." But students of science do well to remind themselves that it is impossible to exceed, and very difficult to succeed, and the easiest thing imaginable to fall short. In other words, we have never been able to collect more material of knowledge than the plan of any temple of science could *work in*, and really did not demand for the completion of the structure, and that very few temples of science have been finished, even in the outline, while all the plain of thought is covered by ruins of buildings begun by thinkers, but unfinished for want of more knowledge. Even where there has been gathered a sufficient amount of knowledge to be wrought by the logical understanding into the form of a science, so that such a mind as Hamilton's would admit it as a science—i. e., a sufficient complement of cognitions of truths put in logical form—another age of labor, in other departments, would so shrink this science that, in order to hold its rank, it would have to *work in* the matter of more knowledge, and, to preserve its symmetry, be compelled to readjust its architectural outlines. In other words, what is science to one age may not be science to its successor, because that successor may perceive that, although its matter had the character of real truth, and its form the character of logical perfection, *as far as it went*, nevertheless, there were not enough cognitions; not enough, just because in the later age it was possible to obtain additional cognitions, which could not have been obtained earlier.

And, in point of fact, has not this been the history of each of the acknowledged sciences? And can any significance be assigned to Sir William Hamilton's definition without taking the word "complement" to mean *all the cognitions possible at the time?* Now, unless at one time men have more cognitions of any subject than at another time, one of two things must be true: either (1) no new phenomena will appear in that department, or (2) no abler observer will arise. But the history of the human mind in the past renders both suppositions highly improbable. If no new phenomena appear, we shall have observers abler than have existed, because, although it were granted that no fresh accessions of intellectual power came to the race, each new generation of observers would have increased ability, because each would have the aid of the instruments and methods of all predecessors. When we go back to consider the immense labor performed by Kepler in his investigations which led to his brilliant discoveries, we feel that if his nerves had given way under his labors, and domestic troubles, and financial cares, or his industry had been just a little less tenacious, he would have failed in the prodigious calculations which led him to his brilliant discoveries, and gave science such a great propulsion. Just five years after the publication of Kepler's "New Astronomy" the Laird of Merchison published, in Scotland, his "*Mirifici Logarithmorum Canonis Descriptio.*" If Kepler had only had Napier's logarithms! But succeeding students have enjoyed this wonderful instrumental aid, and done great mental work with less draught on their vital energies.

The very facts, then, which make us proud of modern science should make scientific men very humble. It will be noticed that the most arrogant cultivators of science are those who are most ready to assail such religious men as are rigid, and hold that nothing can be added to or taken away from theology; and such scientific men make this assault on the assumption that physical sciences are fixed, certain, and exact. How ridiculous they make themselves, a review of the history of any science for the last fifty years would show. Is there any department of physical science in which a text-book used a quarter of a century ago would now be put into the hands of any student? The fact is that any man, who is careful of his reputation, has some trepidation in issuing a volume on science, lest the day his publishers announce his book the morning papers announce, also, a discovery which knocks the bottom out of all his arguments. This shows the great intellectual activity of the age—a matter to rejoice in, but it should also promote humility, and repress egotism in all well-ordered minds. There is, probably, no one thing known in its properties and accidents, in its relations to all abstract truths and concrete existence. No one thing is exactly and thoroughly known by any man, or by all men. Mr. Herbert Spencer well says: "Much of what we call science is not exact, and some of it, as physiology, can never become exact" ("Recent Discussions," p. 158). He might have made the remark with greater width, and no less truth, since every day accumulates proof that that department of our knowledge which we call the exact sciences holds an increasingly small proportion to the whole domain of science.

There is one important truth which seems often ignored, and which should frequently be brought to our attention, viz., that the propositions which embody our science are statements not of absolute truths, but of probabilities. Probabilities differ. There is that which is merely probable, and that which is more probable, and that which is still much more probable, and that which is so probable that our faculties cannot distinguish between this probability and absolute certainty; and so we act on it as if it were certain. But it is still only a "probability," and not a "certainty." It seems as though it would forever be impossible for us to determine how near a probability can approach a certainty without becoming identical with that certainty.

Is not all life a discipline of determining probabilities? It would seem that God intends that generally the certainties shall be known only to himself. He has probably shown us a very few certainties, more for the purpose of furnishing the idea than for any practical purpose, as absolute certainty is necessary for him, while probabilities are sufficient for us. All science is purely a classification of probabilities.

We do not *know* that the same result will follow the same act in its several repetitions, but *believe* that it will; and we believe it so firmly that if a professor had performed a successful experiment before a class in chemistry, he would not hesitate to repeat the experiment after a lapse of a quarter of a century. Scientific men are not infidels. Of no men may it be more truly said that they "walk by faith." They do not creep, they march. Their tread is on made ground, on probabilities; but they believe they shall be supported, and according to their faith so is it done unto them.

And no men better know than truly scientific men that this probability can never become certainty. In the wildest dreams of fanaticism—and there are fanatics in the laboratory, as there are in the sanctuary of God and in the temple of Mammon—it has never been believed that there shall come a man who shall know all things that are, all things that have been, all things that shall be, and all things that can be, in their properties, their attributes, and their relations. Until such a man shall arise, science must always be concerned with the cognition of that which is the real truth as to probabilities, or with probable cognitions of that which is not only real truth, but absolute truth. A scientific writer, then, when he states that any proposition has been "proved," or anything "shown," means that it has been proved probable to some minds, or shown to some—perhaps to all—intelligent persons as probable. If he have sense and modesty, he can mean no more, although he does not cumber his pages or his speech with the constant repetition of that which is to be presumed, even as a Christian in making his appointments does not always say *Deo volente*, because it is understood that a Christian is a man always seeking to do what he thinks to be the will of God, in submission to the providence of God.

A scientific man ridicules the idea of any religious man claiming to be "orthodox." It must be admitted to be ridiculous, just as ridiculous as would be the claim of a scientific man to absolute certainty and unchangeableness for science. The more truly religious a man is, the more humble he is; the more he sees the deep things of God, the more he sees the shallow things of himself. He claims nothing positively. He certainly does not make that most arrogant of all claims, the claim to the prerogative of infinite intelligence. There can exist only one Being in the universe who is positively and absolutely orthodox, and that is God. In religion, as in science, we walk by faith; that is, we believe in the probabilities sufficiently to act upon them.

So far from any conflict being between science and religion, their bases are the same, their modes are similar, and their ends are identical, viz., what all life seems to be, that is, a discipline of faith.

It is not proper to despise knowledge, however gained: whether from the exercise of the logical understanding, or from consciousness, or from faith; and these are the three sources of knowledge. That which has been most undervalued is the chief of the three; that is, faith.

We *believe* before we acquire the habit of studying and analyzing our consciousness. We *believe* before we learn how to conduct the processes of our logical understanding.

We can have much knowledge by our faith without notice of our consciousness, and without exertion of our reasoning faculties; but we can have no knowledge without faith. We can learn nothing from our examination of any consciousness without faith in some principle of observation, comparison, and memory. We can acquire no knowledge by our logical understanding without faith in the laws of mental operations.

This last statement, if true, places all science on the same basis with religion. Although so familiar to many minds, we may take time to show that it is true.

For proof let us go to a science which is supposed to demonstrate all its propositions, and examine a student in geometry. We will not call him out on the immortal 47 : I of Euclid. We can learn all we need from a bright boy who has been studying Euclid a week. The following may represent our colloquy:

*Q.* Do you know how many right angles may be made by one straight line upon one side of another straight line?

*A.* Yes; two, and only two. Innumerable angles may be made by two straight lines so meeting, but the sum of all the possible angles will be two right angles.

*Q.* You say you know that. How do you know that you know it?

*A.* Because I can prove it. A man knows every proposition which he can demonstrate.

*Q.* Please prove it to me.

The student draws the well-known diagrams. If he follows Euclid, he begins with an argument like this:

*A.* There are obviously two angles made when a straight line stands on another straight line.

*Q.* My eyes show me that.

In answer he gives us the well-known demonstration of Euclid, to show that the sum of the two angles is equal to two right angles; and, when he has finished and reached the Q. E. D., he and his examiners *know* that this proposition is true, because he has proved it.

But when we examine his argument we find that he has made three unproved assumptions—namely: 1. That a thing cannot at the same time *be* and *not be;* 2. That if equals be added to equals, the wholes are equal; 3. That things which are equal to the same are equal to one another. It so happens that each of these propositions which he has assumed to be true is, if true, much more important than the proposition which he has proved. Let us point out these three assumptions to our bright student, and then resume our catechism.

*Q.* Could you possibly prove this proposition in geometry if any one of those three assumed propositions were not granted?

*A.* No.

*Q.* Then, if we deny these assumptions, can you prove them?

*A.* No; but can you deny them?

No, we cannot deny them, and cannot prove them; but we believe them, and therefore have granted them to you for argument, and know your proposition of the two right angles to be true, because you have proved it.

Now, here is the proposition which Euclid selected as the simplest of all demonstrable theorems of geometry, in the demonstration of which the logical understanding of a student cannot take the first step without the aid of faith.

From the student let us go to the master. We go to such a teacher as Euclid, and in the beginning he requires us to believe three propositions, without which there can be no geometry, but which have never been proved, and, in the nature of things, it would seem never could be proved—namely, that space is infinite in extent, that space is infinitely divisible, and that space is infinitely continuous. And we believe them, and use that faith as knowledge, and no more distrust it than we do the results of our logical understandings, and are obliged to admit that geometry lays its broad foundations on our faith.

Now, geometry is the science which treats of forms in their relations in space. The value of such a science for intellectual culture and practical life must be indescribably important, as might be shown in a million of instances. No form can exist without boundaries, no boundaries without lines, no line without points. The beginning of geometric knowledge, then, lies in knowing what a "point" is, the existence of forms depending, it is said, upon the motion of points. The first utterance of geometry, therefore, must be a definition of a point. And here it is: "A point is that which has no parts, or which has no magnitude." At the threshold of this science we meet with a mystery. "A point is"—then, it has existence—"is" what? In fact, in form, in substance, it is nothing. A logical definition requires that the *genus* and *differentia* shall be given. What is the *genus* of a "point?" Position, of course. Its *differentia* is plainly seen. It is distinguished from every thing else in this, that every thing else is *something somewhere*, and a point is *nothing somewhere ;* every thing HAS *some* characteristic, a point has *none*. A point is visible or invisible. Is it visible ? Then we can see that which is without parts or magnitude. What is it we see when we do not see any part, do not see any magnitude? Is it substantial or ideal? If substantial, how do we detect its substantial existence ? If ideal, how can an idea have motion, and by simple motion become a substantial existence? Are we not reduced to this ? Ideals produce substantials, or invisible substantials, upon motion, produce visible substantials ; or that which is necessary to matter—namely, form—owes its existence to that which is neither substantial nor ideal—to nothing, in fact. The entire and sublime science of geometry, at one time the only instrument of culture among the Greeks, and so esteemed by Plato that he is said to have written over his door, " Let no one enter here who does not know geometry," in all its conceptions, propositions, and demonstrations, rests upon the conception of that which has no parts, no magnitude. The old saw of the school-men was, "*Ex nihilo nihil fit.*" If each visible solid owes its form to superficies, and each superficies its form to lines, and each line its form to a point—and a point has no form, because it has no parts—then, who shall stone the man that cries out, "*Ex nihilo geometria fit?*"

But lay the first three definitions of geometry side by side: 1. "A point is that which has no parts, or which has no magnitude." 2. "A line is length without breadth." 3. "The extremities of a line are points." Study these, and you will probably get the following results: That which has no parts produces all the parts of that which occupies space without occupying space, and which, although it occupies no space, has extremities, to the existence of which it owes its own existence; and those extremities determine the existence of that which has parts made up of multiplications of its extremities which have no parts. Now, you must know at least that much, or else stay out of Plato's house.

This useful science, without which men could not measure their little plantations, or construct their little roads on earth, much less traverse and triangulate the ample fields of the skies, lays for its necessary foundation thirty-five definitions, three postulates, and twelve axioms, the last being propositions which no man has ever proved; and these fifty sentences contain as much that is incomprehensible, as much that must be granted without being proved, as much that must be believed, although it cannot be proved, as can be found in all the theological and religious writings from those of John Scotus Erigina down to those of Richard Watson, of England, or Charles Hodge, of Princeton.

Does any man charge that this is a mere logical juggle? Then he shall be called upon to point out wherein it differs from the methods of those who strive to show that there is a real conflict between real science and real religion. If any man shall charge me with being an infidel as touching geometry, and try to turn me out of the church of science, I shall become hotly indignant, because I know that Euclid did not believe more in geometry than I do, and I believe as much in the teachings of geometry as I do in the teachings of theology, regarding them both, as Aristotle did, as mere human sciences, ranking theology with psychology, geology, and botany. And, being by profession a theologian, I certainly believe in theology.

And this brings us back to what was stated in the beginning, as one of the causes of this cry of "conflict." It is the confounding of theology with religion. Theology is not religion any more than psychology is human life, or zoölogy is animal life, or botany is vegetable life. Theology is objective; religion is subjective. Theology is the scientific classification of what is known of God; religion is a loving obedience to God's commandments. Every religious man must have some theology, but it does not follow that every theologian must have some religion. We never knew a religious man without some kind of a theology, nor can we conceive such a case. But we do know some theologians who have little religion, and some that seem to have none. There may be a conflict between theology and some other sciences, and religious men may deplore *that* conflict, or may not, according to their measure of faith. There are those whose faith is so large and strong that they do not deplore such a conflict, because they know that if, for instance, a conflict should come between geology and theology, and geology should be beaten, it will be so much the better for religion; and if geology should beat theology, still so much the better for religion: according to the spirit of the old Arabic adage, *If the pitcher fall on the stone, so much the worse for the pitcher; and if the stone fall on the pitcher so much the worse for the pitcher.* Geologists, psychologists, and theologists, must all ultimately promote the cause of religion, because they must confirm one another's truths, and explode one another's errors; and a religious man is a man whose soul longs for the truth, who loves truth because he loves God, who knows if the soul be sanctified it must be sanctified by the truth, even as the mind must be enlarged and strengthened by the truth. He knows and feels that it would be as irreligious in him to reject any truth found in Nature, as it would be for another to reject any truth found in the Bible.

But there is no necessary conflict between even theology and any other science. Theology has to deal with problems into which the element of the infinite enters. It will therefore have concepts some two of which will be irreconcilable, but not therefore contradictory. For instance, to say that God is "an infinite person" is to state the agreement of two concepts which the human mind is supposed never to have reconciled, and never to be able to reconcile. But they are not contradictory. If one should say that there is in the universe a circular triangle, we should deny it, not because the concept of a triangle is *irreconcilable* with the concept of a circle, as consistent in the same figure, which is quite true, but because they are *contradictory.* What is irreconcilable to you may be reconcilable to another mind, because "irreconcilable" indicates the relation of the concept to the individual intellect; but what is contradictory to the feeblest is contradictory to the mightiest mind, because "contradictory" represents the relation of the concepts to one another.

In the definition of a *person* there is nothing to exclude infinity, and in the definition of *infinite* there is nothing to exclude personality. There is no more exclusion between "person" and "infinite" than between "line" and "infinite;" and yet we talk of infinite lines, knowing the irreconcilability of the ideas, but never regarding them as contradictory.

Writers of great ability sometimes fall into this indiscrimination. For instance, a writer whom I greatly admire, Dr. Hill, former President of Harvard College, in one paragraph (on "The Uses of Mathesis," in *Bibliotheca Sacra*), seems twice to employ "contradictory" in an illogical sense, even when he is presenting an illustration which goes to show most clearly that in other sciences, as well as in theology, there are propositions which we cannot refuse to accept, because they are not contradictory, although they are irreconcilable; in other words, that there are irreconcilable concepts which are not contradictory, for we always reject one or the other of two contradictory concepts or propositions.

That is so striking an illustration of the mystery of the infinite that I will reproduce it. On a plane imagine a fixed line, pointing north and south. Intersect this at an angle of ninety degrees by another line, pointing east and west. Let this latter rotate at the point of intersection, and at the beginning be a foot long. At each approach of the rotating line toward the stationary line let the former double its length. Let each approach be made by bisecting the angle. At the first movement the angle would be forty-five degrees, and the line two feet in length; at the second, the angle twenty-two and one-half degrees, and the line four feet; at the third, the angle eleven and one-fourth degrees, and the line eight feet; at the fourth, the angle five and five-eighths degrees, and the line sixteen feet; at the fifth, the angle two and thirteen-sixteenths degrees, and the line thirty-two feet, and so on. Now, as this bisecting of the angle can go on indefinitely before the rotating line can touch the stationary line at all its points, it follows that before such contact the rotating line will have a length which cannot be stated in figures, and which defies all human computation. It can be mathematically demonstrated that a line so rotating, and increasing its length in the inverse ratio of its angle with the meridian, will have its end always receding from the meridian and approaching a line parallel to the meridian at a distance of 1.5708. We can show that the rotating line can cross the stationary line by making it do so as on a watch-dial, and yet we can demonstrate that if it be extended indefinitely it can never touch the stationary line, nor come at the end even as near as eighteen inches to it.

Here are two of the simplest human conceptions, between which we know that there is no contradiction, rendered absolutely irreconcilable to the human intellect by the introduction of the infinite. There is no religion here. And yet there is no mystery in either theology or religion more mysterious than the mystery of the infinite, which we may encounter whenever we attempt to set our watches to the right time if they have run more than an hour wrong.

Another error has been the occasion of this cry of "conflict." It is the confounding of "the Church" with "religion." This confusion has led many an honest soul astray, and is the fallacy wherewith shrewd sophists have been able to overthrow the faith of the ignorant. If the Church—and, in all my treatment of this topic, I must be understood as using "the Church," not as signifying "the holy Church universal," but simply in the sense in which antagonistic scientists employ it—if *the Church* and *religion* be the same, the whole argument must be given up, and it must be admitted that there is a conflict between religion and science, and that religion is in the wrong. Churchmen are guilty of helping to strengthen, if indeed they are not responsible for creating, this error. It has at length been presented plumply to the world in the book of Prof. J. W. Draper, entitled a "History of the Conflict between Religion and Science." The title assumes that there is such a conflict. See how it will read with synonyms substituted: "History of the Conflict between *Loving Obedience to God's Word* and *Intelligent Study of God's Works*." Does Dr. Draper believe there is such a conflict? It is not to be supposed that he does. How, then, did he come to give his book such a title? From a confusion of terms, as will be observed by the perusal of three successive sentences in his preface: "The *papacy* represents the ideas and aspirations of two-thirds of the population of Europe. It insists on a political supremacy, . . . . loudly declaring that it will accept no reconciliation with modern civilization. The antagonism we *thus* witness between *religion* and science," etc. Now, if "the papacy" and "religion" be synonymous terms, representing equivalent ideas, Dr. Draper's book shows that all good men should do what they can to extirpate religion from the world; but if they are not—and they are not—then the book is founded on a most hurtful fallacy, and must be widely mischievous. Their share of the responsibility for the harm done must fall to churchmen.

No, these are not synonymous terms. "The Church" is *not* religion, and religion is *not* "the Church." There may be a church and no religion; there may be religion and no church, as there may be an aqueduct without water, and there be water without an aqueduct. God makes water, and men make aqueducts. Water was before aqueducts, and religion before churches. God makes religion, and men make churches. There are irreligious men in every church, and there are very religious men in no church. Any visible, organized church is a mere human institution. It is useful for the purpose of propagating religion so long as it confines itself to that function and abstains from all other things. The moment it transcends that limit, it is an injurious institution. In either case it is merely human, and we wrong both religion and the Church when we claim for the latter that it is not a human institution. The Church of England is as much a human institution as the Royal Society; and the same may be said of the Church of Rome and the Royal Florentine Academy. A church is as much an authority in matters of religion as a society is in matters of science, and no more. "The Church" has often been opposed to science, and so it has to religion; but "the society" has often been opposed to religion, and so it has to science. "The Church," both before and since the days of Christ, has stood in opposition to the Bible, the text-book of Jewish and Christian religionists, quite as often as it has to science. But "the society," or "the academy," has stood in opposition to science quite as often as it has to religion. Sometimes the sin of one has been laid upon the other, and sometimes the property of one has been scheduled as the assets of the other. It is time to protest, in the interests of the truth of God, and in the name of the God of truth, that religion no longer be saddled with all the faults of the churchmen, all the follies of the scientists, and all the crimes of the politicians. It was not religion which brought Galileo to his humiliating retraction, about which we hear so much declamation; it was "the Church."

But why should writers of the history of science so frequently conceal the fact that "the Church" was instigated thereunto not by religious people, but scientific men—by Galileo's *collaborateurs?* It was the jealousy of the scientists which made use of the bigotry of the churchmen to degrade a rival in science. They began their attacks not on the ground that religion was in danger, but on such scientific grounds as these, stated by a professor in the University of Padua—namely, that as there were only seven metals, and seven days in the week, and seven apertures in man's head, there could be only seven planets! And that was some time before these gentlemen of science had instigated the sarcastic Dominican monk to attempt to preach Galileo down under the text, *Viri Galilæi, quid statis adspicientes in cœlum?*

In like manner, politicians have used "the Church" to overthrow their rivals. "The Church" is the engine which has been turned against freedom, against science, against religion. It would be as logical and as fair to lay all "the Church's" outrages against human rights and intellectual advancement at the door of religion as it would be to lay all its outrages against religion at the door of science and government, because "the Church" has seldom slaughtered a holy martyr to the truth without employing some forms of both law and logic.

Science exists for the sake of religion, and because of religion. If there had been no love for God in the human race, there had been no study of the physical universe. The visible cosmos is God's love-letter to man, and religion seems to probe every corner of the sheet on which such love is written, to examine every phrase, and study every connection. A few upstarts of the present day, not the real men and masters of science, ignore the fact that almost every man who has made any great original contribution to science, since the revival of letters, was a very religious man; but their weak wickedness must not be charged to science any more than the wicked weakness of ecclesiastics to religion.

Copernicus, who revolutionized astronomy, was one of the purest Christians who ever lived—a simple, laborious minister of religion, walking beneficently among the poor by day, and living among the stars by night; and yet one writer of our day has dared to say, in what he takes to be the interest of science, that Copernicus was "aware that his doctrines were totally opposed to revealed truth." Was anything worse ever perpetrated by theologian, or even ecclesiastic? Could *any* man believe in any doctrine which he *knew* was opposed to any truth, especially if he believed that God had revealed that truth? It were impossible, especially with a man having the splendid intellect and the pure heart of Copernicus, who died believing in his "*De Orbium Cœlestium Revolutionibus*," and also in the Bible. And this is the inscription which that humble Christian ordered for his tomb: "*Non parem Paulo veniam requiro, gratiam Petri neque posco; sed quam in crucis ligno dederis latroni, sedulus oro.*"

Tycho Brahe, who, although he did not produce a system which won acceptance, did, nevertheless, lay the foundation for practical astronomy, and build the stairs on which Kepler mounted to his grand discoveries, was a most religious man. He introduces into one of his scientific works ("*Astronomiæ Instauratio Mechanica*," p. A) this sentence: "No man can be made happy, and enjoy immortal life, but through the merits of Christ, the Redeemer, the Son of God, and by the study of his doctrines, and imitation of his example."

John Kepler was a man in whose life the only conflict between science and religion seemed to be as to which should yield the most assistance to the other. He wrought as under Luther's motto, "*Orasse est studisse.*" He prayed before he worked, and shouted afterward. The more he bowed his soul in prayer, the higher his intellect rose in its discoveries; and, as those discoveries thickened on his head, it bowed in humbler adoration. And so that single man was able to do more for science than all the irreligious scientists of the last three centuries have accomplished, while he bore an appalling load of suffering with a patience that was sublime, and, dying, left this epitaph for his tombstone: "*In Christo pie obiit.*"

Of Sir Isaac Newton's, and Michael Faraday's, and Sir William Hamilton's, and Sir James Y. Simpson's religious life, not to mention the whole cloud of witnesses, we need not tell what is known to all men. But the history of science shows that not the most gifted, not the most learned, not the most industrious, gain the loftiest vision, but that only the pure in heart see God. And all true science is a new sight of God.

Herbert Spencer says: "Science may be called an extension of the perceptions by means of reasoning" ("Recent Discussions," p. 60). And we may add, religion may be called an extension of the perceptions by means of faith. And having so said, have we not paraphrased Paul? "Faith is confidence in things hoped for, conviction of things not seen" (Heb. xi. 1). Science has the finite for its domain, religion the infinite; science deals with the things seen, and religion with the things not seen. When Dr. Hutton, of Edinburgh, announced, in the last century, "In the economy of the world I can find no traces of a beginning, no prospect of an end," it is said that scientific men were startled and religious men were shocked. Why should they be? The creation of the universe and its end are not questions of science, and can be known only as revealed to faith. And so Paul says: "Through faith we apprehend intellectually that the worlds have been framed by the word of God, so that that which is seen may have sprung from that which is not seen" (Heb. xi. 3).

# PLASTICITY OF INSTINCT.

By GEORGE J. ROMANES.

NOW that the doctrine which is maintained by Mr. Douglass A. Spalding on this subject has proved itself so completely victorious in overcoming the counter-doctrine of "the individual-experience psychology"—and this along the whole line both of fact and theory—it seems unnecessary for any one to adduce additional facts in confirmation of the views which Mr. Spalding advocates.[1] I shall therefore confine myself to detailing a few results yielded by experiments which were designed to illustrate the subordinate doctrine thus alluded to in Mr. Spalding's article:

[1] *See* Popular Science Monthly for January, 1876.

"Though the instincts of animals appear and disappear in such seasonable correspondence with their own wants and the wants of their offspring as to be a standing subject of wonder, they have by no means the fixed and unalterable character by which some would distinguish them from the higher faculties of the human race. They vary in the individuals as does their physical structure. Animals can learn what they did not know by instinct, and forget the instinctive knowledge which they never learned, while their instincts will often accommodate themselves to considerable changes in the order of external events. Everybody knows it to be a common practice to hatch duck's-eggs under a common hen, though in such cases the hen has to sit a week longer than on her own eggs. I tried an experiment to ascertain how far the time of sitting could be interfered with in the opposite direction. Two hens became broody on the same day, and I set them on dummies. On the third day I put two chicks a day old to one of the hens. She pecked at them once or twice, seemed rather fidgety, then took to them, called them to her, and entered on all the cares of a mother. The other hen was similarly tried, but with a very different result. She pecked at the chickens viciously, and both that day and the next stubbornly refused to have anything to do with them," etc.

It would have been well if Mr. Spalding had stated whether these two hens belonged to the same breed; for, as is of course well known, different breeds exhibit great variations in the character of the incubatory instinct. Here, for instance, is a curious case: Spanish hens, as is notorious, scarcely ever sit at all; but I have one purely-bred one, just now, that sat on dummies for three days, after which time her patience became exhausted. However, she seemed to think that the self-sacrifice she had undergone during these three days merited some reward, for, on leaving the nest, she turned foster-mother to all the Spanish chickens in the yard. These were sixteen in number, and of all ages, from that at which their own mothers had just left them up to full-grown chickens. It is remarkable, too, that although there were Brahma and Hamburg chickens in the same yard, the Spanish hen only adopted those that were of her own breed. It is now four weeks since this adoption took place, but the mother as yet shows no signs of wishing to cast of her heterogeneous brood, notwithstanding some of her adopted chickens have grown nearly as large as herself.

The following, however, is a better example of what may be called plasticity of instinct: Three years ago I gave a pea-fowl's egg to a Brahma hen to hatch. The hen was an old one, and had previously reared many broods of ordinary chickens with unusual success even for one of her breed. In order to hatch the pea-chick she had to sit one week longer than is requisite to hatch an ordinary chick, but in this there is nothing very unusual, for, as Mr. Spalding observes, the same thing happens with every hen that hatches out a brood of ducklings.[1] The object with which I made this experiment, however, was that of ascertaining whether the period of maternal care subsequent to incubation admits, under peculiar conditions, of being prolonged; for a pea-chick requires such care for a very much longer time than does an ordinary chick. As the separation between a hen and her chickens always appears to be due to the former driving away the latter when they are old enough to shift for themselves, I scarcely expected the hen in this case to prolong her period of maternal care, and indeed only tried the experiment because I thought that if she did so the fact would be the best one imaginable to show in what a high degree hereditary instinct may be modified by peculiar individual experiences. The result was very surprising. For the enormous period of eighteen months this old Brahma hen remained with her ever-growing chicken, and throughout the whole of that time she continued to pay it unremitting attention. She never laid any eggs during this lengthened period of maternal supervision, and, if at any time she became accidentally separated from her charge, the distress of both mother and chicken was very great. Eventually the separation seemed to take place on the side of the peacock; but it is remarkable that, although the mother and chicken eventually separated, they never afterward forgot each other, as usually appears to be the case with hens and their chickens. So long as they remained together the abnormal degree of pride which the mother showed in her wonderful chicken was most ludicrous; but I have no space to enter into details. It may be stated, however, that both before and after the separation the mother was in the habit of frequently combing out the top-knot of her son—she standing on a seat, or other eminence of suitable height, and he bending his head forward with evident satisfaction. This fact is particularly noteworthy, because the practice of combing out the top-knot of their chickens is customary among pea-hens. In conclusion, I may observe, that the peacock reared by this Brahma hen turned out a finer bird in every way than did any of his brothers of the same brood which were reared by their own mother, but that, on repeating the experiment next year with another Brahma hen and several pea-chickens, the result was different, for the hen deserted her family at the time when it is natural for ordinary hens to do so, and in consequence all the pea-chickens miserably perished.

I have just concluded another experiment which is well worth recording: A bitch ferret strangled herself by trying to squeeze through too narrow an opening. She left a very young family of three orphans. These I gave, in the middle of the day, to a Brahma hen which had been sitting on dummies for about a month. She took to them almost immediately, and remained with them for rather more

[1] The greatest prolongation of the incubatory period I have ever known to occur was in the case of a pea-hen which sat very steadily on addled eggs for a period of four months, and had then to be forced off in order to save her life.

than a fortnight, at the end of which time I had to cause a separation, in consequence of the hen having suffocated one of the ferrets by standing on its neck. *During the whole of the time that the ferrets were left with the hen the latter had to sit upon the nest*; for the young ferrets, of course, were not able to follow the hen about as chickens would have done. The hen, as might be expected, was very much puzzled at the lethargy of her offspring. Two or three times a day she used to fly off the nest, calling upon her brood to follow; but, upon hearing their cries of distress from cold, she always returned immediately and sat with patience for six or seven hours more. I should have said that it only took the hen one day to learn the meaning of these cries of distress; for after the first day she would always run in an agitated manner to any place where I concealed the ferrets, provided that this place was not too far away from the nest to prevent her from hearing the cries of distress. Yet I do not think it would be possible to conceive of a greater contrast than that between the shrill peeping note of a young chicken and the hoarse growling noise of a young ferret. On the other hand, I cannot say that the young ferrets ever seemed to learn the meanings of the hen's clucking. During the whole of the time that the hen was allowed to sit upon the ferrets she used to comb out their hair with her bill, in the same way as hens in general comb out the feathers of their chickens. While engaged in this process, however, she used frequently to stop and look with one eye at the wriggling nest-full with an inquiring gaze expressive of astonishment. At other times, also, her family gave her good reason to be surprised; for she used often to fly off the nest suddenly with a loud scream—an action which was doubtless due to the unaccustomed sensation of being nipped by the young ferrets in their search for the teats. It is further worth while to remark that the hen showed so much uneasiness of mind when the ferrets were taken from her to be fed, that at one time I thought she was going to desert them altogether. After this, therefore, the ferrets were always fed in the nest, and with this arrangement the hen was perfectly satisfied—apparently because she thought that she then had some share in the feeding process. At any rate she used to cluck when she saw the milk coming, and surveyed the feeding with evident satisfaction.

Altogether I consider this a very remarkable instance of the plasticity of instinct. The hen, it should be said, was a young one, and had never reared a brood of chickens. A few months before she reared the young ferrets she had been attacked and nearly killed by an old ferret which had escaped from his hutch. The young ferrets were taken from her several days before their eyes were open.

In conclusion I may add that, a few weeks before trying this experiment with the hen, I tried a similar one with a rabbit. In this case the ferret was newly born, and I gave it to a white doe-rabbit which had littered six days before. Unlike the hen, however, she perceived the imposture at once, and attacked the young ferret so savagely that she broke two of its legs before I could remove it. To have made this experiment parallel with the other, however, the two mothers ought to have littered on the same day. In this case the result would probably have been different; for I have heard that under such circumstances even such an intelligent animal as a bitch may be deceived into rearing a cat, and *vice versa.*—*Nature.*

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# FLYING-MACHINES AND PÉNAUD'S ARTIFICIAL BIRD.[1]

TRANSLATED FROM THE JOURNAL DE PHYSIQUE,

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NUMEROUS attempts have been made at different times to construct a machine capable of propelling itself through the air. All kinds of aërial propellers have in turn been tried; such as screws, beating wings, umbrellas which open and shut during their reciprocating motion, inclined planes, aërial wheels. But though many of these projects called forth considerable inventive ability, yet, until quite recently, the *helicopteron* (from ἑλικός, any thing spiral or twisted, and πτερόν, a wing—that is, a machine furnished with an aërial screw-propeller) was the only type of machine which had succeeded in raising itself in flight. Several of these helicopterons have been constructed since 1784, at which date Bienvenu made the first that flew. The best known and the most perfect was that which Ponton d'Amécourt constructed in 1864, and which raised itself for a moment by a sudden motion to a height of two and a half metres. It was formed of two superposed right and left handed screws, put in motion by a watch-spring. All other methods of artificial flight, including those of propellers with wings beating the air like those of a bird, remained ineffective, and were the subjects of conflicting hypotheses as to the nature of flight.

In beginning our studies, we have thought that the best means of getting rid of the multiplicity of hypotheses and of conflicting opinions would be to divide the flying-machines that have been invented into a small number of general types; then to reduce each of these types to its essential elements, and finally to design a flying-machine of each of these simplified types possessing all the really essential parts, and easy to construct.

Leaving out of consideration the inventions which are evidently defective, we have thought it possible to divide the majority

[1] The Academy of Sciences of Paris, at its meeting in June, 1875, awarded to M. Pénaud a prize for the discoveries and inventions described in this article.

of the systems of artificial flight into *helicopterons*, *areoplanes*, and *orthopterons* (from ὀρθός, straight, and πτερόν, a wing). The helicopterons sustain themselves by the aid of screws whose axes of rotation are nearly vertical. They may be made to progress either by these vertical screws or by special screw-propellers. The areoplanes have propelling surfaces which are nearly plane and slightly inclined to the horizon. A horizontal motion is given to these surfaces generally by means of screws. Finally, in the orthopterons, the propelling organs are surfaces moving in vertical directions, and generally having reciprocating motions. In this system are embraced the wings of birds and the moving surfaces of the tails of fishes.

The knowledge of the resistance of the air appeared to us the only guide by which we could arrive at a thorough understanding of the manner in which a machine could sustain itself by the actions of its propelling surfaces on this fluid. We entered upon an attentive study of several imperfectly-understood points appearing to us of capital importance; such as the sustaining screw, the aërial inclined plane, and the theory of the equilibrium of flying-machines. The screw-propeller was well understood from its effects in propelling vessels. These researches, which led us to a small number of very simple general laws, permitted us to determine the manner of action and the proportions of the machines which we desired to construct.

It remained to find a motor the easiest of application. Wood, whalebone, and steel, give forces which are at a minimum when referred to their weight; caoutchouc is much more powerful, but the framework necessary to resist its violent tension is necessarily quite heavy. We then conceived the idea of using the elasticity of the torsion of caoutchouc, which finally led to an easy, simple, and effective method of constructing the models of flying-machines.

We applied the new motor first to the helicopteron, after having previously investigated the curious and valuable actions of caoutchouc when subjected to various successive torsions. In April, 1870, we presented models to M. de la Landelle which rose in flight to more than fifteen metres, hovering and fluttering through large inclined circles, and sustaining themselves during more than twenty seconds.

The great superiority of these results over those obtained with preceding helicopterons encouraged us to apply our motor to other systems of artificial flight. On the 18th of August, 1871, in the presence of the Society of Aërial Navigation, we succeeded in making an areoplane fly with various velocities and in different directions, around one of the circles of the garden of the Tuileries. The success of this machine in its ascending motions and in its perfect equilibrium gave the first successful exhibition of a machine on the areoplane type.

Measured directly, and irrespective of any hypothesis, the force required to sustain and propel the areoplane and the helicopteron proved to be relatively moderate, and did not approach the fabulous estimations previously given by Navier. This experiment demonstrated that the muscular strength of birds, although notably greater, for equal weights, than that of mammals, did not exceed a reasonable estimation.

Our helicopterons and areoplanes which performed with success on the 2d of July, 1875, before the Physical Society, have a numerous offspring. They have been imitated with various success by Crocé-Spinelli and MM. Montfallet, Pétard, and Tantin.

The action of these machines, in fully confirming our ideas and calculations on the resistance of the atmosphere, encouraged us to attempt the construction of a mechanical bird with flapping wings. The diversity of the hypotheses as to the nature of flight, proposed in France and in England, though bearing witness to the difficulties to be met with in the construction of this mechanism, yet rendered the problem peculiarly interesting.

The experiments heretofore made with mechanical birds had been very discouraging. M. Artingstall and M. Marcy had alone obtained effective results. M. Artingstall states that, some thirty years since, he had an artificial bird which flew at the end of a tube jointed on to a steam-boiler. M. Marey, whose beautiful physiological experiments are so well known, constructed, in 1870, artificial insects which, attached to a radial tube carrying a counterpoise equal to two-thirds of their weight, rose and flew in a circle by the aid of their wings. The compressed air which set the wings in motion was conveyed to them through the radial tube from a compression-pump worked by hand.[1] It remained to gain the two-thirds of the weight of the insect and to cause the latter to carry with it its motor instead of having the wings moved by a force conveyed to the insect from without.

Encompassed by the divers hypotheses of the action of the wing given by Borelli, Huber, Dutrochet, Strauss-Durckeim, Liais, Pettigrew, Marey, d'Esterno, De Lucy, Artingstall, etc., and in view of the very complicated motions they had assigned to that organ and to each of its quills—motions which are, for the most part, inimitable in a mechanical bird—we decided to reason out for ourselves, by relying on the laws of the resistance of the air and on some of the most simple facts of observation, what are *the motions of the wing really necessary to flight.* We found—1. *A double oscillation*, a depression, and an elevation of the wings transverse to the path of flight. 2. The change of the plane of the same during this double motion; the lower surface of the wing facing below and behind during its depression, so as to sustain the bird, the same surface of the wing facing below and in front during its elevation, so that the wing is raised with the least resistance by cutting the air with its edge while the bird flies. These movements, moreover, were admitted to be correct by a large num-

[1] *See* Fig. 87, on page 202 of Marey's "Animal Mechanism," published in the "International Scientific Series."

ber of observers, and have been concisely demonstrated by Strauss-Durckeim, Liais, and Marey.

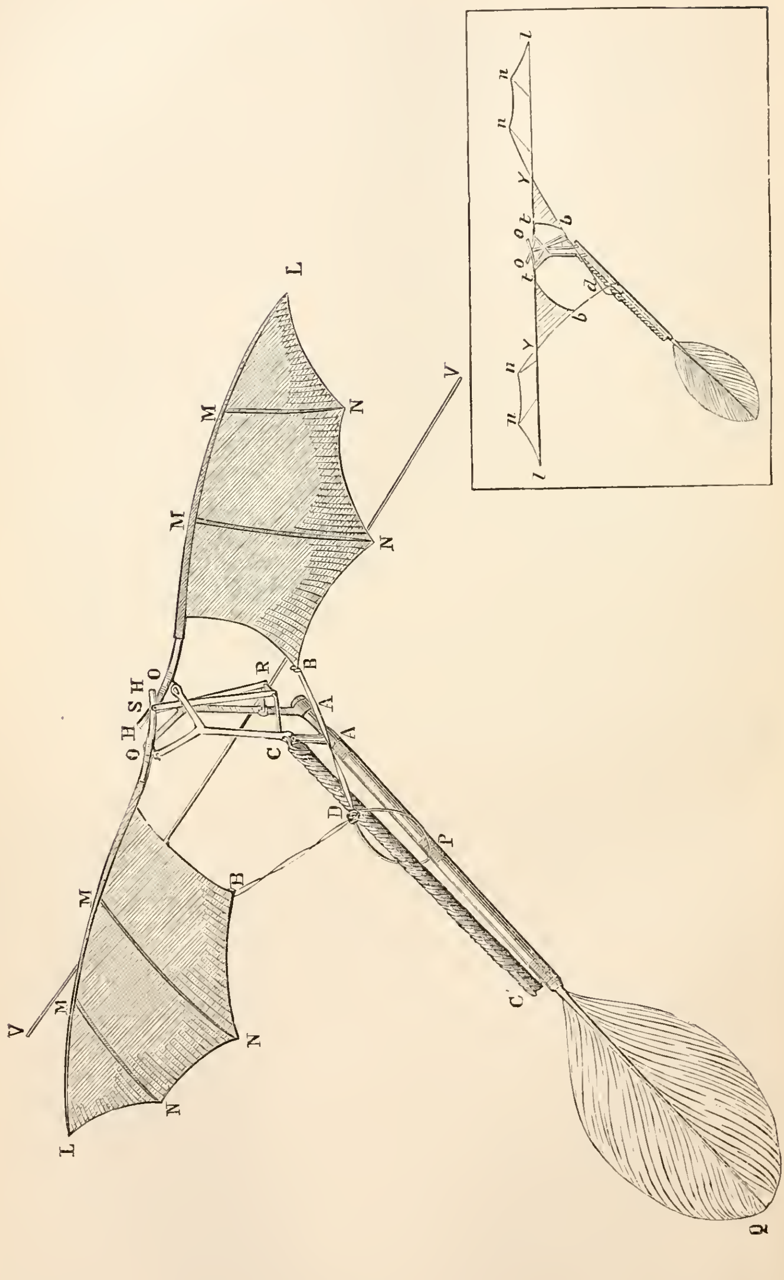
But, in considering the difficulty of the construction of our mechanical bird, we were obliged, notwithstanding our desire to make a machine which should be simple and easy to understand, to try to perfect those actions we have somewhat summarily described. It is evident that the different parts of the wing, from its base to its extremity, act on the air under very different conditions. The interior part of the wing, having small velocity, produces little propelling effect at any moment of its beat; but it is far from being useless, and one may imagine how, by presenting its lower face downward and slightly facing the front, it acts during the rapid translation of the bird, like a kite, as well while the wing is being elevated as during its downward motion, and thus sustaining in a continuous manner a portion of the weight of the bird. The middle portion of the wing has a junction intermediate between that of the interior and that of the outer portion, or end, of the wing; so that the wing, during its action, is twisted on itself in a continuous manner from its base to its extremity. The plane of the wing at its base varies but little during flight; the plane of the median part of the wing is very much displaced on one and the other side of its mean position; finally, the outer part of the wing, and especially its tip, experiences considerable change of plane. This warping of the wing is modified at each instant during its elevation and depression, in the manner just indicated; at the extreme points of its beat the wing is nearly plane. The action of the wing is thus seen to be intermediate between that of an inclined plane and that of a screw with a very long and continually variable pitch.

Notwithstanding the differences found to exist in the hypotheses of various authors when compared with one another and with the one just given, still one or the other of these writers confirms the greater portion of the ideas just advanced. Thus the torsion of the wing had already been pointed out by Dutrochet, and especially by Pettigrew, who long maintained this opinion; only he has taken, according to our view, the change of form occurring during the elevation of the wing for that of the form occurring during its depression, and *vice versa.* These authors clearly saw how the articulations of the bones, the ligaments of the wing, the imbrication and elasticity of the quills, bring about the above result. M. d'Esterno had explained the continuous effect, like that of a kite, of the interior portion of the wing during its depression and elevation; and M. Marey had very appropriately designated that portion of the wing as "passive," at the same time, however, maintaining that the most important action of the wing during flight is due to a general change of its plane produced by the rotation of the humerus on itself.

According to our view there is a sharp distinction to be made between hovering and the ordinary flight of progression, while the amplitude of the changes in the plane of the extremity of the wing is essentially a function of the velocity of translation of the bird. At the extremity of the wing, where the most considerable changes of plane takes place, these changes equal 90°, and even more, during hovering; but then displacements of plane are far less in the flight of progression. According to our calculations the extreme portions of the surface of the terminal feathers of the crow's wing are, during free flight, inclined forward during the depression of the wing only from 7° to 11° below the horizontal, and from 15° to 20° above the horizontal plane during the elevation of the wing. The plane of the wing at its base acts during the above motions like a kite inclined at an angle only of from 2° to 4°.

It is easy to verify the slight inclination of the wing, and consequently the smallness of its angles of action in the air, by observing a flying bird moving in an horizontal line of sight, for we then see only the edges of the wings. It is, in short, inexact to say that the wing changes its *plane;* we can barely say that it changes its *planes.* The truth is, that it is gradually more and more warped in going from its base to its extremity. It was so understood, indeed, by an English author, whose labors we became acquainted with after we had constructed our bird, and to him we are indebted for having saved us several researches. The theory of Sir G. Cayley, published in 1810, differs from ours but in a few particulars. He is of the opinion that the outer portion of the wing in ascending exerts always a propulsive action, and he attributes to the propelling parts and to the sustaining, kite-like parts of the wing, proportions which are relatively the reverse of those to which we have been led by our calculation.

It was with these ideas, favorably judged of by the Academy in September, 1871, that we undertook the application of the torsion of caoutchouc to the problem of the mechanical bird. The wings of our bird are made to beat in the same plane by means of a crank and connecting rods. After several rough trials, we found out that the transformation of motion in the machine required a mechanism very solid relatively to its weight, and I requested M. Tobert, an able mechanist, to construct out of steel a piece of mechanism designed by my brother, E. Pénaud. The accompanying figure represents the apparatus so constructed; *C C′* is the motor of twisted caoutchouc placed above the rigid rod, *P A A*, which is the vertebral column of the machine; from this rod, at *A* and *A*, ascend two rigid forks, which serve below as supports for the crank, *C R*, which is attached to the twisted caoutchouc; and above, at the ends of the forks at *O* and *O*, are the pivots on which the wings oscillate. The links, *R S*, convert the motion of rotation of the crank into the reciprocating motion of the arms, *O M L*, *O M L*. At *Q* is a steering-tail, which we found by experience was best made from one of the long feathers of a peacock's



tail, and which can be inclined upward, or downward, or to one side, and be loaded with wax so that the centre of gravity of the machine can be brought to the proper position.

The warping of the wings, *O L*, is obtained by the mobility of the wing and of the little fingers, *M N*, supporting them on the large rods, *O M L*, which do not partake of this rotation. A little ligament of caoutchouc, *D B*, connects the posterior interior angles of the wings with the middle of the central rod of the machine. This ligament, whose function is similar to that of the posterior paws of the bat, plays the part of an elastic sheet to our wing, so closely resembling the topsail of a schooner. The torsions of the wing are thus automatically regulated, as required, by the combined action of the pressure of the air and of this elastic ligament. The interior third of the surface of the wing acts like a kite during the elevation as well as during the depression of the wing. The external two-thirds, corresponding to the primary and secondary quills of birds, propel and sustain the machine during the downward motions of its wings. The little drawing in the corner shows the wings just about to begin their downward beat. During the elevation of the wing the terminal feathers conform to the sinusoidal track along which they progress in the air; it thus only cuts the atmosphere without acting against it. To start the machine, we simply abandon it to itself in the air.

This machine was exhibited before the Society of Aërial Navigation on the 2d of June, 1872, and flew several times more than seven metres—the length of the public hall—raising itself in a continuous manner, with an accelerated velocity, along a line of flight inclined 15° to 20°. In an open space, the artificial bird flew over twelve to fifteen metres, elevating itself during this flight to about two metres. Another model, exhibited before the same society in October, 1874, flew in an horizontal line, vertically upward, and also ascended obliquely.

On the 27th of last November, at a public exhibition, this model flew from one end to the other of the hall of the Horticultural Society (*see Aéronaute*, February, 1875). On the 2d of July, 1875, it performed with success before the French Physical Society. The velocity of its flight is from five to seven metres per second.

The birds of twisted caoutchouc have been a great success.

M. Hureau de Villeneuve, whose zeal in the study of aërial navigation is well known, and who in his many contributions to the theory of flight since 1868 has discussed the inclination to the horizon of the axes of the scapulo-humeral articulations and their posterior convergence, exhibited, on the 20th of June, 1872, a bird moved by twisted caoutchouc, which, he states, elevated itself vertically to a height of nearly one metre. Continuing his researches with perseverance, he again exhibited his apparatus before the Society of Aërial Navigation on the 13th of January, 1875, after having supplied it with wings similar to those of my bird, and after having adopted several of the peculiarities which had made my machine successful. He then succeeded in giving sustained flight to his machine, which we have ourselves seen fly horizontally nearly seven metres, after having been started by a slight impulse from the hand. M. Tatin, also, in 1874, made two very curious artificial birds, using twisted caoutchouc as a motor. M. Marey has told us that he saw the first named fly in his garden, last November, from eight to ten metres. We have seen the second, nearly identical with our bird, fly in a still more satisfactory manner.

## A MUSEUM EXCHANGE.[1]

By Prof. BURT G. WILDER.

THERE are in this country three institutions more or less available for the distribution of material for Natural History instruction: the Smithsonian Institution at Washington, District of Columbia; the (Agassiz) Museum of Comparative Zoölogy, at Cambridge, Massachusetts; and Prof. Ward's establishment at Rochester, New York.

The first is especially rich in American forms, the collections of government surveys, and the types of Baird's descriptions. There are many duplicates, but these are required for the elucidation of the extent of variation within the species, so that they are available for exchanges in only a limited degree.

The peculiar value of the Cambridge Museum comes from the immense amount of material from all parts of the world, upon which zoölogists are enabled to pursue extended investigations, either at the museum, or, under certain conditions, elsewhere.

Agassiz also desired to prepare collections for educational institutions in Massachusetts, and to provide for teachers an opportunity for summer instruction and for the collection of specimens.

But it is evident that the above-mentioned establishments and arrangements are not yet able to meet a rapidly-growing want of the whole country; namely, the *immediate formation of museums* for the illustration of the courses in natural history which are now generally demanded, in not only the colleges and universities (whether real or so called), but also the normal schools, and even those of lower grade.

Such selected collections need not be either very large or very costly. They should embrace mainly *typical* forms, but contain also some of the peculiar or aberrant species of each large group.

It would be well if some one would make out a list of what are desirable in larger or smaller collections. Meantime, the information

[1] Presented at the Detroit meeting of the American Association for the Advancement of Science.

and the material are, to a great extent, obtainable from the catalogues and the museum of Prof. Ward.

A recent examination of this establishment has suggested a brief sketch of its nature, its capacity for supplying the want above indicated, and of the additions which might advantageously be introduced.

Prof. Ward was a pupil of Agassiz, and afterward Professor of Natural History in Rochester University, where he formed a very extensive and well-arranged museum of geology, mineralogy, paleontology, and zoölogy. Desiring to include with this fac-similes of unique fossils in other museums, Prof. Ward spent three years in Europe, and gradually accumulated moulds of famous fossils. The great expense of this undertaking (nearly $20,000) determined him to make duplicates of the casts, and thus, by degrees, originated the now well-known "Ward Series of Casts of Fossils;" and at present, in many of our educational institutions, large and small, the megatherium, iguanodon, ichthyosaurus, and pterodactyl have become as familiar forms as the professors themselves.

The usefulness of this branch of the establishment is now generally recognized, and, with the mineralogical department, has been graphically described by others,[1] so we may pass to the consideration of what has been and may be accomplished by Prof. Ward for the furnishing of zoölogical museums.

At present, mounted insects and stuffed birds receive but little of his attention, but the collections embrace representatives of the leading groups of the whole animal kingdom, more than 13,000 species being represented. The echinoderms and crustacea, being easily preserved in a dry state, are very numerous. They have recently been carefully rearranged and determined by a professional naturalist.

Prof. Ward keeps twenty-two advertisements in foreign journals, and has correspondents in all parts of the globe, near and remote, so that scarcely a week passes without his receiving word of the sending to him of rare forms.

At the time of our visit he was receiving the results of a late trip to Europe (where he had expended about $10,000 for specimens). On the same day arrived the skins and skeletons of two camels, the one from Asia Minor, the other from Turkey. The taxidermists were engaged upon a grizzly bear, a 1,000-pound turtle, and the now-famous donkey which slew a lion in Cincinnati; while the osteologists were mounting a whale's skeleton for the Peabody Academy of Science at Salem, Massachusetts, and would then commence upon a large series of skeletons for the Smithsonian Institution.

A specimen of the rare tiger-shark (*Crossorhinus dasypogon*) had just arrived from Australia.

Ten men are constantly employed in the reception and arrange-

[1] As by Prof. E. S. Morse, in the *American Naturalist* for April, 1873, and Prof. Alexander Winchell, in the *College Courant* for October 1, 1870.

ment of these specimens, in the preparation of skins and the mounting of skeletons. The chief osteologists and taxidermists were brought from Europe, and their salaries are more than is received by many an assistant professor.

In alcohol are fishes and reptiles, such as the *Lepidosteus*, *Polyodon*, and *Amia*, of our Western rivers, the *Calamoichthys* of Africa, the *Siren* and *Amphiuma* of South Carolina, and the *Proteus* of Europe; while in dry, upper rooms hang hundreds of skins of quadrupeds, large and small, from all parts of the world, and carefully labeled.

The excellence and trustworthiness of the work done by Prof. Ward are further attested by the extent to which he is employed by the Smithsonian Institution, the Cambridge Museum, and others both here and abroad. Indeed, it is no unusual thing for material to come from Europe to Rochester, and be returned to some Continental museum.

But, while gladly commending what is done, we would offer a suggestion as to what might be done with great advantage to our educational institutions and a fair profit to Prof. Ward:

1. Such an establishment should supply the lower vertebrates, the *lamprey* and particularly *amphioxus*, of which, also, sections might be prepared for the microscope.

2. There should be kept, or prepared to order, series of *embryos* of some common animals: among mammals the pig, and among batrachians the frog, are very easily obtained. All *embryos* are, in some respects, more valuable than adults, and, if they were on hand, a demand would surely arise.

3. A series of brains should be added. The models of these, whether plaster or *papier-maché*, are poor substitutes for the real specimens. Nor need the number be very large; a dozen species would fairly illustrate the modifications of the vertebrate encephalon.

Speaking of brains, we cannot forbear expressing the hope that Prof. Ward may shortly be able to impress his clients with the truth of Prof. Wyman's saying that "a skull is doubled in value by cutting in two." The inside is quite as important as the outside, while such vertical bisection, if carefully made, enables us to secure the two halves of the brain but little injured.[1]

4. Other anatomical preparations of soft parts, sections and dissections, are really desired for instruction, and a few typical preparations could readily be made.

5. Finally, we would suggest to Prof. Ward the expediency of

[1] A case in point occurs while correcting the proof of this article. Prof. Ward has received a "blackfish" (*Elobiocephalus melas*). Knowing that the Cornell University would like the brain, he sends me word; but, as the section of the skull for extraction of the brain would impair its value for most purchasers, we have to take the whole skeleton also. The brain, by-the-way, weighs nearly five pounds, two pounds more than the average human brain, and nearly a pound more than that of Cuvier.

making his establishment a medium of exchange between parties in different localities. For instance, A lives in Central New York; he has plenty of *Menobranchus*, and would exchange them for *Menopoma* from the Ohio River, or the gars and spoonbills of the Mississippi, of which B has more than he wants; while both these parties desire sharks, and skates, and pipe-fishes, and the large lamprey from the seacoast where C lives. To purchase and keep all these and many more such on hand involves an enormous expense and risk to a single individual; whereas, if, under certain conditions, Prof. Ward received good specimens of these forms, and stored them at the owner's risk as to fire, and expense as to alcohol, etc., then he could, at a fair commission, transfer them to those who desired them without the expenditure now incurred.

The arrangement could be made like that of the naturalists' agency for books in Salem, Massachusetts, and a periodical list of specimens and prices could be issued. The prices would serve as guides for either exchange or direct purchase.

Such a system of transfer would, it seems to us, not only enable new institutions to rapidly form type collections for class-room instruction, but also encourage them to collect large numbers of duplicates of the forms peculiar to their localities. In this way we should ascertain the extent of individual variation, the manner and rate of development and growth, and, by preparations made on the spot, the structure of the brains and other soft parts, which are seldom perfectly preserved in specimens sent in alcohol from a distance.

## ARE THE ELEMENTS ELEMENTARY?

By F. W. CLARKE,

PROFESSOR OF CHEMISTRY AND PHYSICS IN THE UNIVERSITY OF CINCINNATI.

WHAT are the so-called chemical elements? Are they really elements, or only compounds of remarkable stability? It would be hard to find in physical science a question which has been oftener asked than this. It has furnished all sorts of investigators with abundant food for speculation. Men of the highest scientific ability have grappled with the problem, and left it still unsolved; others have constructed elaborate theories, which claimed to settle everything. Still the debate goes on. We cannot prove that the elements are truly what we call them, nor can we show beyond all doubt that they are compound in their nature. We may, however, weigh the opposing probabilities, and see which side of the question is the stronger. Whichever way the balance turns, the superstructure of chemistry will be but little affected. We know that all our recognized compounds are formed by the union together of two or more supposed elements; and no revelations concerning the nature of the latter can well disturb that established knowledge. However we may speculate, the experimentally-ascertained facts will remain unaltered. They may receive slightly different theoretical interpretations, without having their practical bearings changed in the least degree.

The prevalent view of the subject, that the elements are elementary, is held by philosophical chemists in a purely provisional way. We need a convenient working hypothesis, and these sixty-three substances are elements for aught we absolutely know to the contrary. As far as we are at present experimentally concerned, then, we call them elements, bearing always in mind the possibility that they may be compounds. They have never been decomposed; we have no means adequate to their analysis; not one of them can be obtained from materials in which it does not already exist. But all this evidence is only negative. How do we know but that some future discovery may render possible the decomposition of these supposed elements? Shall we assert positively that we have reached the ultimate analysis, and may never hope to go any farther? Obviously, so definite a statement would be unjustifiable, and no sane chemist would venture to make it. The uncertainty of the subject may well be illustrated by a reference to chemical history. At the beginning of the present century the alkalies and alkaline earths were thought to be elements. They were not decomposable by any means then known, so that the supposition was perfectly fair. A very few years passed away, the galvanic battery was brought into use, and presently it was found that each of these bodies was a compound, containing a metal united with oxygen. Perhaps a similar advance in our knowledge may demonstrate the possibility of decomposing many of the substances now regarded as elementary. Such a discovery might work in either one of three ways. It might largely increase the number of supposed elements, by dividing each one into two or more new bodies. It might reduce the number by proving that our elements were formed by the union, in various proportions, of only a very few simpler substances. Or it might demonstrate the unity of matter, just as recent science has demonstrated the unity of force, and give us only one true element underlying all material forms. Such a culmination of our knowledge would be grand, indeed!

The evidence, then, upon which we assert the elementary nature of the fifty metals and thirteen non-metals, is very incomplete. On this side of the question there is really no other important testimony, save that just cited. Arguing from our present inability to decompose certain bodies, we assume for convenience that they are indecomposable. Now let us see what there is in favor of the opposite view.

One of the first things learned by the student in chemistry is, that the so-called elements are readily classifiable into a few natural groups.

The members of any one of these groups resemble each other chemically in the closest manner, forming compounds of strong similarity, and often are very much alike in their physical properties also. The thought at once arises, Can these elements be totally distinct from each other—have they nothing in common—are these resemblances only due to chance? Such a supposition could scarcely be admitted, since Science excludes chance from her list of natural agencies. These relationships must mean something—but what?

If we look beyond the points of similarity to the points of difference between related elements, we shall find that these too are subject to regularity. The members of a group vary from each other, not in a meaningless, helter-skelter way, but systematically, so that they may be arranged in regular series. Take, for example, the group formed by the strikingly similar metals, calcium, strontium, and barium. If, now, we compare these with reference to any physical property, we shall find that strontium will always be between the other two. It is heavier than calcium and lighter than barium; and the same thing holds true of strontium compounds when compared with the corresponding compounds of its two associates. The integrity of the series is perfect; for in no case can the middle member be placed either at the beginning or the end. The nitrogen group is even more remarkable. Arranging its recognized members in the order of their atomic weight, they are as follows: nitrogen, phosphorus, arsenic, antimony, and bismuth. The first of these elements is gaseous at all known temperatures; phosphorus is a solid, but easily convertible into a gas by heat; arsenic is a denser body still, and less readily vaporized; antimony follows in regular order; and finally, bismuth, the heaviest of the series, can be distilled only with considerable difficulty. Here, then, is a gradation both in specific gravity and in boiling-point, the lowest member of the group, in each of these particulars, being that with the lowest atomic weight; and the reverse. If we ascend from these elements to their compounds, we shall also notice some curious chemical regularities. Each member of the group unites with oxygen to form a pentoxide, from which an acid may be derived. Compare, now, these five acids: nitric is very strong, and violently corrosive; phosphoric is a little weaker, and acts much less vigorously; arsenic is feebler still; antimonic is extremely weak; and the corresponding bismuth compound is just barely recognizable as being an acid at all. Can these regular gradations be purely accidental and meaningless?

Examples like these might be adduced almost indefinitely. Series after series could be brought forward, all illustrating the same principle. Exceptions occur now and then, but they are so few that for present purposes they may be disregarded. Of course they mean something, but they are neither sufficiently abundant nor important enough to affect our arguments. The regularities are so numerous and so remarkable as to outweigh many times over all seeming variations. All this evidence is, however, inadequate in one respect: the relations thus far pointed out cannot be simply expressed in figures. Are there, then, any numerical relations connecting the elements? This question may be answered, partly by studying their atomic weights, and partly by an examination of their specific volumes.

The regularities which connect the elementary atomic weights have been examined and discussed by many investigators from widely differing points of view. Some chemists have contented themselves with the naked facts; others have considered the bearing of those facts upon chemical theories; and a third class, with less caution than ignorance, have speculated upon them in the wildest and most reckless manner. Of course a full summary of the whole subject, however interesting it might prove, would be out of place in a condensed argument like this. All we can do here is to glance at a few of the many relations known, and afterward consider them in their connection with our main subject. The general reader who cares to go deeper into the question will do well to consult the original papers of Dumas, Gladstone, J. P. Cooke, Kremers, Mendelejeff, and others.

Of the relations now under consideration, the one most frequently cited is as follows: Many elements are most naturally arranged in threes, of which the middle member has an atomic weight very nearly a mean between the atomic weights of the other two. Thus we have calcium, atomic weight, 40; strontium, 87.5; and barium, 137. Here, if the value of strontium were 88.5, it would be an exact mean. Again, chlorine has the atomic weight 35.5; bromine, 80; and iodine, 127; the second being almost precisely midway between the first and third. A still closer agreement with theory is furnished by lithium, sodium, and potassium, whose values are respectively 7, 23, and 39.1. A fourth example is afforded by potassium, 39.1; rubidium, 85.4; and cæsium, 133; while a fifth case is offered by phosphorus, 31; arsenic, 75; and antimony, 122. To be sure, these illustrations afford only an approximation to regularity; but then the variations are themselves somewhat regular. In each of these twos the middle term is just a little too low to be an absolute mean between its associates; that is, the variations from theory are all in one direction. It is hardly possible at present to say whether this means anything, or is only ascribable to accident. One more example of regularity among atomic weights is worth noting, namely, the relation which connects the members of the oxygen group. Here we have oxygen, 16; sulphur, 32; selenium, 79.5; and tellurium, 128. These higher numbers are simple multiples of the lowest; there being only a variation of half a unit (minus) in the case of selenium. Since these elements are very similar in their chemical relations, this regularity is extremely significant. Can it be due to chance, and void of real meaning?

But all these relations *prove* nothing—they merely suggest. Standing by themselves they would signify comparatively little; but considered with other analogous evidence they help to found an almost overwhelming argument. The concurrent testimony supplied by the specific or atomic volumes of the elements is particularly strong.

The specific volume of any substance is the quotient obtained upon dividing its atomic weight by its specific gravity. This value may be supposed to represent the volume of an atom of the substance plus the sphere of unoccupied space immediately surrounding and belonging to it. Leaving theoretical definitions out of account, however, we shall find, upon comparing the specific volumes of solid and liquid substances, many extraordinary relations. Often, all the members of an elementary group have equal values. This is the case with the closely-related metals platinum, iridium, osmium, palladium, rhodium, and ruthenium. They have different atomic weights and different specific gravities; yet the quotient obtained upon dividing the former by the latter is the same in every instance. The same thing holds good of the group formed by iron, cobalt, nickel, chromium, manganese, copper, and perhaps also uranium. Here the regularity extends even beyond the elements themselves, for their corresponding compounds have, with few exceptions, equal specific volumes also. An altogether different, but on the whole more remarkable, relation is furnished by the alkaline metals lithium, sodium, potassium, and rubidium; whose specific volumes are respectively 11.9, 23.7, 45.1, and 56.2. These values are almost exactly multiples of the first, standing to it in the ratio of 1 : 2 : 4 : 5. The slight variations from accuracy in this case are very far within the limits of experimental error. Almost as remarkable multiple relations are found in several other series, and apply not only to the specific volumes of the solid elements, but to their values in liquid compounds also. Closely connected with this subject is that of crystalline form. As a general, though not invariable rule, elements having equal specific volumes are isomorphous; that is, crystallize alike; a fact which may be extended to a very large number of compound series as well.

It would be easy to go on to almost an indefinite extent multiplying examples of relationship between the elements. There is hardly any set of physical properties which may not be made to emphasize the idea that these substances are internally related. Take, for example, their specific heats, which, multiplied by their atomic weights, give a constant quantity in the neighborhood of 6.3. That is, according to the law of Dulong and Petit, all elementary atoms have equal capacities for heat. But space is limited, so that we must omit the consideration of many important facts, and pass to the theoretical discussion of those already cited. All this evidence suggests quite emphatically that the elements are not totally distinct and independent bodies. Are they, then, compounds formed from a few simple substances, or are they modifications of but one primal matter? Strong arguments may be adduced in favor of either view, although neither can be yet demonstrated.

The idea that a very few true elements, uniting together in a variety of proportions, may give rise to all the bodies which we now look upon as elementary, derives perhaps its strongest support from an analogy pointed out by Prof. Cooke something like twenty years ago. He first called attention to the many serial relations which connect the members of any elementary group, and then showed how much these groups resemble the homologous series of organic chemistry. In such a series we have a number of compounds each differing from its immediate predecessor in a very definite way. Thus, in the series of alcohol radicles, we have first the hydrocarbon methyl. Adding to this an atom of carbon and two of hydrogen, we get the second member of the series; the third is formed by the same addition to the second, the fourth similarly derived from the third, and so on. The difference between the molecular weights of any two successive members in this series is always the same. Just so in some groups of elements, as we have already seen. The atomic weight of lithium is seven, add sixteen and we get that of sodium, while another increase of sixteen gives the value of potassium. Again, the atomic weight of sulphur is that of oxygen plus sixteen; three times sixteen more brings us to selenium, and another forty-eight reaches the equivalent of tellurium. Here certain multiples of sixteen are missing; do they correspond to the atomic weights of undiscovered elements? Such a speculation is curious, but not very profitable.

The analogy, then, between the groups of elements and the homologous series of organic compounds is quite striking, although it may not be very precise. Hence Cooke suggested that, if the elements were compounds, their resemblances might be explained by supposing them to form series like the hydrocarbons, in which bodies of similar constitution are akin in general properties. Now, this conception was certainly very brilliant, and rendered intelligible many important facts which before it were unclassified. It did not, however, suggest the possible unity of matter, but merely put the ultimate question regarding the nature of the elements a step farther back. Instead of many, it gave us the idea of few elementary bodies; why and how these differed were yet to be found out. Prof. Cooke was, fortunately, too cautious a chemist to put forward views of this sort dogmatically; he did not offer a theory even; he only made suggestions to be taken later at their true value, whatever that might be.

The other side of the question, that of the unity of matter, has been worked up by several chemists in a variety of ways. Some have studied the phenomena of crystallization and drawn their conclusions therefrom; others have taken up the subject from a dynamical point of view. Given atoms of one kind only, how to arrange these in different aggregations so as to present all the phenomena offered by our supposed elements in their relations to the various modes of energy? Perhaps in the discussion of this problem Gustavus Hinrichs would stand first. His conclusions may be easily questioned, but the ability and ingenuity displayed in reaching them cannot be denied.

To the general reader, or to the beginner in chemistry, the difficulties confronting the unitary view of matter may seem to be very great. Doubtless they are; but then every side of the subject is beset with difficulties. Obstacles must be surmounted, and the worst are not in this direction. The mind unused to speculations of this sort will probably encounter its greatest embarrassment in trying to understand how one substance alone can assume such a diversity of forms. That such a thing is within the limits of possibility, may be illustrated by reference to the facts of allotropy and isomerism. Quite a number of our present elements are known to be capable of existing in a variety of dissimilar modifications. Carbon is found as charcoal, graphite, and diamond; phosphorus exists both in its white and in its red modifications; oxygen is allotropic as ozone. Similar examples are furnished by arsenic, selenium, and, very notably, by sulphur. Among compounds, especially in organic chemistry, many cases occur in which several different bodies have precisely the same elementary composition. For instance, the essential oils of rose, bergamot, orange, lemon, lavender, turpentine, rosemary, nutmegs, myrtle, peppermint, etc., unlike as they may be in outward properties, are all composed of carbon and hydrogen in exactly the same percentages. The same atoms occur, but differently arranged. Many other sets of isomeric bodies are known in which this diversity of atomic arrangement can be distinctly traced, and the reasons for difference clearly pointed out. The limitations of space prevent their description here.

Now, since a single element may exist in several different forms, and since the same atoms can unite together so as to produce compounds very unlike each other, the chief objection to the unitary view is removed. Why may not all the so-called elements be allotropic modifications of one, or else isomeric bodies formed by the union of two or three such modifications? Such a supposition is by no means absurd, although, to be sure, it is not capable of rigid demonstration. It is only a speculation, but then within it are some fair probabilities. These may be strengthened by an appeal to spectroscopic evidence, and to the prevalent hypothesis concerning the origin of our planet.

If we examine the spectra of our supposed elements, we shall notice no more striking fact than the extent to which they differ in complexity. Some bodies give spectra of only one or two lines, while others are represented by hundreds. This atom emits light of a single wave-length, that one gives out rays of nearly half a thousand different kinds. Now, what do these facts mean? Do they indicate structural differences within molecules such that each bright line in a spectrum corresponds to a true element? Such a notion, if true, would lead to an alarming multiplication of elementary bodies, increasing our present confusion to an indefinite extent. If every possible wave-length of light represented a special element, the number of elements would be infinite. Clearly, then, this speculation, although frequently suggested, has very little to recommend it, and need not be entertained. Still, the fact of varying complexity among the elementary spectra remains to be accounted for. It certainly suggests a corresponding difference of complexity among the elements themselves, but of what nature? This question can hardly be answered directly, although it admits of interesting discussion, for which, unfortunately, we have little space to spare. Suffice it to say that spectroscopic phenomena are quite in harmony with the idea that all matter is at bottom one, our supposed atoms being really various aggregations of the same fundamental unit. It is approximately true that the simpler spectra are furnished by the elements of low atomic weight, while the multitudes of lines come from the heavier atoms. There are prominent exceptions to this rule, still it affords some support to our central idea.

But the spectroscope makes its most emphatic suggestions in favor of the unity of matter when it is applied to the study of the heavenly bodies. This subject I discussed in The Popular Science Monthly for January, 1873, and some months later Lockyer gave it prominence in England, his paper calling forth a good deal of comment. Therefore, only a brief *résumé* of my original suggestions is desirable now.

Everybody knows that the nebular hypothesis, as it is to-day, draws its strongest support from spectroscopic facts. There shine the nebulæ in the heavens, and the spectroscope tells us what they really are, namely, vast clouds of incandescent gas, mainly, if not entirely, hydrogen and nitrogen. If we attempt to trace the chain of evolution through which our planet is supposed to have grown, we shall find the sky is full of intermediate forms. The nebulæ themselves appear to be in various stages of development; the fixed stars or suns differ widely in chemical constitution and in temperature; our earth is most complex of all. There are no "missing links" such as the zoölogist longs to discover when he tries to explain the origin of species. First, we have a nebula containing little more than hydrogen; then a very hot star with calcium, magnesium, and one or two other metals added; next comes a cooler sun in which free hydrogen is missing, but whose chemical complexity is much increased; at last we reach the true planets with their multitudes of material forms. Could there well be a more straightforward story? Could the unity of creation receive a much more ringing emphasis? We see the evolution of planets from nebulæ still going on, and parallel with it an evolution of higher from lower kinds of matter.

Just here, perhaps, is the key to the whole subject. If the elements are all in essence one, how could their many forms originate save by a process of evolution upward? How could their numerous relations with each other, and their regular serial arrangements into groups, be better explained? In this, as in other problems, the hypothesis of evolution is the simplest, most natural, and best in accordance with facts. Toward it all the lines of argument presented in this article converge. Atomic weights, specific volumes, and spectra, all unite in telling the same story, that our many elements have been derived from simpler stock.

I know that all this is only speculation, but surely it is not baseless. Science is constantly reaching forward from the known to the unknown, partly by careful experiment, and partly by the prophetic vision of thought. It first discovers facts, and then seeks to interpret them, although oftentimes the interpretation is not capable of absolute proof. So with the material of this article. We have seen that many relations connect in some mysterious way those bodies which we commonly regard as simple, and we have sought to determine their meaning. What can they mean, save that the elements are not elementary? How could the elements have originated but by a process of evolution?

# THE NATURE OF FLUORESCENCE.[1]

By Dr. EUGENE LOMMEL,

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THE question now arises, What becomes of the rays that have undergone absorption? Are they in fact, as they appear to be, annihilated? A series of phenomena now to be considered will give us an answer to these questions.

If water containing a little *esculine*, a substance contained in the bark of the horse-chestnut in solution, be placed in a flask, and the rays of the sun or of the electric lamp, concentrated by a lens situated at about its focal distance from the vesel (Fig. 1), be directed upon it, the cone of light thrown by the lens into the interior of the fluid will be seen to shine with a lovely sky-blue tint. The particles of the solution of esculine in the path of the beam become spontaneously luminous, and emit a soft blue light in all directions. The cone of light appears brightest at the point where it enters into the fluid through the glass, and quickly diminishes in brilliancy as it penetrates more deeply.

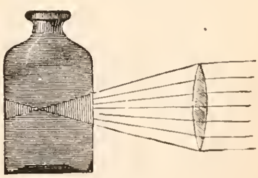

Fig. 1.—Illustration of Fluorescence.

There are great numbers of fluid and solid bodies which become

[1] From "The Nature of Light," No. XIX. of the "International Scientific Series."

similarly self-luminous under the influence of light. This peculiarity was first observed in a kind of spar occurring at Alston Moor, in England, which, itself of a clear green color, appears by transmitted solar light of a very beautiful indigo-violet color. From its occurrence in calcium fluoride the phenomenon has been named *fluorescence*.

In order to understand more precisely the circumstances under which fluorescence occurs, the solution of esculine must again be referred to. The light, *before* it reaches the lens, must be allowed to pass through just such another solution of esculine contained in a glass cell with parallel walls. The cone of light proceeding from the lens, as long as it passes through the air, does not appear to have undergone any material change, it is just as bright and just as white as before. In the interior of the fluid, however, it *no longer presents a blue shimmer, but becomes scarcely perceptible.*

Thus it is seen that light which has traversed a solution of esculine is no longer capable of exciting fluorescence in another solution of esculine. Those rays consequently which possess this property must be arrested by the first solution of esculine. Similar results are obtained in the case of every other fluorescent substance.

The general proposition can therefore be laid down, *that a body capable of exhibiting fluorescence fluoresces by virtue of those rays which it absorbs.*

In order to determine what rays in particular cause the fluorescence of esculine, the spectrum must be projected in the usual way; but, instead of its being received upon a paper screen, it must be allowed to fall upon the wall of a glass cell containing a solution of esculine, that is to say, upon the solution itself, and it must then be observed in what parts of the spectrum the blue shimmer appears. The red and all the other colors consecutively down to indigo appear to be absolutely without effect. The bluish shimmer first commences in the neighborhood of the line *G* (Fig. 2), and covers not only the violet part of the spectrum, but *stretches far beyond the group of lines H* to a distance which is about equal to the length of the spectrum visible under ordinary circumstances.

From this the conclusion must be drawn that there are rays which are still more refrangible than the violet, but which in the ordinary mode of projecting the spectrum are invisible; these are termed the *ultra-violet rays.* They become apparent in the esculine solution because they are capable of exciting the bluish fluorescent shimmer in it. If sunlight have been used in the above experiments, the well-known Fraunhofer's lines appear upon the bluish ground of the fluorescing spectrum, not only from *G* to *H*, but the ultra-violet part also appears filled with numerous lines, the most conspicuous of which are indicated by the several letters *L* to *S* (Fig. 2). That these lines, like the ordinary Fraunhofer's lines, belong properly to solar light, and do not depend upon any action of the fluorescing substance, is evident from the circumstance that with the electric light they are no more apparent in the ultra-violet than in the other colors, and further, because the same lines are seen in the solar spectrum, whatever may be the fluorescing substance under examination.

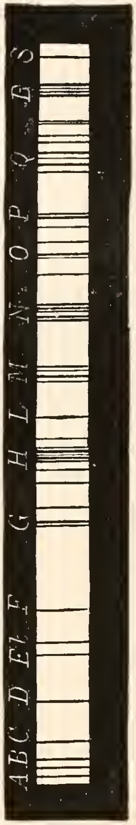

Fig. 2.—Solar Spectrum with the Ultra-violet Portion

*Quartz* has the power of transmitting the ultra-violet rays far more completely than glass. If, therefore, the glass lens and prism hitherto used for projecting the spectrum be replaced by a quartz lens and prism, the ultra-violet part of the spectrum is rendered much brighter and is extended still farther than before.

The ultra-violet rays of the spectrum can, moreover, be seen, without the intervention of any fluorescing substance, through a glass, or, still better, through a quartz prism, if the bright part of the spectrum between *B* and *H* (Fig. 2) be carefully shut off. With feeble illumination its color appears indigo-blue, but with light of greater intensity it is of a bluish-gray tint (lavender). The ultra-violet rays thus ordinarily escape observation, because they produce a much feebler impression on the human eye than the less refrangible rays between *B* and *H.*

An explanation is thus afforded why the solution of esculine, apart from its absorption, is colorless when seen by transmitted light; for, since it absorbs only the feebly luminous violet and the entirely imperceptible ultra-violet rays, the mixed light that has passed through it still appears white, and is not rendered materially fainter.

If the solar spectrum be thrown in the above-mentioned manner upon the fluid, its fluorescing part everywhere exhibits the same bluish shimmer; and spectroscopic examination shows that this bluish light has always the same composition, whether it is excited by the *G* rays, or by the *H* rays, or by the ultra-violet rays, and that it is formed of a mixture of red, orange, yellow, green, and blue. It is thus seen that the different kinds of homogeneous light, as far as they are generally effective, produce *compound* fluorescent light of identical composition, the constituents of which, nevertheless, are collectively *less refrangible than, or are at most equally refrangible with*, the exciting rays.

Among other fluorescing bodies may be mentioned the solution of quinine, which is as clear as water, and has a bright-blue fluorescence; the slightly yellow petroleum, with blue fluorescence; the yellow solution of turmeric, with green; and the bright-yellow glass containing uranium, which fluoresces with beautiful bright-green fluorescence. It admits of easy demonstration that in these bodies also it is the more refrangible rays that call forth fluorescence. For, if we illuminate them with light which has passed through a red glass, no trace of fluorescence is visible. But, if the red be exchanged for a blue glass, the fluorescence becomes as strongly marked as with the direct solar light. A remarkable phenomenon is presented in the splendid bright-green light which is emitted by uranium glass under the action of blue illumination.

The highly-refrangible rays which possess in so high a degree the power of exciting fluorescence are contained in large proportion in the light emitted by a Geissler's tube filled with rarefied nitrogen. In order to expose fluorescing fluids to the influence of this light, the arrangement represented in Fig. 3 may be employed with advantage. A narrow tube is surrounded by a wider glass tube, into which the fluid is introduced by a side opening which can be closed if required. Another form of Geissler's tube is represented in Fig. 4, which con-

Fig. 3.—Geissler's Fluorescence Tube.

Fig. 4.—Geissler's Tube with Uranium Glass Spheres.

tains in its interior a number of hollow spheres composed of uranium glass. Where a beam of reddish violet nitrogen light traverses the tube, the uranium glass balls shine with a beautiful bright-green fluorescent light.

The electric light passing between carbon-points is rich in rays of high refrangibility, indeed the ultra-violet end of its spectrum reaches even farther than that of the solar spectrum. In the light of the magnesium-lamp the ultra-violet rays are also abundant, and both sources of light are therefore particularly well adapted to produce fluorescence, while gas and candle light are nearly inoperative on account of the small amount of the more refrangible rays they contain.

It would nevertheless be incorrect to infer from the above facts that the more refrangible rays are exclusively capable of exciting fluorescence. A red fluid which is an alcoholic solution of naphthaline red, and which in ordinary daylight fluoresces with orange-yellow tints of unusual brilliancy, will serve to demonstrate that even the less refrangible rays are capable of producing this effect. In fact, if the spectrum be projected upon the glass cell containing the fluid (Fig. 5), the yellow fluorescent light will be seen to commence at a point intermediate to *C* and *D*, and therefore still in the red, and to

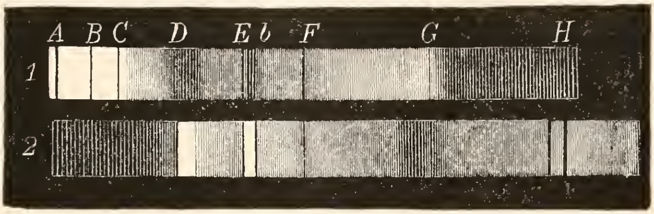


FIG. 5.—ABSORPTION AND FLUORESCING SPECTRUM OF NAPHTHALINE RED.

extend over the whole remaining spectrum as far as the ultra-violet. The strongest fluorescence by far is shown behind the line *D* in the greenish-yellow rays. It then again diminishes, and becomes a second time more marked between *E* and *b;* thence onward the fluorescence becomes fainter, then increases again in the violet, and gradually vanishes in the ultra-violet. In naphthaline red, therefore, there are rays of low refrangibility, namely, the green-yellow rays behind *D*, by which its fluorescence is most powerfully excited.

The fluorescence spectrum received upon the fluid shows, as we have already mentioned, three regions of stronger fluorescence, and the absorption spectrum of naphthaline, which, by placing a small cell filled with the solution in front of the slit, may be obtained upon a paper screen, gives a key to the cause of this phenomenon. In this spectrum Fig. 5 (1), a completely black band is visible in the green-yellow behind *D*, a dark band between *E* and *b*, while the violet end appears shaded. On employing a very strong solution of the naphthaline coloring material, the whole spectrum vanishes with the exception of the red end, which remains apparent to a point behind *C*. If now the absorption spectrum be compared with that thrown upon the fluid, the intimate relation between absorption and fluorescence that has already been pointed out in the esculine solution is corroborated in the minutest particulars. *For every dark band in the absorption spectrum corresponds to a bright band in the fluorescing spectrum.* Every ray absorbed by the fluid occasions fluorescence, and the fluorescent light produced is the brighter, the more completely the ray is absorbed.

A second example of the excitation of fluorescence by rays of small refrangibility is exhibited by a solution of chlorophyll. The spectrum projected upon this green fluid fluoresces of a dark-red color, from *B* to a point within the ultra-violet, exhibiting at the same time bright bands which correspond with the dark bands in the absorption spectrum. Between *B* and *C*, where the greatest amount of absorption occurs, the fluorescence is also the most marked. But it is the middle red rays which here act so powerfully as excitants. It is remarkable that the red fluorescent light which the chlorophyll solution emits likewise lies, in regard to its refrangibility, between *B* and *C*. Chlorophyll solution affords a proof that all rays of the spectrum, with the exception of the extreme red in front of *B*, are capable of calling forth fluorescence. Their capacity for doing so depends simply on the power of absorption of the fluorescing substance. The most refrangible violet and ultra-violet rays are, however, characterized by the circumstance that they are capable of exciting all known fluorescing bodies.

Fluorescent light is only perceived so long as the fluorescent substance is illuminated by the exciting rays. As soon as the light falling on it is obstructed, the colored shimmer vanishes. It is only in the case of some fluorescing solid substances, as, for example, fluor-spar and uranium glass, that, with the aid of appropriate apparatus (Becquerel's phosphoriscope), a very short continuance of the fluorescence may be observed to take place in the dark.

There are, however, a number of bodies which, after being excited to self-luminosity by a brilliant light, continue to shine for a certain time in the dark. A series of pulverulent white substances, namely, the sulphur compounds of calcium, strontium, and barium (which should be kept in hermetically-sealed glass tubes), do not exhibit the faintest light in a dark room. Moreover, if they be covered with a yellow glass and illuminated with the light of a magnesium-lamp, they remain as dark as before. But if the yellow be exchanged for the blue glass, and the magnesium-light be allowed to play upon them for a few seconds only, they emit in the dark a soft light, each powder having its own proper tint of color. This power of shining in the dark *after having been exposed to the light is called phosphorescence.* The property is possessed in a high degree not only by the above-named artificially-prepared substances, but by various minerals, as the diamond, fluor-spar, and a variety of fluor-spar called chlorophane.

# THE CONTROVERSY ON ACOUSTICAL RESEARCH.

## TYNDALL ON SOUND.[1]

THE work of Prof. Tyndall on the philosophy of sound has won for itself, in its former editions, the highest possible recognition among scientific men, not only in England, but in other countries. A little more than a year ago, the second edition of this book was translated into German under the special supervision of such eminent investigators as Helmholtz and Wiedemann. In the work before us we have the third revision of the eminent professor's observations under this head. In preparing it, he says, he has subjected the previous edition to a careful reëxamination, and, in so doing, has "amended as far as possible its defects of style and matter, and paid at the same time respectful attention to the criticisms and suggestions which the former editions called forth."

In the preface to this publication it is announced by Prof. Tyndall that the new matter of greatest importance which has been introduced into it is an account of an investigation which during the past two years he has been conducting in connection with the Elder Brethren of the Trinity House. It may not be known to all our readers that what we call our Lighthouse Board at Washington is known in England as "The Trinity House." The title carries us back to the era when monasticism was prevalent in Europe. In its original charter, the body was named "The Masters, Wardens, and Assistants of the Guild, Fraternity, or Brotherhood of the most Glorions and Undivided Trinity, and of St. Clement, in the Parish of Deptford Stroud, in the County of Kent." In the year 1836, an act of Parliament vested in this "Trinity House," as then constituted, the entire control of the lighthouses of England and Wales, and gave it certain powers over the lights in Scotland and Ireland. Prof. Tyndall appears to have entered on his duties as "the scientific adviser" of the Elder Brethren shortly after his return to England at the close of his lecturing tour in the United States in the year 1873. In the seventh chapter of the present volume, under the head of "Researches on the Acoustic Transparency of the Atmosphere in Relation to the Qnestion of Fog-Signaling," he gives the processes and the results of some very interesting observations which he has conducted under the patronage of the British Trinity House. The general results of these observations had already transpired, but in the work before us they have received the professor's definite statement side by side with a narrative of the researches from which they have been deduced. It is to this portion of the volume, containing "the new matter of greatest importance," that we propose to confine our attention in this short review.

[1] From the *Nation* of October 28, 1875.

The reader who turns to this seventh chapter will find that it opens with an "introduction" professing to give "a summary of existing knowledge" in the matter of fog-signaling. The writer states that while the *velocity* of sound has formed the subject of repeated and refined experiments by the ablest philosophers, "the publication of Dr. Derham's celebrated paper in the 'Philosophical Transactions' for 1708 *marks the latest systematic inquiry into the causes which affect the intensity of sound in the atmosphere.*" And, after making this statement, the professor immediately adds as follows: "Jointly with the Elder Brethren of the Trinity House, and as their scientific adviser, I have recently had the honor of conducting an inquiry designed to fill *the blank here indicated.*" In order still further to impress on the reader a sense of the magnitude of this "blank," Dr. Tyndall indulges in one or two preliminary references which, he says, "will suffice to show the state of the question when this [his] investigation began." The first of these references cites the opinion of Sir John Herschel to the effect that fogs and falling rain, and more especially snow, had been found by Derham "to tend powerfully to obstruct the propagation of sound." The second of his references is made to what he calls "a very clear and able letter" addressed by Dr. Robinson, of Armagh, to the British Board of Trade in 1863. In this "very clear and able letter" Dr. Robinson states that sound is the only known means for coping with fogs, but about it, he adds, "the testimonies are conflicting, *and there is scarcely one fact relating to its use as a signal which can be considered as established.*" But Dr. Robinson is clear on one point—to wit, that "fog is a powerful damper of sound."

On the strength of these historical references, Dr. Tyndall ventures the remark that, prior to the investigation conducted by him, the views enunciated under this head by Derham, Herschel, and Robinson, "were those universally entertained." It was in order to fill "the blank" indicated by the universal prevalence of such erroneous opinions that *his* inquiry, he says, was set on foot. And his inquiry, he tells us, was begun May 19, 1873.

Now, it is a matter, not only of scientific knowledge, but of public notoriety in this country, that extensive researches on "the causes which affect the intensity of sound in the atmosphere" had been made by the United States Lighthouse Board long before Prof. Tyndall began his investigations. That he should have chosen to ignore the fact in the body of his present volume becomes only the more surprising when, on turning to its preface, we find that he was, as he confesses, "quite aware *in a general way* that labors, like those now for the first time made public, had been conducted in the United States," and "this knowledge," he subjoins, "was not without influence upon my conduct." If his knowledge of the similar labors conducted under this head in the United States was not, as he acknowledges, without influence on his conduct in giving direction to his researches, it will naturally occur to ordinary minds that this knowledge should also have been " not without influence " on his pen when he was professing to give a summary of the existing state of science on this subject. And when to this statement of the case, as acknowledged by himself, we add that he was made acquainted with the nature and purport of Prof. Henry's explorations on this question, not only " in a general way," but also in a very special way, it becomes still more inexplicable that, in defining " the blank " which he claims to have filled by his recent inquiry, he should have disregarded the labors and results of American science, and that, too, while profiting by the instruments and methods of that science in the very conduct of his investigations. The reader will understand the force of our remark that Prof. Tyndall was acquainted with the researches of Prof. Henry, not only " in a general way," but also in a special way, when we state that a paper by the latter—on the abnormal phenomena of sound in relation to fog-signaling—was read by its author in the hearing of Prof. Tyndall at a meeting of the Washington Philosophical Society, called for the purpose of doing honor to the British *savant* while he was sojourning in the national capital. And the force of our remark that he has ignored the results of American science in magnifying " the blank " which he describes, while profiting by the instruments and methods of that science in conducting his inquiry, will be understood when we say that the researches of Prof. Tyndall were prosecuted with the help of a steam-siren, gratuitously lent to him by the Lighthouse Board at Washington, constructed and patented by a citizen of New York, and introduced by Prof. Henry into the lighthouse system of the United States.

We are now prepared for the next stage of this review. It so happened that while Prof. Tyndall was conducting his researches on sound in relation to fog-signaling, an officer of the United States Corps of Engineers, Major Elliot, had been deputed by the Lighthouse Board at Washington to make a tour of inspection in Europe, with instructions to report upon matters relative to lighthouse apparatus and the management of lighthouse systems. Major Elliot reached London a few days before Prof. Tyndall began his experiments at Dover, and was courteously invited to be present, but for want of time was compelled to forego the privilege. The results of the English experiments were, however, subsequently communicated to Major Elliot by Sir Frederick Arrow, the Deputy Master of Trinity House (who, we are sorry to say, has since deceased), and were embodied in his report on the " European Lighthouse Systems," as recently published. The publication of Major Elliot's report was accompanied, in the annual report of the United States Lighthouse Board for the year 1874, with the following observations :

" Major Elliot gives a detailed account of a late series of experiments by the

Trinity House Board on fog-signals. Now, although this account is interesting in itself to the public generally, yet, being addressed to the Lighthouse Board of the United States, it would tend to convey the idea that the facts which it states were new to the board, and that the latter had obtained no results of a similar kind; while a reference to the Appendix to this report *will show that the researches of our Lighthouse Board have been much more extensive on this subject than those of the Trinity House, and that the latter has established no facts of practical importance which had not previously been observed and used by the former.*"

The "Appendix" here referred to is from the pen of Prof. Henry, the chairman of the board, and details elaborate experiments on sound in relation to fog-signaling, as pursued in the service of the United States Lighthouse Board since the year 1855. Brought to book by this "Appendix," Prof. Tyndall asks his readers, in the preface of the present edition of his volume, to bear in mind that "the Washington Appendix was published nearly a year after his [my] report to the Trinity House." But in so writing it seems to have escaped his notice that in a subsequent part of this same preface he has confessed that he was "quite aware in a general way" that labors like his own had been conducted in the United States, and that "*this knowledge was not without influence on his conduct.*" And in so writing he forgets, too, that he was an interested listener to the paper read by Prof. Henry on this subject in his hearing while he was in the United States, and before he had turned any attention at all to the phenomena of sound in connection with fog-signals. He states in the body of his book, as already mentioned, that his inquiry under this head began on May 19, 1873, several months after his "general" and his special knowledge of what had been accomplished in this country. And yet, in the face of all these facts and acknowledgments he has allowed his "summary of existing knowledge" on the subject to stand without any recognition of American science in the premises —a suppression which does as little credit to his scientific generosity as to his literary art, for he can be convicted of delinquency in respect of the former by the inconsistency of statement into which he has fallen through a want of dexterity in the latter.

We may, therefore, safely leave the acknowledged record to substantiate the claims of the United States Lighthouse Board when they represent that their researches, running through many years, "are much more extensive on this subject than those of the Trinity House." It remains for us only to consider the second branch of their representation—namely, that the latter (the Trinity House) "has established no facts of *practical importance* which had not been previously observed and used by the former (the United States Lighthouse Board)." In support of this statement we may point to the fact that Prof. Tyndall nowhere pretends to have established by his researches any improvements whatsoever on the methods or instruments of fog-signaling as practised in the United States. On the contrary, he acknowledges that in the choice of fog-signals for British use his "strongest recommendation applies to an instrument for which we are indebted to the United States." He will remember, moreover, that while he was sojourning in the United States he sought and obtained opportunities from Prof. Henry to observe the operation of the steam-siren in the lighthouse at Sandy Hook. At that time, if not before, he was made acquainted with the progress not only of American science but also of American art under this head. And in view of the fact that, as the "scientific adviser" of the Elder Brethren of the Trinity House, he has counseled them to discard their English horns and whistles and to substitute for them the steam-sirens which have been, for several years, in the use of our American lighthouses, it would seem that the second branch of the claim advanced by the board at Washington stands in as little need as the first of any additional reënforcement at our hands. Bacon rejoiced in the fact that his philosophy was a philosophy which brought forth fruit in the service of man. The progress of American science in this department has been constantly bearing fresh fruit in the interests of commerce and for the relief of the mariner. Daboll's trumpet, an American invention, came to supersede the use of gongs, and bells, and horns, and guns. To-day the steam-siren, an instrument devised and perfected under the direction of the United States Lighthouse Board, is acknowledged to be without a rival as an efficient fog-signal.

It is no part of our present purpose to institute a critical inquiry into the conflicting views of Prof. Henry and of Prof. Tyndall with regard to the hypotheses respectively espoused by each for the explanation of the phenomena of sound in its passage through wide tracts of air. Prof. Henry believes that the direction and the rate of wind-currents are important elements in the problems presented by the phenomena in question. Prof. Tyndall admits that "the well-known effect of the wind is exceedingly difficult to explain," but he insists on making up the fagot of his scientific opinions on the subject at once and forever without taking the "viewless winds" into his account. He finds a sufficient explanation of all the abnormal phenomena in the assumption of ideal clouds of vapor mingling with the atmosphere so as to disturb its homogeneity, and thereby to quench the body of sound. There is nothing in the working hypothesis of Prof. Henry which excludes any truth there may be in the working hypothesis of Prof. Tyndall. But, in the present provisional state of his inquiries on the subject, the former is disposed to question the sufficiency of the explanation adduced by the latter as an efficient cause of all the phenomena in question. With the modesty and reserve of the true physical philosopher, in the present unfinished state of scientific inquiry, Prof. Henry waits for the wider knowledge which shall furnish the basis of an assured induction meeting all the requirements of the problem.

Prof. Tyndall, however, is impatient of any contradiction. He admits that he has not verified the effect of wind-currents "by means of a captive balloon rising high enough to catch the deflected wave," but none the less he ventures to propound his hypothesis as the last word of science in the premises. Indeed, he takes great credit to himself for having been able to rise above "the authority" of Prof. Henry in this investigation. He says that in one of his "phases of thought" on the question he passed through the solution "which Prof. Henry now offers for acceptation," "weighed it in the balance," and "found it wanting." And, as if this language were not supercilious enough, he proceeds to indulge in the following self-complacent reflections:

"But though it [Prof. Henry's solution of ocean-echoes] thus deflected me from the proper track, shall I say that *authority in science is injurious?* Not without some qualification. It is not only injurious, but deadly, when it cows the intellect into fear of questioning it. But the authority which so merits our respect as to compel us to test *and overthrow all its supports*, before accepting a conclusion opposed to it, is not wholly noxious. On the contrary, the disciplines it imposes may be in the highest degree salutary, though they may end, *as in the present case, in the ruin of authority.*"

It is impossible to conceive of language more expressive of vanity, conceit, and arrogance, than this ascription of intellectual superiority to which Prof. Tyndall treats himself on the assumption that he has laid "the authority" of Prof. Henry in "ruins" upon the question of atmospheric sound. At no time and in no place has Prof. Henry assumed to speak "by authority" on the subject. The man of straw whom Tyndall sets up under cover of Henry's name, in order to exhibit upon it the strength and prowess of his intellectual muscle, is a cheap device of rhetoric which a much inferior man might have disdained to employ in a case like this. The cause of science does not profit by the self-laudation of its votaries, and Prof. Tyndall's praises are in the mouths of too many people to render it necessary for him to praise himself at the expense of Prof. Henry or of anybody else.

## REPLY OF PROFESSOR TYNDALL.[1]

*To the Editor of the Nation.*

SIR: I have been favored with a copy of the *Nation* of October 8th, and would ask permission to make a few remarks on the *critique* of my work on "Sound" therein contained.

With regard to Prof. Henry, I hope I am not presumptuous in venturing the opinion, and expressing the belief, that his earlier scientific labors were marked by rare power and originality, and that his later years have been usefully and honorably employed in the service

[1] From the *Nation* of December 23, 1875.

of his country. Such, if I dare say so, are the sentiments which I have ever expressed regarding Prof. Henry here and elsewhere.

When I first learned that he was in danger of falling into what I considered to be grave scientific error, I went as far as friendliness dared go to avert it. I addressed to him a private letter, in which I tried to impress upon him the completeness and conclusiveness of the evidence which he seemed disposed to call in question. He did not honor that letter with any notice, preferring to discuss the subject publicly in the "Report of the Washington Lighthouse Board." He was clearly within his right in doing so; but I submit that I only exercised my right when I met him on ground thus chosen by himself.

No English gentleman that I have consulted can discern in what I have written any violation of the dignity of scientific debate; but your article would lead to the inference that I had both violated common honesty and taken leave of common-sense. I will not quote your words, because I cherish the hope that when you have reflected on them you will regret them. When I say "you," I mean the editor of the *Nation*, whose acquaintance I had the honor to make, and whose kindness I had the privilege to experience, in New York—I do *not* mean the writer of the article. Let me respectfully assure you, then, that, when I spoke of being "deflected by authority," "Prof. Henry's solution of ocean-echoes" was not at all in my mind, nor his "ruin," partial or total, in my calculations. Consider, I pray you, how impossible it is that this could have been the case. The "deflection" spoken of is expressly described as occurring at the outset of an investigation begun in May, 1873, *whereas the Washington report containing Prof. Henry's solution of ocean-echoes is the report for* 1874, *which did not reach Europe until the spring of* 1875. This, then, is the crumbling foundation on which your critic builds his odious charge. In verity, the remark on which he pours his peroratory invective was not meant for "laudation" of any kind, but merely to show the "polar" character of authority—its good side and its bad.

It is easy, as you know, Mr. Editor, to sneer and to assail; but less easy to show, without going into details not worth the labor, that the sneer is unmeaning, and the assault unfair. Nevertheless, the broad lines on which, in the present instance, I would meet my anonymous assailant may, I think, be made clear. He industriously mixes together things which ought to be kept apart—experiments on fog-signals and inquiries into "the causes which affect the transmission of sound through the atmosphere." The "blank" which I proposed to fill is stated, with unmistakable clearness, to have reference solely to such "causes." Neither Herschel nor Robinson, as far as I know, ever made an experiment on fog-signals; still I quote them. Why? Because they are the most eminent and authoritative exponents of the theories of acoustic opacity which up to last year were entertained by the highest scientific minds. Theirs, moreover, and Arago's (not Prof. Henry's), was the "authority" which "deflected" me at first. Apart from the wind, the "causes" of acoustic opacity indorsed by these eminent men were rain, hail, snow, haze, and fog—everything, in short, that affected the optical clearness of the atmosphere. Prior to the South Foreland investigation, where, I would ask, is a "systematic inquiry" into these causes to be found? Surely, if such an inquiry has been published, it can be courteously pointed out and calmly discussed. If you can prove its existence you will have the right to demand from me the very fullest apology and reparation for stating that "no such systematic inquiry had to my knowledge been made." Even then I could not charge myself with untruth; for my "knowledge" was, and is, arithmetically what I have affirmed it to be; but I can confess ignorance and express regret.

Give me your patience while I endeavor still further to make this matter clear. As regards the invention of instruments and their practical establishment as fog-signals, so far was my knowledge behind "the science of the United States," that I had never seen or heard one of those great steam-whistles until I met them at the South Foreland. The common "siren" is well known to have been a familiar instrument with me, but the fog-signal I first saw and heard upon its native soil in America—not, however, as your critic puts it, but at the request, twice repeated, of Prof. Henry. Further, to the best of my recollection, prior to the month of May, 1873, I had only heard one or two experimental blasts from a fog-trumpet. In such work, then, I had neither part nor lot; and, if you will permit me to say so, though it is of the utmost practical value, I should hardly label such work with the name of "science." Quite apart from those practical achievements lies the inquiry into "the causes which affect the transmission of sound through the atmosphere." And, if I except the sagacious remark of General Duane which has been so curtly brushed aside, not a scintilla of light has been cast upon these causes by any researches ever published by the Lighthouse Board of Washington.

Will you allow me to say, in passing, that Major Elliot, the able and conscientious officer whose excellent "Report on the Lighthouses of Europe" was so displeasing to the board, *did* accept the invitation to Dover, and that to the present hour I feel indebted to him for the information and advice given to me at the time?

Upon my "conduct" and the knowledge which "influenced" it, your critic rings the changes of his wit. It is, after all, a very simple and straightforward matter. The "conduct" consisted in my emphatic advice to the Elder Brethren of the Trinity House not to confine themselves to home-made apparatus, but to include American ones in their inquiry. The subsequent trial led to the abandonment of the English instruments, and the adoption of others from Canada and the United States. The *siren*, for example—which your critic erroneously says was lent "gratuitously" to *me*[1]—was paid for in February, 1874, and two others are at this moment on their way from New York to England. Both by word and deed have we acknowledged our real obligations to the United States; but what we did not and could not acknowledge (for it was non-existent) was, any solution of the conflicting and anomalous results obtained with these fog-signals—results so conflicting and so anomalous as to cause reflecting minds to entertain doubts as to the capacity of the observers. Apart from the friendship shown to me at the time, all that I remember of the meeting at Washington, to which your critic refers, is the utter perplexity of everybody present, myself included, in regard to the matter in hand. I had my guess—others had theirs; but we were quite at sea in our guesses, without a signal to guide us through the intellectual fog.

Knowing, indeed, the difficulty of the subject, when its investigation was first proposed to me by the Elder Brethren, I shrank (as Faraday had done before me) from a work of such obvious labor and such uncertain scientific promise. Doggedly, however, we attacked it, determined to go through the mechanical processes already followed by others, even if they led, as regards science, to an equally barren result. Out of the darkness at length came the dawn. We prolonged our investigations until they embraced every agent, save one, to which influence had been previously ascribed. The exception was snow. This, however, was directly met by observations made upon the *Mer de Glace* in the bitter winter of 1859, and which have been entirely confirmed by the later observations of General Duane. Having negatived antecedent theories, we wrought our way positively to the basis of the whole question. This we found in a cloud-world, invisible to the eye of sense, but as visible and certain to the mental eye as the ordinary cloud-world of our atmosphere. The lights and shadows of these "acoustic clouds"—the action of which must, at one time or another, have been noticed by every peasant within range of a peal of bells—sufficed to account for the most astounding variations of intensity. This, I say, has been established, not only by patient and long-continued observations afloat, but by laboratory experiments as indubitable as any within the range of physical science.

And, let me add, it was neither whistles nor trumpets, nor yet the siren, which pointed out the way to this solution, but experiments with *guns* ably served by artillerymen from Dover Castle.

I will not make any further draft upon your generosity, though, were it worth while to do so, other fallacies of fact and logic in your critic's article might be exposed. He says, or intimates, for example, that I became "adviser" to the Trinity House after my "lecturing tour in the United States in 1873." I relieved Michael Faraday of this duty in May, 1866. My friends in New York have already had

[1] It was lent to the Trinity House Corporation; and I expressly signalize the lending as "an act of international courtesy worthy of imitation."

to disperse other delusions regarding the "profits" of that "tour." Such statements are credible to the mean, incredible to the high-minded, and were therefore never thought worthy of refutation by me. And why should I now waste a word upon your critic's closing sentences? It will not make him noble to be told that envy is ignoble; that, if ever "praise" has been adjudged to me by his countrymen, it is not because I went out of my way to seek it. It came to me unasked—an incident, not an aim—shining, as your own Emerson would put it, pleasantly because spontaneously, upon the necessary journey of my life. It was not, I can truly say, the applause of large assemblies that constituted my chief happiness in the United States, but the ever-growing proof, for the most part undemonstrative, that, without swerving from my duty, I had gained a modicum of the affection of the American people. *That* I prized, and *that* I have sought to keep free from fleck, material or intellectual. For reasons best known to himself, your critic does not relish this relation; and he will damage it if he can. I cherish the belief that he will be unsuccessful. I have the honor to be, your obedient servant,

JOHN TYNDALL.

LONDON, *November* 23, 1875.

## SKETCH OF THOMAS STERRY HUNT, LL.D., F.R.S.

THE subject of the present notice, of whom an excellent portrait appears in this number, although still in middle life, has made extensive contributions to American science during the past generation, and has permanently identified his name with its progress and development. Choosing two of the most rapidly-advancing sciences, chemistry and geology, as his field of work, and studying them especially in their intimate and extensive interactions, he has had a large and honorable share in giving form to our present knowledge upon these subjects. Although an indefatigable experimenter and an extensive observer, Dr. Hunt is also eminently an original and philosophic thinker, and has taken an influential part in the establishment of the most matured scientific theories. He was early in the field of chemical speculation, and aided essentially in that revolution of views which has ended in the establishment of the "new chemistry."

THOMAS STERRY HUNT was born on the 5th of September, 1826, in Norwich, Connecticut, where he received his early education. He began the study of medicine, but soon abandoned it for chemistry and mineralogy, and in 1845 became a private student with the present Prof. Benjamin Silliman at New Haven, acting meanwhile as chemical assistant to Prof. B. Silliman, senior, in the chemical laboratory of

Yale College. In 1847, while preparing to continue his studies in Great Britain, he was chosen to be chemist and mineralogist to the Geological Survey of Canada, then recently established under the direction of Sir William Logan, and having its headquarters at Montreal. This position he held for twenty-five years, resigning it in 1872. He was, during this time, for several years a professor in the Laval University at Quebec, where he lectured on chemistry and geology in the French language, and was afterward Professor of Chemistry and Mineralogy at McGill University, Montreal. Coming to Boston in 1872 he took the chair of Geology in the Massachusetts Institute of Technology, made vacant by the resignation of Prof. William B. Rogers, a post which he still occupies. He has never married.

His earlier scientific labors were chiefly in the domain of chemistry. Prof. B. Silliman, in his "History of American Contributions to Chemistry," which appeared in the "Proceedings of the Centennial of Chemistry" (*American Chemist* for 1874), says:

> "The name of no American chemist occurs more frequently, or in a more important relation to the progress and development of our science during the past quarter of a century, than that of Dr. Hunt. His contributions have been equally valuable in theoretical chemistry, in chemical philosophy, and in geological and mineralogical chemistry. No other author has covered a wider range than he. Not less than one hundred and thirty entries are found under his name in the second and third series of the *American Journal of Science*, and adding those published in Canada, England, and France, and some memoirs in the proceedings of various American societies, the total roll of his papers amounts to about one hundred and sixty titles."

A considerable proportion of these, however, relate to pure geology.

From the "History" just quoted, and from a biographical notice in The American Cyclopædia, we learn of Dr. Hunt's important contributions to theoretical chemistry, and his attempts to introduce into the sciences of chemistry and mineralogy a new philosophy, some points of which will be found in his address in 1874, at the Centennial of Chemistry at Northumberland, Pennsylvania, entitled "A Century's Progress in Chemical Theory." His papers on these subjects were widely copied and translated, and have greatly influenced modern chemistry. At an early date Dr. Hunt prepared a summary of organic chemistry, which he first defined to be the chemistry of carbon and its compounds, and which forms a part of Silliman's "First Principles of Chemistry" (1872). A statement of some of the aspects of the science will be found in the last annual address before the Massachusetts College of Pharmacy, delivered by him, on "The Relations of Chemistry to Pharmacy and Therapeutics" (Boston, 1875); and we present an abstract of this in the present number. It is said of Dr. Hunt, in the notice above referred to, that his researches on the chemistry of soda and mineral waters have probably been more extended than those of any other living chemist. These have been both synthetic and analytic, and we owe to him elaborate studies of the chemistry of lime and magnesia, undertaken with reference to the origin of the native combinations of these bases. Mention should also be made of his contributions to a chemical cosmogony and to a comprehensive theory of chemical and dynamical geology, a sketch of which will be found in his essay on "The Chemistry of the Earth," in the "Smithsonian Report" for 1869.

Dr. Hunt's numerous contributions to chemistry and geology in their technical applications relating to soils, fertilizers, peat, building-materials, the manufacture of salt, and the ores and metallurgy of iron and copper, will be found in the publications of the Geological Survey of Canada, and in part in the proceedings of the Institute of Mining Engineers. *See* also his essay on "The Coal and Iron of Southern Ohio" (Salem, 1874). A large part of the reports of the Canada Survey during twenty-five years was contributed by him, and also the latter half of the large volume entitled "Geology of Canada" (1863).

Among Dr. Hunt's later contributions to geology are his studies of "Granites and Granitic Veinstones;" "The Geognosy of the Appalachians and the Origin of Crystalline Rocks" (1871); and the "History of the Names Cambrian and Silurian in Geology" (1872). His views as to the crystalline, stratified rocks, their genesis, their great antiquity as opposed to the notion of their more recent origin, and his grouping and classification of them, undertaken after many years of research and comparison over a wider field than has been studied by any other American geologist, constitute a new departure in the science. They have attracted much attention, and, despite some attacks, are finding a wide recognition, both in this country and in Europe. The three essays just named, together with some others, on various subjects of chemical geology, including mineral waters, dolomites, gypsum, petroleum, and ore-deposits, with many notes and additions, and with selections from his papers on the philosophy of chemistry and mineralogy, have lately been published in a volume entitled "Chemical and Geological Essays" (Boston, 1875). Of this work a notice appeared in The Popular Science Monthly, vol. vi., p. 372. It is understood that he is now preparing a "Handbook of American Geology." During the past summer he has been engaged in the new Geological Survey of Pennsylvania under Prof. Lesley.

Dr. Hunt was President of the American Association for the Advancement of Science in 1870. He is a member of the National Academy of Science, the American Philosophical Society, and the American Academy of Boston. In 1859 he was elected a Fellow of the Royal Society of London. He is a member of the Imperial Leopoldo-Carolinian Academy of Germany, and of the Geological Societies of France, Belgium, Austria, Ireland, etc. He was a member of the International Juries at the Great Expositions at Paris in 1855 and 1867, and on the latter occasion was made an officer of the Legion of Honor.

# EDITOR'S TABLE.

### *SOUNDING A NEWSPAPER FOG.*

THE readers of the MONTHLY will find elsewhere in our pages an article which appeared several weeks ago in the *Nation*, containing an attack upon Prof. Tyndall, which, from the character of its charges, and the bitterness of its tone, excited the surprise and regret of many. It was replied to by Prof. Tyndall, whose letter we also republish. It will be seen that the assault is directly met, and, in his rejoinder to Prof. Tyndall's letter, the writer in the *Nation* admits that he was in error, while his admission covers the main and most offensive imputations. But, as his further comments are calculated to continue a false impression, and as base charges always go faster and farther than their retractions, especially when considerable time elapses before they can be authoritatively contradicted, it is desirable that we should here briefly review the leading features of the case.

The charge against Prof. Tyndall, as the reader will see, is generally, that, in the third and recently-published edition of his work on "Sound," he has not done justice to the contributions of American science toward the elucidation of the subject of fog-signals. More specifically it is that, when in this country, he got information upon the subject from a paper read by Prof. Henry, went home and entered upon the investigation himself, published in his book the results of his own inquiries, and, while acknowledging that he knew generally of what had been done in America, and that it was not without influence on his conduct, yet that he ignored or "suppressed" from his summary of existing knowledge upon the subject any recognition of what had been accomplished by the United States Lighthouse Board under the direction of Prof. Henry.

Now, let us see what Prof. Tyndall's position was as avowed by himself in a statement widely published in this country months before the attack in the *Nation* was made. The August number of THE POPULAR SCIENCE MONTHLY contains, in full, the preface to the third edition of "Sound," in which the American relations of the matter are considered. A summary is there given of the experiments of Prof. Henry in regard to the penetration of fog by sound, and the performance of various instruments of American construction designed to be used as coast-signals; and the remark is added that "it is quite evident from the foregoing that, in regard to the question of fog-signaling, the Lighthouse Board of Washington have not been idle." Prof. Tyndall states, furthermore, that he had recommended American instruments for fog-signaling to the British authorities as superior to the English instruments, and that they had been adopted on his recommendation. Every fair-minded reader, upon perusal of that paper, will agree, we think, that Prof. Tyndall wrote truthfully when he said: "In presence of these facts it will hardly be assumed that I wish to withhold from the Lighthouse Board of Washington any credit which they may fairly claim."

But, having thus testified to the character, extent, and importance of American work upon this subject, Prof. Tyndall proceeds to state what in his opinion the Lighthouse Board has failed to do. He says: "My desire is to be strictly just; and this desire compels me to express the opinion that their report fails to establish the inordinate claim made in its first paragraph. It contains observations, but contradictory observations; while, as regards the establishment of any principle which should reconcile the conflicting results, it leaves our condition unimproved."

A distinction is here drawn, and again recognized in his letter, that goes to the root of the subject; the distinction, namely, between experiments on fog-signals made for direct purposes of utility, and similar experiments conducted with a view to the establishment of scientific principles. This discrimination is all-important. It is no doubt possible to have both objects more or less in view in such an inquiry; but it is also possible that either may so predominate as to characterize the respective courses of investigation, and yield very dissimilar results. Elaborate experiments may promote practical ends, and contribute little or nothing to science; or they may advance scientific knowledge without any immediate influence upon practice. It was claimed by Prof. Henry, in his Appendix to the report of the Lighthouse Board for 1874, that the researches of the board had been more extensive on this subject than those in England, as well as prior to them; but the question remains, To what purpose were they carried on? The answer to this question, defining the character and object of the inquiries, is immediately given in the statement that the American results of "practical importance" are in advance of the English. The writer in the *Nation* speaks of "American science" as bearing Baconian fruit, such as Daboll's trumpet and Brown's steam-siren. These devices and construction are, no doubt, highly important, but there is certainly a wide difference between the invention of whistles and systematic inquiries into the causes of acoustical phenomena. No one doubts the immense value to the country and to civilization of the labors directed by Prof. Henry, as chairman of the Lighthouse Board; but he has himself declared their practical character, and how broadly true is this characterization appears from a passage in a letter which he wrote to the Secretary of the Treasury, dated February 22, 1875, defending the Washington board against an attack made upon it in Congress. It is noteworthy, also, as showing that, when Prof. Henry wishes to protect himself from adverse criticism, he falls back upon the verdict pronounced by Prof. Tyndall in this very matter of fog-signals. Prof. Henry said: "The board has a standing committee on experiments which has accepted and sought to test every invention that could be supposed to aid the mariner. Many illuminants, various devices in engineering, expedients for floating aids, plans, and theories of all kinds, have received its attention. To this accusation can be opposed on behalf of the board the verdict of foreign nations, the tributes of scientific associations, and the contented judgment of maritime and commercial men from whom no complaints are received. Its buoys are excellent in their construction; its buoy-service is well performed; its light-ships are equal to any in the world; its lights are entirely satisfactory to the commercial and nautical men for whose interest they are maintained; and its fog-signals surpass, in the finding of Prof. Tyndall, who conducted a series of experiments for the Trinity House Board, those of all other nations, and have been adopted for England." But it is claimed that Prof. Henry's investigations constitute also an important contribution to "American science," in relation to fog-signaling. Prof. Tyndall denies that they have at all advanced our scientific knowledge upon the subject, and the writer in the *Nation* had this denial before him when he wrote. It was his plain business, then, to disprove it if he could, and give the evidence that Prof. Tyndall was in error.

The simple question is, What new scientific principles have been established, or what causes elucidated by

Prof. Henry's investigations, constituting an advance of scientific knowledge in this branch of acoustics, that Prof. Tyndall has omitted or "suppressed" in his work? If any thing has been accomplished in this country toward the scientific solution of such acoustical problems in relation to fog-signaling—if any new light has been cast upon the phenomena that explains anomalies and reconciles contradictions, which was not acknowledged by Prof. Tyndall in his book—we submit that it was the obvious duty of the writer in the *Nation* to point out what it was. He should have indicated the gap in Prof. Tyndall's summary of the present state of knowledge, or he should have shown us what principles or results, there stated, are due to American research. He says: "It is no part of our present purpose to institute a critical inquiry into the conflicting views of Prof. Henry and of Prof. Tyndall with regard to the hypotheses respectively espoused by each for the explanation of the phenomena of sound, in its passage through wide tracts of air." Yet the whole question turns on the scientific "views" contributed by Prof. Henry which it is alleged that Tyndall has ignored. He speaks of the views "respectively espoused" by the parties; but the question is on the views *originated*. Prof. Henry is understood to adopt the theory propounded by Prof. Stokes at the British Association in 1857, according to which sound-waves are tilted through the air under the influence of wind. That theory is certainly not "suppressed" from the new edition of "Sound." In his rejoinder to Prof. Tyndall's letter, the *Nation's* critic reaffirms his assertion, saying, "The question between us is not one of *science*, but of *historical fact*." But his complaint in the first article was certainly of the non-recognition of "American science." Obviously Prof. Tyndall had to decide what is science and what is not, which looks to us very much like a scientific question. In his "summary of existing knowledge," it was not his business merely to chronicle experiments. He had to deal only with such systematic inquiries into causes as yield results properly entitled to take their place in the body of scientific knowledge. We do not say that Prof. Henry's researches have failed to extend the domain of positive scientific knowledge, but only that the writer in the *Nation* was bound to establish this, before accusing Prof. Tyndall of delinquency in not recognizing it.

But it is the closing passage of the *Nation's* article which has excited the greatest surprise, betraying, as it obviously does, a vicious state of feeling on the part of the writer. He there represents Prof. Tyndall as having claimed to demolish the authority of Prof. Henry, and as swaggering over the "ruin" he had accomplished. In half a dozen lines, Tyndall is accused of "superciliousness," "self-complacency," "vanity," "conceit," "arrogance," and "self-laudation;" and this upon an utterly false and absurd interpretation of some incidental remarks in his preface. The following is the passage that called forth this storm of offensive epithets:

"The clew to all the difficulties and anomalies of this question is to be found in the aërial echoes, the significance of which has been overlooked by General Duane, and misinterpreted by Prof. Henry. And here a word might be said with regard to the injurious influence still exercised by authority in science. *The affirmations of the highest authorities, that from clear air no sensible echo ever comes, were so distinct, that my mind for a time refused to entertain the idea.* On the day our observations at the South Foreland began, I heard the echoes. They perplexed me. I heard them again and again, and listened to the explanations offered by some ingenious persons at the Foreland. They were an 'ocean-echo;' this is the very phraseology now used by Prof. Henry. They were echoes 'from the crests and slopes of the waves;' these are the words of the hypothesis which he now espouses. Through a portion of the month of May, through the whole of June, and through nearly the whole of July, 1873, I was occupied with these echoes; one of the phases of thought then passed through, one of the solutions then weighed in the balance and found wanting, being identical with that which Prof. Henry now offers for solution.

"But though it thus deflected me from the proper track, shall I say that authority in science is injurious? Not without some qualification. It is not only injurious, but deadly, when it cows the intellect into fear of questioning it. But, the authority which so merits our respect as to compel us to test and overthrow all its supports before accepting a conclusion opposed to it, is not wholly noxious. On the contrary, the disciplines it imposes may be in the highest degree salutary, though they may end, as in the present case, in the ruin of authority. The truth thus established is rendered firmer by our struggles to reach it."

A correspondent of the *Nation* from Baltimore, quoting the above passage, characterizes the "glaring injustice" of the concluding portion of its article, and adds: "Any candid reader can see that the passage on which your reviewer bases such serious imputations cannot possibly bear the interpretation which every one reading it as given in your review is compelled to put upon it. Prof. Tyndall never indicates that it was the authority of Prof. Henry that impeded him in his researches." The sentence italicised in the extract upon the previous page is perfectly conclusive in showing what Prof. Tyndall did mean by the authority which embarrassed him until he rejected it.

In his letter Prof. Tyndall puts an end to the charge, so that the *Nation* is compelled to acknowledge itself "in error in supposing that the claim of Dr. Tyndall to have ruined authority was aimed at Prof. Henry." One would think that, when the *Nation's* critic had been convicted of blundering by a correspondent, and when his fabric of detraction had been so effectually demolished by Prof. Tyndall himself that the writer was compelled to back out of it, he would have had the grace to drop the subject. But, on the contrary, he renews the insulting imputation. Having made a slanderous charge entirely upon the assumption that Prof. Tyndall was exulting in the ruin of Prof. Henry's authority, and having barbed his article with this libel, when it was swept away, he says: "It would have been more in order for him to show the propriety of his language in claiming to have 'ruined' the 'authority' of any one among his scientific predecessors, for it was on the alleged self-conceit implied in such a claim as made by himself that we based our 'peroratory invective.'"

Now, we aver that there is nothing in the passage quoted that is open to the offensive construction here put upon it, and which never would have been thought of, but for the unscrupulous distortion of its meaning by the *Nation's* critic; but that the real import of the extract is entirely contrary to that which has been ascribed to it. That which was written to enforce the lesson of cautious self-examination and circumspection in dealing with the mental difficulties of scientific research is wrested into an opposite expression of arrogance and self-conceit. It is not to be forgotten, here, that the scientific man, to the extent of his originality and power, is a questioner of things established. His attitude is that of an enemy of authority. It is his recognized business, as evinced by the common forms of speech, to "subvert" authority, to "break down" authority, to "overthrow," "crush" and "ruin" authority. Call the motive which impels the man of science what you please, the fact remains that in virtue of his being a man of science, aiming to arrive at new views, he is a destroyer of authority. But just because this is his necessary work he is in danger from the state of mind it produces; and it becomes important not to forget that there is good as well as bad in authority. Prof. Tyndall simply intimated the need there is that the inquirer should be on his guard. Every one familiar with his writings is aware that he differs from most of his scientific colleagues by looking habitually from the subject he is investigating to the working of his own mind in the investigation, and by frequently throwing parenthetical remarks of a philosophical, rather than of a strictly scientific significance, into his expositions. The interjected observations about authority in the preface are clearly of this kind. In his "Lectures on Light," second edition, page 80, he remarks: "Newton's espousal of the emission theory is said to have retarded scientific discovery. It might, however, be questioned whether, in the long-run, the errors of great men have not really the effect of rendering intellectual progress rhythmical, instead of permitting it to remain uniform, the retardation in each case being the prelude to a more impetuous advance. It is confusion and stagnation rather than error that we ought to avoid." Now, the underlying thought in the passage from the preface above quoted is manifestly the same as that here expressed. The object in both cases is, simply to bring out the uses of authority, and no candid reader will recognize any element of "self-laudation" in the one case any more than in the other.

It has hitherto been thought that, as discoveries are the result of mental operations, science is always the gainer, when an intelligent account is given of the intellectual processes by which a new result is reached; but it now seems that if one refers to his own thoughts he must expect to be snubbed as an egotist. And, particularly, if he attains conclusions of moment, involving the upsetting of former theories, and where it is of increased importance to know the mental operations that lead to them, he will be pretty certain to find some mocking cynic who will twit him with his "self-consciousness, explaining to itself and to others how it grew so great." It is a little comical, however, to take lessons in humility from a writer who mounts the judgment-seat and exhausts the vocabulary of abuse in depreciating others; or to listen to homilies on modesty from a journal that sets up each week to criticise all that is going on in the universe—while both are convicted of detraction on the basis of the most brazen perversions.

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### "*THE CONFLICT OF AGES.*"

We ask careful attention to the argument of President White on the "Warfare of Science," the first installment of which opens the present number of the Monthly, and the second of which will appear in our next issue. The import of his clear-cut thesis, and the vigor, learning, and logical force, with which it is sustained, will command the admiration of all intelligent students of the subject. But that which makes President White's discussion unique, and especially valuable, at this time, is the copious notes and references by which it is enriched and fortified, and which open the way to the whole literature of the question for the benefit of those who desire to consult the original authorities. At this time, when the hot temper of controversy leads to much random and reckless statement, it is desirable to know, very clearly, what can be proved, and where the proof can be found: President White's article is, therefore, opportune, and will be especially valued at present, while it must also take its place as a permanent contribution to a question which is bound to be of increasing interest in the future.

That we may not be accused of partiality or injustice to opposite views, we print also, in this number, an elaborate and earnest argument, delivered at the inauguration of Vanderbilt University, by Dr. Deems, on the other side of the question. The address is liberal in spirit, and often bold in its concessions, but we can hardly assent to its opening declarations. The author maintains that "the recent cry of 'the Conflict of Religion and Science' is fallacious and mischievous to the interests of science and religion, and would be most mournful if we did not believe that, in the very nature of things, it must be ephemeral. Its genesis is to be traced to the weak foolishness of some professors of religion, and to the weak wickedness of some professors of science."

On the contrary, we consider this conflict to be natural and inevitable, to be wholesome rather than mischievous; and having convulsed the world for centuries, and being still rife, with little prospect of speedy adjustment, we hardly see how it can be regarded as "ephemeral." Nor can it be much dependent upon the attributes here assigned to some of the controversialists. If the said professors of religion were brayed in a mortar until all their folly departed from them, and the said professors of science were all regenerated, the relations of the subjects would still give rise to hostility, and raise up new antagonists. No truce among the leaders can affect the deeper issues as viewed by the general mind. Something ought to be learned from experience, and that there has been a long and fierce antagonism between what has passed under the name of religion, and what has passed under the name of science, is sufficiently shown from the evidence furnished by President White. That the antagonism continues, is not because of the wrong-headedness of a few partisans who are bent upon stirring up strife, but because science is driving on with its researches, regardless of any thing but the new truth it aims to reach, while the religious world is full of anxiety and dread about what is going to happen as a consequence of this uncontrollable movement. Those who think the existing phase of the alleged conflict illusive are requested simply to consider the attitude of mind of the great mass of devout and sincerely religious people toward the more advanced scientific conclusions and scientific men of the present day. It is no test of the matter to determine how the great body of religious people now regard the science established in former times. The religious liberality of each age is put upon its trial by the questions arising in each age. In our own time biology is the branch of science that is most progressive and occupies the attention of, perhaps, the largest number of investigators who are busy inquiring about the origin of life, the antiquity of man, cerebral psychology, the laws of force manifested in living beings, and the evolution of organic forms in the course of Nature. How are such inquiries regarded by the multitude of devoutly religious people? Are they not considered "dangerous?" Are they not viewed by this class exactly as the new doctrines in astronomy and geology were viewed by the same class in former times, that is, as hostile to faith and subversive of religion? Is there no conflict here? Are the brand of "materialism" which is put upon biological study in our times, and the charge that a materialistic science is aiming to cut up religion by the roots, indicative of harmony between these parties? Science must go on, and, if her results thus far are bad, there is no prospect that they will be better in the future. There can be only one basis of substantial peace, and that is the entire indifference of religious people, *as such*, to the results of scientific inquiry. This they cannot attain until far better instructed than at present; and we apprehend that it will take very considerable time to reach that desirable consummation.

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### *END OF THE PENIKESE SCHOOL.*

The proposition made three or four years ago, and due, as we understood, to Prof. Shaler, to establish a School of Natural History at Nantucket for the benefit of the teachers of the country, and at the time of their vacation, we thought one of the most feasible and important educational movements of the time. The plan was comprehensive, involving the services of some twenty lecturers who were masters of the several departments of natural history; and it was received with such favor throughout the country, that it was certain a very large number of students would have collected there to avail themselves of the superior instruction that could have been afforded. The island, besides, was conveniently accessible, and the accommodations offered by the town ample, excellent, and moderate in price. There was, in short, large practical promise in the enterprise.

But it was not carried out, and in its stead there grew up another school in natural history, under the auspices of Messrs. Agassiz and Anderson, on another island, difficult of access and without accommodations. But few pupils could be taken, and the large expenses of the experiment, under the peculiar circumstances, had to be defrayed from without. The necessary funds not being forthcoming, the project collapsed, and the school is numbered among the things that were. Much regret has been expressed at the result; but we shed few tears over the failure of the Penikese School. Why should money be wasted in sustaining a school in an ill-chosen station that limits its usefulness and entails inordinate expense? We observe that the editor of *Nature*, in announcing the abandonment of the institution, and explaining the unpleasant controversy that accompanied it between Mr. Anderson, the donor of the island, and the trustees, speaks in a tone of strong regret at the result. He thinks it unfortunate that Mr. Anderson had not contributed a little more money, as, "had he done so, those interested in the success of the school would have had time to set about raising something like an endowment fund, and *a fine opportunity would have been afforded to the United States Government to show their appreciation of practical scientific teachers and scientific research.*" The italics here are our own, and the suggestion they convey admirably illustrates the easy tendency and universal readiness there is to go to Government for help to sustain every thing that cannot be sustained by the appreciation and liberality of the community. A school absurdly located, costly, and restricted, is not supported by the public—with all its appreciation of education and readiness to contribute to it whenever its contributions are wisely expended—and so the state is invoked to assume the burden due to bad calculations. We think it is a good deal better that the concern should have been wound up than to have dragged along in a precarious way, or got a subsidy from the Legislature, as it will perhaps cease to be a hindrance to the organization of other schools in better circumstances.

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### *THE EDUCATION QUESTION AT MONTPELLIER.*

There are many indications of a very serious struggle, almost coextensive with civilization, between ecclesiastical authority and the liberal spirit of the age on the subject of education. Religion may not be responsible for it, but religious bodies are involved in it, and it threatens to become a matter of increasing difficulty, notwithstanding our vaunted enlightenment and the success of free government. The most numerous sect of Christendom has its own policy on the subject of education, and clings to it invincibly, though with a wise discretion in the avowal of its claims. The passages given in the following letter are an undisguised statement of the demands of the Romish Church as to its right to educate mankind.

The following letter from Prof.

Tyndall, bearing upon this subject, lately appeared in the London *Times:*

"A learned French friend has favored me with a copy of a letter recently published in France, and bearing the following title: 'Letter of Monsignor the Bishop of Montpellier to the Deans and Professors of the Faculties at Montpellier.' Its date is the 8th of this month of December, 1875. One or two extracts from it may not be without their value for the people of England and of America, to whom, in our day, has fallen the problem of education in relation to the claims of Rome.

"The bishop writes to the deans and professors aforesaid:

"'Now, gentlemen, the holy Church holds herself to be invested with the absolute right to teach mankind; she holds herself to be the depositary of the truth—not a fragmentary truth, incomplete, a mixture of certainty and hesitation, but the total truth, complete, from a religious point of view. Much more, she is so sure of the infallibility conferred on her by her Divine Founder, as the magnificent dowry of their indissoluble alliance, that even in the natural order of things, scientific or philosophical, moral or political, she will not admit that a system can be adopted and sustained by Christians, if it contradict definite dogmas. She considers that the voluntary and obstinate denial of a single point of her doctrine involves the crime of heresy, and she holds that all formal heresy, if it be not courageously rejected prior to appearing before God, carries with it the certain loss of grace and of eternity.

"'As defined by Pope Leo X., at the Sixth Council of the Lateran, "Truth cannot contradict itself; consequently, every assertion contrary to a revealed verity of faith is necessarily and absolutely false." It follows from this, without entering into the examination of this or that question of physiology, but solely by the certitude of our dogmas, we are able to pronounce judgment on any hypothesis which is an anti-Christian engine of war rather than a serious conquest over the secrets and mysteries of nature.'

"Liberty is a fine word, tyranny a hateful one, and both have been eloquently employed of late in reference to the dealings of the secular arm with the pretensions of the Vatican. But 'liberty' has two mutually exclusive meanings—the liberty of Rome to teach mankind, and the liberty of the human race. Neither reconcilement nor compromise is possible here. One liberty or the other must go down. This, in our day, is the 'conflict' so impressively described by Draper, in which every thoughtful man must take a part. There is no dimness in the eyes of Rome as regards her own aims; she sees with a clearness unapproached by others that the school will be either her stay or her ruin. Hence the supreme effort she is now making to obtain the control of education; hence the assertion by the Bishop of Montpellier of her 'absolute right to teach mankind.' She has, moreover, already tasted the fruits of this control in Bavaria, where the very liberality of an enlightened king led to the fatal mistake of confiding the schools of the kingdom to the 'doctors of Rome.'

"Your obedient servant,

"John Tyndall.

"Athenæum, *December* 16, 1875."

The University of Montpellier, to the deans and faculties of which the above notification is addressed, is one of the oldest and most honored universities of Europe. It was founded in the twelfth century, its medical faculty by the Spanish Arabs. Situated in what was formerly called Languedoc, one of the southern portions of France, it has a botanical garden, the first that was established in Christendom. Its Observatory has for ages been in repute, its Museums of Natural History and Fine Art have long been celebrated. It has made its city one of the intellectual centres of France.

In this university was first translated into Latin Ptolemy's great Greek work, the "Alma Gest." One of the regents was the first European to make tables of the moon, and to determine the obliquity of the ecliptic. He is honorably mentioned by Copernicus. In literature it is distinguished by being the seat of the earliest cultivation of a modern language. From the romance literature of Langue d'Oc, Petrarch and Dante took their inspirations.

But in another respect it has a memorable celebrity. Here the Inquisition was first organized, and Languedoc was the seat of the most dreadful persecutions that the world has ever witnessed. Thousands of persons were put to death, whole cities were burnt. The French Protestantism of the middle ages was extinguished by fire and sword. The professors and doctors of the university were expelled from the country.

Six centuries have not sufficed to abate this ecclesiastical bigotry. There is the Bishop of Montpellier claiming for his Church the exclusive right to teach mankind. He leaves no doubt as to what sort of teaching it would be. Nothing inconsistent with the dogmas of the Church. None of your astronomy, or geology, or physiology, or other atheistic sciences. Let American colleges and universities lay this thing to heart! Their turn may some day come.

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## LITERARY NOTICES.

The Nature of Light, with a General Account of Physical Optics. By Dr. Eugene Lommel, Professor of Physics in the University of Erlangen. With 188 Illustrations. D. Appleton & Co. No. XIX. "International Scientific Series." Pp. 356.

A book has long been wanted, making clear to the popular mind the most interesting and important principles of the beautiful science of optics. The subject is usually treated in a meagre way as a subdivision in our text-books of physics, and, even in the largest of these, the discussion of light is usually very incomplete. But no subject is more worthy of separate treatment, and Dr. Lommel has made a volume well worthy of its position in the "International Scientific Series." An interesting portion of one of his chapters, that dealing with the curious and wonderful phenomena of fluorescence, is given in our present number, furnishing a fair illustration of the clearness of the author's writing and the freshness of his presentation.

In an elaborate notice of the work, which appeared in *Nature*, it is remarked: "In the present treatise, Prof. Lommel has given an admirable outline of the nature of light and the laws of optics. Unlike most other writers on this subject, the author has, we think wisely, postponed all reference to theories of the nature of light, until the laws of reflection, refraction, and absorption, have been clearly set before the reader. Then, in the fifteenth chapter Prof. Lommel discusses Fresnel's famous interference experiment, and leads the reader to see that the undulatory theory is the only conclusion that can be satisfactorily arrived at. A clear exposition is now given of Huyghens's theory, after which follow several chapters on the diffraction and polarization of light-bearing waves. The reader is thus led onward much in the same way as the science itself has unfolded, and this, we think, is the surest and best way of teaching natural knowledge."



Mind: A Quarterly Review of Psychology and Philosophy. No. I., January, 1876. Pp. 156. Price $1.00, subscription $4.00 a year. Republished by D. Appleton & Co., New York.

We have here the promise of a periodical new in its plan, broad and important in its scope, and very ably sustained. It represents the new departure in psychological study, from the point of view taken by Bain and the modern school; in fact, the project of its establishment is largely due to Prof. Bain himself, who will have an active share in its management, although the responsible editor is Prof. George Croom Robertson, of University College, London. The range and quality of this work will be best gathered from the following passages taken from the prospectus:

"MIND will be an organ for the publication of original researches, and a critical record of the progress made in Psychology and Philosophy.

"Psychology, while drawing its fundamental data from subjective consciousness, will be understood in the widest sense, as covering all related lines of objective inquiry. Due prominence will be given to the physiological investigation of Nerve-structures. At the same time, Language and all other natural expressions or products of mind, Insanity and all other abnormal mental phases, the Manners and Customs of Races as evincing their mental nature, mind as exhibited in Animals generally—much of what is meant by Anthropology, and all that is meant by Comparative Psychology—will come within the scope of the Review.

"The practical application of psychological theory to Education will receive the attention it so urgently claims at the present time.

"Beyond Psychology, account will be taken of Logic, Æsthetics, and Ethics, the theory of mental functions being naturally followed by the doctrine of their regulation.

"For the rest, MIND will be occupied with general Philosophy. Even as a scientific journal, it cannot evade ultimate questions of the philosophical order, suggested as these are with peculiar directness by psychological inquiry. There is, also, a function truly philosophical which only the investigator of mind is in a position to discharge, the task, namely, of collating and sifting the results of the special sciences with a view alike to insight and conduct. But MIND will, further, expressly seek to foster thought of bold sweep—sweep that can never be too bold, so be that it starts from a well-ascertained ground of experience, and looks to come again there to rest."

The first number well justifies the promises here made, and there is every reason to believe that the succeeding issues will do so in a still greater degree.

Report of the Forty-fourth Meeting of the British Association for the Advancement of Science: held at Belfast, in August, 1874. London: John Murray, 1875.

One of the most valuable features of the yearly volumes of the British Association is the publication of extended "Reports on Researches in Science," which are annually made on special subjects by small committees of eminent men who are themselves working in those subjects. Thus, in the volume before us, there are no less than *thirty* such reports, occupying about 360 octavo pages. The Association often aids in an investigation by the appropriation of a small sum of money, and in return it receives a report on the progress of the work, besides the gratification of having assisted some research that otherwise might have been long delayed.

For instance, since 1848 reports have been given upon the observations of Luminous Meteors, which contain nearly all the known facts relating to meteorites, arranged in an orderly form, and in some degree sifted. This report for 1873–'74 contains 90 pages.

Reports on Earthquake Phenomena, on Tides, on the Waves of the Atmosphere, on Magnetic and Meteorological Observations, and many other similar subjects, are to be found in the pages of the past volumes, and often the facts of such reports are collected nowhere else. From the present volume we extract almost at random the titles of a few of these reports, which may serve to show the nature of the subjects which are yearly brought to the attention of the meetings: "Report on the Recent Progress and Present State of Systematic Botany" (27 pages); "On the Rainfall of the British Isles for 1873–'74" (43 pages); "On the Treatment and Utilization of Sewage" (14 pages); "On Cyclone and Rainfall Periodicities in Connection with Sun-spots" (23 pages); "On the Erratic Blocks of England and Wales" (8 pages); "On Instruments for measuring the Speed of Ships" (9 pages), etc. The committees making these reports counted among their members the most eminent men of England—Lyell, Lubbock, Boyd-Dawkins, Bentham, W. K. Clifford, Balfour Stewart, Clerk-Maxwell, Huxley, Galton, Sir William Thomson, Huggins, Lockyer, De la Rue, and many others scarcely less known. With such subjects reported on by so eminent specialists, it is easy to see how these reports have come to have so high a value.

The Belfast meeting was attended by nearly 2,000 members, and over £2,000 was received from fees, etc.; £1,080 was appropriated for scientific purposes; £400 for various works of the section of mathematics and physics (printing mathematical tables, rainfall and meteor reports, thermo-electricity, etc.); £155 for researches in chemistry; £280 for various geological explorations; £170 for biology; £100 for the Palestine Exploration Fund; £25 for statistics (economic effect of combinations of laborers or capitalists); and £50 for instruments for measuring the speed of ships. This abstract will give some idea of the practical benefit to science which the Association gives, and it is also instructive as showing for what purposes its money is spent.

The last 232 pages of the volume are devoted to an abstract of the proceedings of the sections. We find that the section of mathematics and physics occupies 44 pages, the chemical section has 22 pages, geological 29 pages, biological 64 pages, geographical 24 pages, statistical 27 pages, and finally that the mechanical section occupies 20 pages. In a rough way this shows the amount of attention paid to the various branches at the 1874 meeting, and it is accurate enough to indicate the great amount of work now doing in biology in England, which is a noteworthy feature of this and preceding reports.

Strength of Beams under Transverse Loads. By W. Allan. Pp. 114. Also Sewerage and Sewage Utilization. By W. C. Corfield, M. A. New York: Van Nostrand. Pp. 128. Price, 50 cents each.

In the first of these two little volumes the practical builder will find a discussion of the most important and common cases of horizontal beams under vertical loads. The problems are worked out without having recourse to the higher mathematics. The second volume contains, in abridged form, a series of lectures delivered by Prof. Corfield before the School of Military Engineering at Chatham, England. The question of sewerage and sewage utilization is one of the urgent problems of modern life, and it yet awaits satisfactory solution. Meanwhile, Mr. Van Nostrand does the public a service by placing within the reach of all the views of so eminent an engineer as Prof. Corfield upon these subjects.

Notes of the Manufacture of Pottery among Savage Races. By Ch. Fred. Hartt, A. M. Pp. 70. Rio de Janeiro: *South American Mail* print.

Prof. Hartt here, in the first place, briefly considers the question of the origin of the ceramic art. When, where, how did it originate? No positive answer can be given to these questions. Like other human arts, it is the result of a long evolution, and its simple beginnings we may never be able to find out. So much, however, is certain, namely, that the finest porcelain wares are the true lineal descendants from the pottery of the savage. The author next considers the materials employed and the methods followed in the building of a vessel. Before the advent of Europeans, pottery in America was made by hand, the potter's wheel being unknown. He finds the method of fashioning vessels out of coils of clay widely practised in South America. The manufacture is everywhere exclusively in the hands of the women.

The Difference of Thermal Energy transmitted to the Earth by Radiation from Different Parts of the Solar Surface. Pp. 10.

This is a reprint of a communication in *Nature* by Mr. John Ericsson, in which he points out defects in Father Secchi's method of measuring the intensity of the sun's radiant heat. Secchi's method is that of projecting the sun's image on a screen, and then measuring the temperature at different points by means of thermopiles. Ericsson adopts the method of *direct* observation, and employs a special apparatus devised by himself. Mr. Ericsson estimates the absorption by the solar atmosphere at not over 0.144 of the radiant heat emanating from the photosphere. The intensity of radiation from the border of the sun he estimates at 0.638 of the intensity of radiation from an equal area of the central region.

Check-List of Noctuidæ of America, north of Mexico. By A. R. Grote, A. M. Pp. 28, with Plate. Price, $1. Buffalo, N. Y.: Reinecke & Zesch.

Of the twelve hundred North American species of *Noctuæ*, less than thirty, we are informed by Mr. Grote, are considered identical with European forms. The facts seem to point to a common origin of many of the forms, and it is the author's opinion that the European and North American *Noctuæ* are in part descended from species living over a common territory, and that the Glacial epoch separated the stocks. The list of species here given includes a complete synonymy of the *Noctuidæ* of America north of Mexico, so far as known. It is invaluable to the student of entomology.

State Medicine in its Relations to Insanity. By Dr. Nathan Allen. Pp. 31.

Dr. Allen considers the subject of insanity in the six New England States. He finds that in Massachusetts, from 1850 to 1870, the increase of insanity was 12 per cent. greater than the increase of population, and the same is to be said of the other New England States. He favors consigning the chronic insane to *homes*, instead of keeping them in hospitals. What they need is, not medical treatment, but suitable exercise, sunlight, air, proper nourishment, etc. He also advocates the adoption by the State of measures for the *prevention* of insanity. The dissemination of more correct views of the true way of living and a more rigid observance of the laws of health and Nature would, no doubt, greatly diminish the frequency of mental disease.

The New Method of Graphical Statics. By A. J. Du Bois, C. E., Ph. D. 60 Illustrations. Pp. 80. Price, $2. New York: Van Nostrand.

This book is made up of a series of articles which appeared originally in Van Nostrand's *Engineering Magazine*. The author's object is to win more general attention to a new method for a graphical solution of statical problems, which, during the last ten years, has been gradually developed and perfected, and which offers to the architect, civil engineer, and constructor, a simple, swift, and accurate means for the solution of a great number of practical questions.

Report upon the Condition of Affairs in Alaska. By H. W. Elliott. Washington: Government Printing-Office. Pp. 277.

In 1874 Mr. Elliott was directed by the Treasury Department to visit Alaska, for the purpose of studying and reporting upon the present condition of the seal-fisheries; the haunts and habits of the seal; the preservation and extension of the fisheries; the statistics of the fur-trade; and the condition of the natives. The results are contained in the volume before us. The work is full of valuable information. It is divided into nine chapters, treating of the "Character of the Country;" "Condition of the Natives;" "Duty of the United States Government;" "Trade and Traders;" "The Sea-Otter;" "The Seal-Islands;" "Habits of the Fur-Seal;" "The Sea-Lion;" "Fish and Fisheries;" and the "Ornithology of the Prybilov Islands."

Our Wasted Resources. By William Hargreaves, M. D. New York: National Temperance Society. Pp. 201. Price, $1.25.

Dr. Hargreaves quotes statistics to show that, in 1873, the income of the people of the United States exceeded $7,000,000,000. He thinks that, to the use of intoxicating drinks, nearly all of the crime and pauperism of the country is to be attributed. He compares the cost of intoxicating liquors with the total receipts of sundry industries; sums up the losses of the country from the trade in liquors; tries to show that the use of liquors and the liquor-trade destroy the influence of education. Finally, he lays down the proposition that "the use of and the traffic in strong drinks impede the progress of the Christian Church, and the spread of the gospel."

Notes of Travel in Africa. By C. J. Andersson. New York: Putnam's Sons. Pp. 318. Price, $2.00.

There appears to exist in the public mind a genuine interest in the exploration of Africa, and the number of books of African travel published within the last ten years is enormous. The writings of C. J. Andersson have in no small measure contributed to the awakening of this curiosity, and doubtless the present work, made up from the memoranda of that distinguished traveler, will be read with the same eagerness as his earlier publications.

Dissertations and Discussions. By J. Stuart Mill. New York: Holt & Co. Pp. 294. Price, $2.50.

This is the fifth volume of the "Dissertations and Discussions," and it completes the series. It contains five papers on "Land Tenure;" also essays on "Endowments;" on "Labor;" on "Treaty Obligations;" on Maine's "Village Communities;" Taine's "Intelligence;" Grote's "Aristotle;" Baer's "L'Avere e l'Imposta;" and Leslie's "Land Question."

A Practical Treatise on Soluble Glass. By Dr. Lewis Feuchtwanger. Pp. 164. New York: L. Feuchtwanger & Co.

The author points out the manifold uses of soluble glass, for instance, as a means of preserving timber and making it non-inflammable; as an ingredient in the composition of artificial stone; for mixing with paints to be applied to the surface of metals, glass, and porcelain; in soap-making; in calico-printing, etc.

Report of the Commissioner of Education for 1874. Pp. 935.

Contains, in addition to the observations and suggestions of the commissioner, a great mass of statistics relating to the state of education throughout the country in the year 1874.

Dr. Draper's "Conflict."—There have been published of Dr. Draper's book, "The Conflict," eight editions in America, and five in London. It has been translated into French, and is in its third edition in Paris. The German translation made by Dr. Rosenthal has had a similar success. A Polish translation has been made in the University of Warsaw; a Servian one by Prof. Meta Rakitch, in Belgrade. The Spanish translation is by Señor Arcemis, the astronomer of Cadiz. The Russian is under examination by the censorship.

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PUBLICATIONS RECEIVED.

Exploration of the Colorado River of the West. By Major J. W. Powell. Washington: Government Printing-Office. Pp. 291, with Maps.

Science By-ways. By R. A. Proctor. Philadelphia: Lippincott. Pp. 422. Price, $4.00.

Selection and Use of the Microscope. By J. Phin. New York: Industrial Publication Co. Pp. 131. Price, 75 cents.

Report on the Wisconsin Institution for the Blind, 1875. Madison, Wis.: E. B. Bolens. Pp. 20.

Bulletin of the United States National Museum, No. 2. Washington: Government Printing-Office. Pp. 50.

American Journal of Microscopy. Monthly. New York: Industrial Publication Co. 50 cents per year.

Forms of Life found in the Oral Cavity. By C. N. Peirce, D. D. S. Lancaster, Pa.

Pennsylvania Journal of Dental Science. Pp. 23.

Bridge and Tunnel Centres. By J. B. McMaster. New York: Van Nostrand. Pp. 106. Price, 50 cents.

Scientific Monthly. E. H. Fitch, Editor and Publisher. Toledo, O.: Pp. 96. Price, $3.00 per annum.

Geological Notes. By W. B. Rogers. Pp. 13.

Circulars of the Bureau of Education. Washington: Government Printing-Office. Pp. 130.

Vick's Floral Guide for 1876. Rochester, New York: Vick & Co. Quarterly, 25 cents per year.

Geological Survey of Minnesota, 1874. By N. H. Winchell. St. Paul: *Pioneer Press* print. Pp. 36, with Maps.

Transactions of the American Society of Civil Engineers, 1875. Pp. 49.

Safety-Valves. By R. H. Buell. New York: Van Nostrand. Pp. 100. Price, 50 cents.

Mammoth Cave of Kentucky. By W. S. Forwood, M. D. Philadelphia: Lippincott. Pp. 241, with Illustrations.

Three Months in Old Hospitals of Paris. By R. Ludlam, M. D. Philadelphia: Sherman & Co. Pp. 16.

Report of the United States Treasurer, 1875. Washington: Government Printing-Office. Pp. 67.

Post-Nasal Catarrh. By B. Robinson, M. D. New York: Trow & Son. Pp. 29.

Does Matter do it all? By Epes Sargent. Boston: Colby & Rich. Pp. 16.

Zappus Hudsonius, and Lagopus Leucurus. By E. Coues. Washington: Government Printing-Office. Pp. 10.

Necessity of a Mechanical Laboratory. By R. H. Thurston. Philadelphia: W. P. Kildare, Printer. Pp. 10.

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## MISCELLANY.

**Relations of Chemistry to Pharmacy and Therapeutics.**—We present herewith the main points of an instructive address delivered by Dr. T. Sterry Hunt before the Massachusetts College of Pharmacy, on "The Relations of Chemistry to Pharmacy and Therapeutics."

With the eighteenth century is connected the birth of modern chemistry; and, while Priestley and Lavoisier are honored as having given a new impulsion to chemical theory, the Swedish apothecary Scheele will always be remembered as one who probably enriched the science with more discoveries than either of them. The three brightest names on the roll of great chemists in our century have been gathered from the ranks of the pharmaceutical profession, viz., Davy, Liebig, and Dumas. But the debt owed by chemistry to pharmacy has been amply repaid: the labors of the chemist have transformed the pharmaceutical art, replacing empiricism by science, enriching the materia medica with a vast number of new substances, and introducing new processes. Such old-fashioned drugs as coral, egg-shells, and the like, were shown by the chemist to possess no other value than belongs to the calcareous salts of which they are chiefly composed. Iodine was shown to be the active principle in the drug, calcined sponge; and henceforth iodine takes the place of the crude and bulky residue from the burning of sponge. In like manner quinine and morphine replaced cinchona-bark and opium.

In cases where the medicinal virtues are not apparently lodged in a single principle capable of being isolated, pharmacy has recourse to other processes, and obtains by expression, percolation, and evaporation, or distillation, often *in vacuo*, concentrated extracts which enable us to dispense with the crude drugs. Thus, for a rough example, by means of the sulphide of carbon the subtile perfumes of the violet and jasmine have been isolated. The artificial formation of urea and valerianic and benzoic acids opened up a new field for chemistry and pharmacy. By a careful dissection, as it were, of certain organic principles, we have learned to reconstruct them; and the triumphs of this method are seen in the artificial production of indigo, orcine and alizarine, and the odorant principle of vanilla. What wonder, then, that the chemist should now aspire to produce, artificially, the active principles of the poppy and cinchona, and render cheaper those precious drugs, morphine and quinine? These problems are destined to be solved at no distant day.

The history of anæsthetics is next traced by the author from the discovery of the physiological action of nitrous oxide by Davy to that of chloral by Liebreich. From this he passes to the subject of the chemical changes undergone by drugs in the animal economy, and the relations of these changes to physiological action. The mineral salts of many of the metals, such as sulphates and chlorides, act, to a great extent, like foreign substances when taken into the stomach, forming insoluble compounds with albuminous matters; but, when combined with certain organic acids, these metals are in a condition favorable to absorption. Thus, it is that the citrates, tartrates, and lactates of bismuth, antimony, iron, etc., are now advantageously employed in medical practice.

It having occurred to a chemist that salicylic acid might be antiseptic like carbolic acid, he made experiments which resulted in showing that in this almost tasteless body we possess an antiseptic agent of great power.

The immense advance made in the pharmaceutical art and the constant contributions brought to it by chemistry demand each year a higher education for the profession of pharmacy, and the day cannot be far distant when the need of a regular training and a thorough scientific education will be held to be as indispensable for the pharmacist as for the physician and the surgeon.

**Haeckel on Scientific Institutions.**—In his latest book ("Ziele und Wege der heutigen Entwickelungsgeschichte") Prof. Haeckel, the great apostle of Evolution in Germany, announces the discovery of the following law: "In all the magnificent scientific institutes founded in America by Agassiz, the following empirical law, long recognized in Europe, has been confirmed, viz.: that the scientific work of these institutes and the intrinsic value of their publications stand in an inverse ratio to the magnitude of the buildings and the splendid appearance of their volumes. . . . I need only refer," he adds, "to the small and miserable institutes and the meagre resources with which Baer in Königsberg, Schleiden in Jena, Johannes Müller in Berlin, Liebig in Giessen, Virchow in Würzburg, Gegenbaur in Jena, have not only each advanced his special science most extensively, but have actually created new spheres for them. Compare with these the colossal expenditure and the luxurious apparatus in the grand institutes of Cambridge, Leipsic, and other so-called great universities. What have they produced in proportion to their means?"—*Pall Mall Gazette.*

**Maturity of Timber-Trees.**—A paper in the "Transactions of the Scottish Arboricultural Society" contains the following information with regard to the time required for various kinds of timber-trees to reach maturity: "The oak can never be cut down so profitably when small as when well matured, and having plenty of heart-wood. The timber is seldom of much value until it has reached the age of 100 years. Ash can be cut down more profitably in its young state than other hard-wood trees. When clean grown, and from thirty to forty years of age, it is in great demand for handle-wood and for agricultural implements. Beech is of very little value in its young state, and is seldom cut till well grown. Birch can be cut down profitably at about forty years old. Horse-chestnut, when grown on good soil, and in a sheltered position, can be profitably cut down when it attains large dimensions. Elms (Scotch and English) should never be cut until they are from eighty to one hundred years old. Poplars can generally be profitably sold when about fifty years old. Sycamore, growing in good soil, may be profitably cut down when about one hundred years old."

**Source of the Nitrogen used by Plants.**—The average life of an apple-tree in Normandy is estimated by M. Isidore Pierre at fifty years, and its nitrogen product (in leaves, fruit, wood, and roots) at 26 kilogrammes (about 60 pounds). This amount of nitrogen corresponds to 5,200 kilogrammes of farm manure, or 100 kilogrammes per year. But the tree is far from receiving any such amount; according to the author, the most liberal cultivator does not supply more nitrogen than is found in the seeds. The question then arises, Whence comes the remainder of this nitrogen? M. Thenard, in a communication to the Paris Academy of Sciences, denies that it comes directly from the soil, or from the manure, and holds that it is derived from the air *through* the soil. In confirmation of this, he cites the grape-vines of Clos-Vougeot, the youngest of which were planted in 1234, and which annually receive only one kilogramme of manure. The amount of nitrogen contained in this quantity of manure is inconsiderable, as compared with what is contained in the grapes, the leaves, and the wood.

**Cranial Measurements.**—Two noteworthy results of the comparative measurements of the crania belonging to historic and prehistoric times were dwelt upon by Prof. Rolleston, in his presidential address to the Section of Anthropology, at the last meeting of the British Association. It might be assumed that skulls from the earliest sepulchres would present the smallest capacity, and that the size of the brain-case has since increased with the intellectual development of our race. But this assumption is curiously contradicted by the facts. Indeed, the cubic contents of many skulls from the oldest known interments considerably exceed the capacity of modern European skulls of average build. Surprise at such a result may, however, be tempered by the reflection that the skulls which we have obtained from the earliest tumuli are probably those of the chiefs of their tribes, who may have been selected by virtue of their great energy. Nor should it be forgotten that in savage communities the chiefs come in for a larger share of food, and are, consequently, men of well-developed frames, and of more portly presence than their fellows. As to the poorer specimens of humanity in those days we probably know nothing, as they were denied burial in the tumuli, and have left their remains we know not where. Another curious fact is, that the female skulls from the earliest sepultures do not differ in capacity from the contemporary male skulls to the same degree as the crania of the two sexes differ at the present day. But it must be borne in mind that in those early times there was a greater struggle for existence, and that the division of labor was not carried out to a large extent, so that the tendency to a differentiation of the crania was less marked than in modern times.

**An Indian Mill.**—On the farm of Mr. Hollis Smith, near Marengo, Calhoun County, Michigan, there exists an interesting monument of aboriginal life, known in the locality as "The Indian Mill." As described in a letter to us by Mr. W. H. Payne, of

Adrian, it consists of a great block of free-stone, about fifteen feet in length and five feet in width. Near one edge of this block there is a hole fifteen inches deep, having a diameter at the top of twenty inches, resembling a large mortar. "At the time of my visit," writes Mr. Payne, "this 'mill' was filled with water from recent rains. This was measured as it was dipped out, and amounted to fourteen gallons. Early settlers report that this spot was frequented by Indians, who brought thither their corn to be ground or pounded in this stone mortar. In the vicinity are seen many broad, smooth-faced stones, whose surfaces seem to have been highly heated. It is not improbable that these were used by Indians whereon to bake their cakes of corn. The grain was pounded as follows: A spring-pole was attached to one of the trees which stood near, and from the free end of this was suspended over the mortar, by means of twisted bark, a stone of convenient form and size. Stones suitable for this purpose lie beside the 'mill,' and it is probable that they once served the purpose above indicated."

**Excommunicated Insects.**—*À propos* of the efforts in progress to destroy the phylloxera and other insect scourges in France, a writer in *La Nature* gives a curious bit of information relative to the way in which such pests used to be proceeded against when science, save so far as it could be made to agree with Romish dogmas, had no existence for the world. In 1120, the Bishop of Laon formally excommunicated all the caterpillars and field-mice. In 1488, the grand-vicars of Autun commanded the parish priests of the vicinity to enjoin the weevils to cease their ravages, and to excommunicate them. In 1535, the grand-vicar of Valence cited the caterpillars to appear before him for trial. He kindly assigned them counsel for their defense, and, as they did not appear, proceeded against and sentenced them, *in contumaciam*, to clear out of his diocese—a command which they probably obeyed!

During the seventeenth century, thirty-seven similar judgments, against both insects and quadrupeds, were issued. One is on record, during the eighteenth century, fulminated against a cow; and there is still another, of later date, due to a judge of Falaise, who condemned and hanged a sow for killing a child.—*Christian Intelligencer.*

**Putting out Fires at Sea.**—Liquid carbonic acid is proposed by Lieutenant F. M. Barber, U. S. Navy, as an agent for extinguishing fires on board ship. His plan, as communicated to the *American Chemist*, is to have, in some suitable place in the ship, a flask or flasks about three feet in length, and one foot in diameter, containing about 100 pounds of the gas in the liquid state. From the top of the flask, a small iron pipe is to be permanently fitted along the water-ways throughout the entire length of the ship. From this main pipe branch pipes pass to every storeroom and compartment, each branch to be controlled separately by means of a cock. On the alarm of fire, the hatches are to be battened down, the cock in the branch pipe leading to the compartment where the fire is discovered is to be opened, and also the cock in the main next the gas-flask. The liquid gas passes out through the pipe in the form of vapor as soon as the pressure is removed, and is driven to the apartment where the fire is. This compartment it fills from the bottom up, without being diluted with the air. Given the cubic contents of any compartment, and the cubic space occupied by the cargo in it, sufficient gas can be admitted so as to render it absolutely certain that no fire can exist there. By then shutting the cock in the main pipe, the remainder of the gas is kept from vaporizing until such time as it may be required. This method of extinguishing fires is absolutely effectual; furthermore, it is simple, and involves no great expense. The only difficulties which seem to stand in the way of its practical application, are—1. The want of an apparatus for the expeditious and economical production of the liquid gas; and, 2. The want of suitable vessels to hold it at all temperatures. These difficulties, however, have been removed, and hence there exists no reason why all ships should not be provided with this effectual means of preventing disaster by fire.

In England, an apparatus for extinguishing fires on shipboard was recently patented. This apparatus, the "pyrolector," as it is called, consists of a small double pump worked by hand, which sucks up through a tube on each side of it strong muriatic acid, and a solution of bicarbonate of soda; these commingle in a generator forming part of the pump, and the carbonic-acid gas and bicarbonate solution pass at once down a metal pipe to the hold, along whose keelson runs a perforated wooden box which admits of the gas passing through to the burning material. The agent, therefore, for the extinction of fire, is dry carbonic-acid gas, which has no action on the cargo. The *Chemical News* describes as follows an exhibition lately given of the working of the "pyroletor:" "The entire hold of a large wooden barge was covered to a depth of several feet with wood-shavings and cotton-waste saturated with turpentine and naphtha. A temporarily-raised and by no means air-tight wooden deck, with loosely-fitting boards, formed the wide hatchway-covering. The combustible material having been set on fire, the flames immediately ran along the entire cargo and issued above the temporary deck, which was then covered with boarding. The 'pyroletor' having been brought into action, the fire was completely extinguished in four minutes, though nearly half a gale was blowing." It is computed that a 1,200 ton ship requires half a ton of each of the chemicals, costing about $100.

**Physical Characters of the British.**—Dr. Beddoe, at the recent meeting of the British Association, advocated the necessity, from a practical point of view, not from that of mere scientific curiosity, of obtaining more extensive and accurate information as to the physical characters of man in Britain than could be obtained by private investigations. He desired to inquire thoroughly and systematically into the rates of growth, average stature, weight, etc., of men and women under normal or abnormal conditions, so as to have a fair starting-point for further investigation and action. Lord Aberdare said that some time since it was ascertained that the Irishman was superior to the Scotchman in vigor, and that the Englishman was lowest of the three. This he attributed to the fact that in Ireland and Scotland children were fed on food appropriate to them. He moved that a committee be appointed to collect observations on the subject of the heights and weight of human beings in Great Britain and Ireland, and that a grant of money be made to defray the expenses of such an inquiry. This resolution was adopted.

**Native Home of the Rocky Mountain Locust.**—In view of the great interest and alarm excited by the ravages of the grasshoppers in the West last year, Prof. C. V. Riley, State Entomologist of Missouri, gives, in the last seventy-five pages of his Seventh Annual Report, a very full and interesting account of the natural history of this insect, including the plants it feeds on, the parasites that feed on it, and a history of its noted incursions, with the means that may profitably be employed to arrest its depredations. From the section on its "native home" we quote some interesting remarks concerning the *spread* of the insect.

Having in July, 1874, given the opinion that the swarms of that year would reach the western counties of Missouri too late to do serious damage, and that they would not extend eastward beyond a line drawn, at a rough estimate, along longitude 17° west from Washington—an opinion, by-the-way, that was remarkably confirmed by subsequent events—the professor here proceeds to give his reasons for that conclusion:

'But it will be asked, 'Upon what do you base this conclusion, and what security have we that at some future time the country east of the line you have indicated may not be ravaged by these plagues from the mountains?' I answer that, during the whole history of the species, as I have attempted to trace it in the chronological account already given, the insect never has done any damage east of the line indicated, and there is no reason to suppose that it ever will do so for the future. . . .

"'But why,' it will again be asked, 'will not the young from the eggs laid along the eastern limit you have indicated hatch and spread farther to the eastward?' Here, again, historical record serves us, and there are, in addition, certain physical facts which help to answer the question.

"There is some difference of opinion as to the precise natural habitat and breeding-place of these insects, but the facts all indicate that it is by nature a denizen of great altitudes, breeding in the valleys, parks, and plateaus of the Rocky Mountain region of Colorado, and especially of Montana, Wyoming, and British America. Prof. Cyrus Thomas, who has had an excellent opportunity of studying it—through his connection with Hayden's geological survey of the Territories—reports it as occurring from Texas to British America, and from the Mississippi (more correctly speaking, the line I have indicated) westward to the Sierra Nevada range. But in all this vast extent of country, and especially in the more southern latitudes, there is every reason to believe that it breeds only on the higher mountain elevations, where the atmosphere is very dry and attenuated, and the soil seldom, if ever, gets soaked with moisture. . . .

"My own belief is, that the insect is at home in the greater altitudes of Utah, Idaho, Colorado, Wyoming, Montana, Northwest Dakota, and British America. It breeds in all this region, but particularly on the vast hot and dry plains and plateaus of the last-named Territories, and on the plains west of the mountains; its range being bounded, perhaps, on the east by that of the buffalo-grass.

"In all this immense stretch of country, as is well known, there are vast tracts of barren, almost desert land, while other tracts, for hundreds of miles, bear only a scanty vegetation, the short buffalo-grass of the more fertile prairies giving way, now to a more luxurious vegetation along the water-courses, now to the sage-bush and a few cacti. Another physical peculiarity is found in the fact that while the spring on these immense plains often opens as early, even away up into British America, as it does with us in the latitude of St. Louis, yet the vegetation is often dried and actually burned out before the first of July, so that not a green thing is to be found. Our Rocky Mountain locust, therefore, hatching out in untold myriads in the hot sandy plains, five or six thousand feet above the sea-level, will often perish in immense numbers if the scant vegetation of its native home dries up before it acquires wings; but if the season is propitious, and the insect becomes fledged before its food-supply is exhausted, the newly-acquired wings prove its salvation. . . . Prompted by that most exigent law of hunger—spurred on for very life—it rises in immense clouds in the air to seek for fresh pastures where it may stay its ravenous appetite. Borne along by the prevailing winds that sweep over these immense treeless plains from the northwest, often at the rate of fifty or sixty miles an hour, the darkening locust-clouds are soon carried into the more moist and fertile country to the southeast, where, with sharpened appetites, they fall upon the crops like a plague and a blight. . . . The hotter and drier the season, and the greater the extent of the drought, the earlier will they be prompted to migrate, and the farther will they push on to the east and south.

"The comparatively sudden change from the attenuated and dry atmosphere of five to eight thousand feet or more above the sea-level to the more humid and dense atmosphere of one thousand feet above that level, does not agree with them. The first generation hatched in this low country is unhealthy, and the few that attain maturity do not breed, but become intestate and 'go to the dogs.' At least, such is the case in our own State, and in the whole of the Mississippi Valley proper. . . ."

**Temperature and Vegetation in Different Latitudes.**—A communication on this subject was made by M. Alphonse de Candolle to the Academy of Sciences of Paris, and reported in the *Comptes Rendus* for June 7th. The object of the inquiry was to test the accuracy of the very common observation that vegetation comes forward much more rapidly in spring in northern latitudes than in the warmer regions of the temperate zone. Experimenting with seeds of several species of plants sent to him from Northern and Southern Europe, he found that those from the north were most precocious. Twigs, obtained in the winter, of the white poplar, tulip-tree, catalpa, and the *Carpinus betulus*, from Montpellier, were there tried with twigs from the same species at Geneva. They were laid aside, so that their temperature might become alike, and were then placed in water, a little sand being put in the bottom of the jar.

The German, or more northern branches, leafed out first; the difference of time between the leafing of the respective pairs being from eighteen to twenty-three days.

It is an interesting question, "Why do northern plants develop more rapidly than southern ones?" Prof. de Candolle comments on it in this wise: "The buds of a tree are in a continual struggle. The later, like badly-placed ones, develop imperfect branches which are oftener stifled. The most precocious prevail, unless indeed they suffer from frost. In this way comes a selection, and a successive adaptation of the tree to the climate."

Buds, by this means, acquire peculiarities which are persistent. If there be promptness and quickness of growth, these qualities are continually reproduced. An instance of the persistency of acquired peculiarities is given in a horse-chestnut tree near Geneva, which, on a single branch, produced double flowers about the year 1822, and has continued to do so; and all the doubled-flowered horse-chestnuts in the world are thought to be derived from that stock.

De Candolle, however, speaks of the more profound hibernal repose of northern plants producing in the buds greater susceptibility to the heat of spring. But, Prof. Gray, commenting on this in the *American Journal of Science* for September, suggestively remarks that "the way in which this increased susceptibility arises is not stated," and adds, "that natural selection would operate upon trees as upon cereal grains, inducing precocious races better adapted to the short summers, only more time would be required in case of the tree."

**Influence of Water on Climate.**—At the late meeting of the British Association, Prof. Hennessy read a paper on the "Inflence of the Physical Properties of Water on Climate." The object of the paper was to contradict the opinion formerly expressed by Sir J. Herschel, that "water does not distribute heat in any thing like the same degree as land." According to Prof. Hennessy, of all substances largely existing in Nature, water is the most favorable to the absorption and distribution of solar heat. A sandy soil, such as that of the Sahara, although capable of exhibiting a very high temperature during the day, becomes cool during the night, and is one of the worst media for storing up the heat derived from sunshine. Water, on the contrary, stores up heat better than almost any other body. An objection was offered by Prof. Everett, based on the generally-accepted fact that the temperature of the Southern Hemisphere is lower than that of the northern, despite the greater predominance of water in the former. This Prof. Hennessy denied to be a fact.

**Curious Behavior of a Snake.**—For the following account of an interesting exhibition of serpent-cunning, we are indebted to Mr. E. Lewis, of Brooklyn: "On the 20th of June last, while visiting at the house of a relative on Long Island, I saw on his lawn an adder, a species of snake common in that region. It seemed gentle, and, when approached, made no effort to escape. Wishing to observe its motions, I touched it with a stick, when, instead of moving away, it commenced a series of contortions that greatly surprised me. Nothing that I had seen in the motion of serpents of any kind showed so clearly as did this instance the extraordinary flexibility of their vertebral column. The contortions ended by the creature thrusting its head and open mouth into the loose dirt on the surface as if in great distress, when, partially extending itself and turning on its back, it lay as if quite dead. I lifted it on the stick, and carried it some yards, and laid it on the grass, but observed, in laying it down, that it showed some rigidity, in its tendency to turn or lie on its back. Others, who had witnessed the action of the snake, now left, and I stepped behind a tree for further observation.

"In two or three minutes the head of the snake rose a little, and I could see that it was observing the situation. Presently it turned on its belly, and was in a position to move away; but, on being touched, it turned on its back again. Finally, it raised its head, turned over, and, seeing no one, crawled slowly away.

"This behavior in the snake was new to me, and has not been observed by any with whom I have conversed concerning it. It seems to me probable that it arose from the instinct of self-preservation, or from the equally strong instinct for preservation of its young. No young ones were seen, however, but they may have been near in the grass, and it was a season of the year when their presence might be expected. There was certainly nothing more curious or strange in the snake's feigning death than in birds feigning lameness, and other animals feigning death, when themselves or their young are in danger; but I conclude the phenomenon is unusual with serpents."

**A New Enemy of Submarine Cables.**—In 1865 the world-renowned special correspondent of the London *Times*, W. H. Russell, modestly gave utterance to a prophecy which time has since fulfilled almost to the letter. He then wrote: "As a mite would in all probability never have been seen but for the invention of cheese, so it may be that there is some undeveloped creation waiting *perdu* for the first piece of gutta-percha, which comes down (to the sea-bottom) to arouse his faculty and fulfill his functions of life—a gutta-percha boring and eating *teredo*, who has been waiting for his meal since the beginning of the world." This enemy of submarine cables has already made his appearance, as was briefly announced in a recent number of The Monthly. It is a crustacean, less than a quarter of an inch in length, and known as *Limnoria terebrans*. "One breakfast which he may take," says Dr. J. H. Gladstone, "may cost more than the breakfast of any luxurious Roman epicure in ancient times, because he may destroy a whole cable, and it may take a year to repair the damage which he may do in a minute."

**Hawkshaw on the Channel Tunnel.**—In the course of the debate which followed the reading of a paper on the proposed tunnel between England and France, at the Bristol meeting of the British Association, Sir John Hawkshaw made a speech, in which he expressed his perfect confidence in the ultimate success of that great undertaking. "The question arises," said he, "as to the risk in tunneling through the chalk. Of course we cannot measure that risk with any certainty, but we are constantly in the habit of undertaking engineering work which sometimes involves an unknown amount of risk, and it becomes the business of the engineer to encounter these risks. Prof. Hébert seems to expect that the chalk, although it may be continuous, as we have ascertained it to be, all across the channel, may have such fissures in it that, in constructing the tunnel at the depth we propose to go, it is possible we may cut through the chalk into the green sand. Suppose that were so, it would not deter me from encountering this work. A great mistake is often made with reference to the percolation of water. Water, though it passes through sand, passes with very slow velocity. I have had to make deep excavations in sand fifty or sixty feet below the level of the sea, and though water comes rather rapidly at first, until it has drawn away a portion of the water which is in the sand adjacent to your work, yet, after that, it comes with extreme slowness. Therefore, I am not afraid of percolation of water in that sense. With regard to the percolation of water through the solid chalk, that is of no consequence; water passes so slowly through chalk, that it might continue to pass, and nobody would care about it. Of course there is a thing that might occur which would be serious. If you could imagine a clear, open fissure from the bottom of the sea to the tunnel, where water could pass, there is no doubt, with that enormous pressure, it would pass with very great velocity, and would be a very troublesome thing to encounter. I do not myself believe in there being any such fissure. That is almost the only difficulty which, I think, would hinder this tunnel. I do not mean to say that would stop it, but it is possible, if we met with a thing like that, we should have to have recourse to something else, which I have not yet devised, because I do not expect it."

**Sanitary Condition of Watering-Places.**—At the Baltimore meeting of the American Public Health Association, Prof. Henry Hartshorne read a report on the sanitary condition of our popular watering-places. The report points out the danger to health at such resorts from the contamination of drinking-water by soil saturated with sewage. To prevent this, one or both of two measures must be adopted, namely—1. To use for cooking and drinking either rain-water or water conveyed from a distant, uncontaminated source; or, 2. To protect the soil from contamination by the construction of impervious wells for receiving all impure matters. The former of these measures is always safest; for the latter to be carried out without injury to health requires close and constant supervision. The report finally expresses a desire that records of disease and mortuary statistics of the watering-places in the United States be collected at some central point

**Geology at the Syracuse University.**—The elementary instruction in geology at Syracuse University, which heretofore has been distributed through the first and second terms of the collegiate year, will be given this year during February and March, so as to occupy the attention of the students with this subject almost exclusively during those two months. The plan is intended to accommodate the large number of persons of all ages who feel the desirableness of an outline acquaintance with geology, and who might be able to devote two months to the study, while their convenience does not permit them to take an entire geological course, or to keep the study in hand six months or a year. Simultaneously with the elementary course, two advanced courses will be set on foot during the months named; one of these courses will be Lithological, and the other Paleontological. Prof. Alexander Winchell will have the general direction of this special school of geology, with numerous assistants, among whom are Prof. James Hall, Prof. Burt G. Wilder, and Prof. Edward D. Cope. The school opens on Tuesday, January 25th.

**The Value of Vivisection.**—The question of vivisection was the subject of an address by Dr. William Rutherford, at the last meeting of the British Medical Association. Physiology, he observed, is an experimental science. Apart from experiments which are the result of artifice, disease and accident are constantly bringing about conditions which partake of the nature of experiments, and are sometimes of great physiological significance. Still, this teaching of disease and accident leads us but a short way, and the pursuit of physiological truth by their aid is often an uncertain, devious, and complicated method. Dr. Rutherford effectively contrasted the very imperfect and indirect theoretical method of physiological instruction in the past with that by demonstration and experiment in the present time. No one can doubt for a moment that the reasoning, critical faculties are truly educated where men are trained to see and examine for themselves the experimental evidence on which physiological knowledge rests. Dr. Rutherford holds that definite, critical knowledge of animal mechanism cannot be attained unless students be shown experiments on living animals.

**Prolific Peaches.**—At a meeting of the Academy of Natural Sciences of Philadelphia, Mr. Meehan exhibited some branches of peach, in which the young fruit were in twos and threes from one flower. They were from the Chinese double-flowering kind. He remarked that, as is well known, plants with double flowers are rarely fertile. Either the stamens are wholly changed to petals, or the less vital conditions which always accompany this floral state are unequal to the task of producing perfect pistils. Vitality, however, he observed, is more or less affected by external conditions, independently of the mere structure of organs, and this was well illustrated by the remarkable fertility of the peach last season. This abounding vitality had evidently extended to the double peaches, and had influenced the development of the female organs to an unusual extent. These facts have an interest in botanical classification. Lindley removed the cherry, plum, peach, and their allies from the *Rosaceæ*, chiefly because they had but a single free carpel, and grouped them as *Drupaceæ*. The production of two and three carpels in this case shows the true relation, and it might be of use to those interested in "theories of descent."

**Stability of Chinese Civilization.**—In accounting for the wonderful cohesion of the great Chinese Empire, the Prussian traveler Von Richthofen says that the causes of this phenomenon are manifold. First, the pitiless extermination of such tribes as the Man-tse. Then the complete fusion of uncultured races with the civilized Chinese, from which has resulted an homogeneous people, with one language, the same manners, and the same traditions. But above all stands the fact that Chinese civilization is indigenous. In Europe, civilization is the result of the efforts of several nations, and has been attained only at the cost of much strife and sacrifice, one people transmitting to another its hard-earned advantages. But in China civilization was developed in more orderly fashion, and is the product of the genius of a single people. The Chinese have very rarely come in contact with neighboring peoples, nor have they borrowed from the Hindoos any thing save Buddhism, and that has certainly been of no advantage to the nation. For 4,000 years they have faithfully preserved the religious and political principles set forth in the decrees of the Emperor Yan, and, though again and again the edifice raised upon this firm foundation has tottered, it has been again set up on the same basis. These principles, which alone uphold the unity of this vast empire, stand to this day intact, nor does Von Richthofen perceive any evidences of senile weakness in the body politic; on the contrary, he thinks that in the future Chinese civilization will have a mighty development, without losing any of its native characteristics. The principles which governed its first establishment, and which are still influential in moulding it, are in fact perfectly in accordance with natural laws, being simply the application to the social and political state of the principles of the paternal authority and filial obedience. In China the authority of the father of a family is unlimited, the obedience of the son is absolute. The emperor, as the father of his subjects, the mandarins, his representatives, receive from the people a filial obedience, but at the same time the sovereign must conform himself to the holy maxims of Confucius. There may be cases of defection, rebellion; functionaries may yield to corruption, as has been the case of late years; but sooner or later order will be restored, and the mandates of the central power will be again respected to the outermost limits of the empire.

**European Life in India.**—The "Value of European Life in India" was the subject of a paper read at the last meeting of the British Association by Dr. F. J. Mouat. The author stated that within the present century the annual loss of European life in India had gradually and steadily decreased from about 60 per 1,000 to an average of 15 or 16. This decrement is still in progress. Among 24,500 British army officers in India, from 1861 to 1870, the death-rate from all causes was not quite 17 per 1,000. In the Madras Presidency, in the same period, among corresponding classes, the average rate was somewhat less; and, among carefully-selected European railway employés, the parliamentary returns show the mortality rate to be about 10 per 1,000. The author expressed the opinion that the Anglo-Saxon colonization of the plains of India is impossible; but that in the hill country a healthy, vigorous, European population could take root and flourish. On the whole, he regarded the present state of the question as most encouraging, and that the risks to life in India of persons who were sound in constitution, and reasonably prudent in their mode of life, are not much in excess of those incurred in more temperate climates.

**Cost of a Small-Pox Epidemic.**—At the recent meeting of the American Health Association a paper was read by Dr. Benjamin Lee, on the cost to the city of Philadelphia of the small-pox epidemic which existed there in the winter of 1871–'72. When the disease first appeared, no effective measures were taken to combat it. The public treasury could not bear the expense, it was said; besides, were any thoroughgoing action to be taken by the city authorities, traders from abroad would learn that the disease prevailed in the city, and would go to other markets. Dr. Lee's paper is intended to show that herein the authorities were "penny wise, pound foolish." The direct and the indirect losses caused to Philadelphia by that one visitation of small-pox amount to an enormous sum of money, a small fraction of which would have sufficed, if judiciously expended, to insure immunity from the disease. The losses as computed by Dr. Lee exceed $20,000,000.

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## NOTES.

The article on "the Horseshoe Nebula in Sagittarius" in the number of The Popular Science Monthly for January, 1876, contains two annoying errors which the editor desires to correct. In Fig. 2, page 271, the letters *W* and *E* and also the letters *N* and *S* are interchanged.

In Fig. 6, page 279, great injustice is done to M. Trouvelot's drawing, owing to the introduction by the engraver of two bright patches near *e* and *d*, and *c* and *h* (*see* figure). These should be as faint as the nebulosity near *g*.

The cores of a pair of enormous ox-horns were discovered, some years since, in Adams County, Ohio, at the depth of about 18 feet below the surface of the ground. According to the *American Journal of Science* they measure nearly 6 feet from tip to tip, and are 22 inches in circumference. The original horns must have been of enormous size, as the core of the horns of the ox is about one-third of the entire length.

These horns are now in the Museum of the Cincinnati Society of Natural History.

It is an error to suppose that the lion is stronger than the tiger. Dr. Haughton has proved that the strength of the lion in the fore-limbs is only 69.9 per cent. of that of the tiger, and the strength of his hind-limbs only 65.9 per cent. Five men can easily hold down a lion, but it requires nine men to control a tiger.

In the course of his researches into the habits of insects, it was found by Lubbock that an ant, which has a large number of larvæ to carry from one place to another, goes and fetches several other ants to aid in the work, while, if there are only a small number of larvæ, only a few helpers are called in.

It is stated by Dr. George Maclean, of Princeton, in a communication to the editors of the *American Journal of Science*, that on one occasion, after some experiments with phosphuretted hydrogen, prepared from phosphorus and solution of potash, on retiring to bed, he found his body to be luminous with a glow like that of phosphorus exposed to the air. Some of the gas, escaping combustion, or the product of its burning, must have been absorbed into the system, and the phosphorus afterward separated at the surface have there undergone eremacausis.

Three instances of extraordinarily rapid growth of plants are recorded in the *Gardener's Chronicle*. First, a *Sequoia gigantea*, planted in 1855, in Loire-Inférieure, France, is now more than 72 feet high, and, about a yard from the ground, has a girth of 7 feet. In the same locality, a plant of *Bambusa mitis* threw up a stem of more than 22 feet in two months, while a *Yucca albospica* produced an inflorescence 8 feet high.

According to Dumas there are two distinct kinds of ferments: those which, like yeast, are capable of self-reproduction, and those which, like diastase and synaptase, are without this property. It has been observed by Muntz that ferments of the former class are neutralized by chloroform; not so those of the latter class.

Prof. S. P. Sharples, of Boston, has drawn up tables showing the range of difference between different specimens of pure milk as regards the amount of solid matter they contain. The highest percentage of solid matter is 19.68, the lowest 9.3.

It is stated in a French journal, *Le Charbon*, that experiments made at Bordeaux with cork, as a substance for developing illuminating gas, have led to such good results that it is proposed to establish a cork gas-house in that city. The waste of cork-cutting shops is distilled in close vessels, and the flame of the resulting gas is more intense and whiter than that of coal-gas. The blue portion of this flame is much less, and the density of the gas much greater than that of common illuminating gas.

It is stated by Galton that in England country boys, of fourteen years, average an inch and a quarter more in height, and seven pounds more in weight, than city boys of the same age, as shown by the examination of a large number of boys in country and city schools.

Dr. Robert Barnes, writing in the *Obstetrical Journal*, questions the propriety of admitting women to the practice of medicine. The reason he assigns is, that there exists a natural incompatibility between science and the female brain. The church and the law he considers to be the professions most congenial to the "somewhat arbitrary character of the female intellect." Clergymen and lawyers are, as a rule, the enemies of science, says Dr. Barnes, and in the women they find their most useful allies.

From observations made in Colorado by a member of the Academy of Natural Sciences, of Philadelphia, it would appear that grasshoppers can foresee, and provide, some time in advance, against certain changes in the weather. It happened that, while a party of persons were riding in a carriage, the question of the probability of rain was discussed, when suddenly the grasshoppers, which just before had filled the air, descended like a shower to the ground. In two or three minutes, not a grasshopper could be seen in the air, and very soon rain commenced to fall. Immediately after the rain had ceased, the insects took flight again, but in the course of half an hour, without any particular indication of rain, they suddenly plunged to the earth again. Again the rain began to fall. This process was repeated by the grasshoppers three times in one afternoon, and each descent was followed by rain.

Herr Marno, of Gordon's Nile Expedition, has reported to the Vienna Geographical Society the particulars of a journey made by him for a distance of 150 miles to the southwest of Lado. This brought him to the Makraka territory, the natives of which he says resemble the Niam-Niams, in respect of their diminutive stature, their lighter color, and their general habits.

In view of the recent barbarous exhibition at the Tombs, the *Scientific American* recommends the employment of electricity, as not only sure and instantaneous in its action, but a painless means of killing the criminal.

Dumas sums up as follows the results of numerous experiments made in order to test the efficacy of the sulpho-carbonate of potassium, in destroying the grape-phylloxera: In the first place, the phylloxera is destroyed wherever the solution of the salt or its vapor penetrates. Secondly, the vine itself suffers no injury. Occasionally, a very few living phylloxeræ are seen after treatment; but these come from other neighboring vines which have not been treated with the sulpho-carbonate, or have been hatched from eggs which have in some way been protected from the action of the salt.

Dr. Rudolf von Willemoes-Suhm, naturalist attached to the Challenger expedition, died at sea on the passage from Hawaii to Tahiti, on September 13, 1875, aged twenty-eight years. He was a native of Schleswig-Holstein, and was educated at the Universities of Göttingen and Bonn. He early showed a very strong taste for natural history, and when only a boy published papers on the habits of European birds. After leaving Bonn he was appointed Privat-Docent in Zoölogy in the Munich University. He went to Italy in 1868, making zoölogical observations at Spezzia, and in 1872 visited the Faröe Islands. He then joined the Challenger expedition. He was a man of unusual acquirements and culture.

The biennial prize of 20,000 francs has been awarded by the Institute of France to M. Paul Bert, for his discoveries on the effects of oxygen in the act of respiration. Some of the principal results of Bert's researches have been stated in the pages of the Monthly. According to the eminent physiologist, Claude Bernard, Bert's discoveries are "the most astounding that have been made since the discovery of oxygen by Priestley."

The Royal Society of London has awarded to Mr. Crookes a "Royal Medal," for his various chemical and physical researches, more especially for his discovery of thallium, his investigation of its compounds, and determination of its atomic weight, and for his discovery of the repulsion referable to radiation.

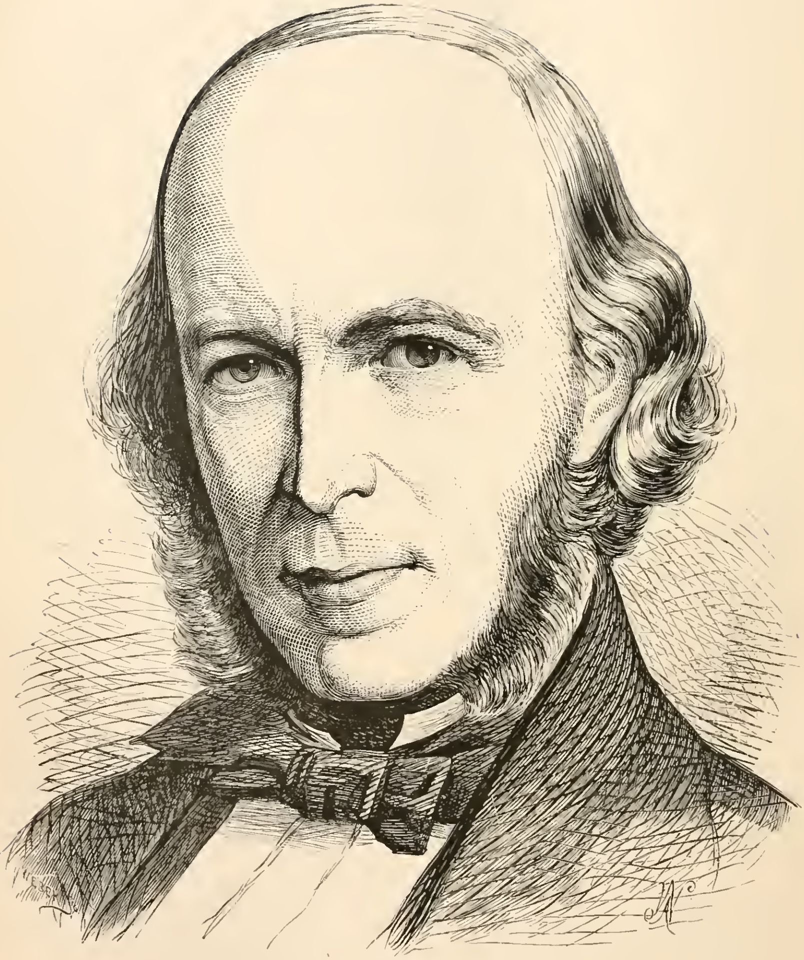
An interesting experiment made by G. Planté, and described by him to the Paris Academy of Sciences, may possibly explain the spiral form of many of the nebulæ. The two copper electrodes of a battery of 15 elements being immersed in water containing one-tenth of sulphuric acid, the pole of a magnet is brought near to the end of the positive electrode. Immediately the cloud of metallic particles, borne away from this electrode by the current, assumes in the liquid a gyratory, spiral motion, resembling in appearance a spiral nebula.

It will be gratifying to our readers to learn that the preliminary operations of the expedition sent under the auspices of the Hydrographic Office, United States Navy, to determine telegraphically the relative longitudes of points in the West Indies, have been so far successful. Captain Green, U. S. N., assisted by the officers of the United States ship Gettysburg, and by Mr. Rock, civil assistant, has so arranged his programme that the two temporary observatories at Havana and Key West are in the same circuit, and that the signals made at either station are recorded *directly*, without the intervention of the observer at the second station, on his chronograph. It is to be presumed that an important element of uncertainty is thus eliminated. All the arrangements for the work are in good order, and Captain Green acknowledges the most cordial assistance from the officials of the Government and of the cable companies.

The production of gum in fruit-trees, M. Prillieux regards as a disease, which he names *gummosis*. The alimentary substances in the interior tissues, instead of promoting the plant's growth, are diverted to the production of gum, and a portion of them accumulates about gummy centres, which seem to act as centres of irritation. The production of gum at the expense of nutritive matter has no limit short of the complete exhaustion of the plant. The best remedy is scarification. To cure the disease, the materials appropriated to forming gum must be restored to their normal destination. Hence, a more powerful attraction for them must be introduced than that of the gummy centres. Now, the wounds of the bark necessitate the production of new tissues, and, under this strong excitation, the reserve matters are employed in the formation of new cells, and cease to be attracted in the wrong direction.

An instrument for the rapid examination of oils and textures by means of electricity has been invented by Prof. Palmieri. The instrument will—1. Show the quality of olive-oil; 2. Distinguish olive-oil from seed-oil; 3. Indicate whether olive-oil has been mixed with seed-oil; 4. Show the quality of seed-oils; 5. It will indicate the presence of cotton-fibres in silk and woolen textures.

It is stated by Dr. Malherbe that sewing-silk is sometimes impregnated with acetate of lead, and that seamstresses are frequently poisoned by introducing such thread into the mouth.



HERBERT SPENCER.

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# HYDROGRAPHY.

HYDROGRAPHY (from the two Greek words, ὕδωρ, *water*, and γράφω, *description*, is the important branch of physical science and descriptive geography which has for its object the graphical representation of the waters of our globe and their shores, with all their properties bearing upon navigation.

Their exploration to this end, their description by means of charts and directions for the use of the navigator, as also the generalization of the local data in order to ascertain the laws governing the physical phenomena upon which navigation depends, the winds, currents, weather, tides, terrestrial magnetism, etc., is the responsible and arduous task of the nautical surveyor and hydrographer.

The most essential requirement for navigation is charts, general charts of entire oceans, or parts of them and their shores, compiled by the hydrographer from existing data, and special charts of smaller areas, of harbors, roadsteads, etc., prepared from special surveys. The earliest sea-charts date from the middle of the fourteenth century. They were necessarily rude and imperfect, the earth's shape and dimensions being then unknown, the log for measuring nautical miles not in use, and the means for ascertaining astronomical positions very imperfect.

The discovery of America and the Cape of Good Hope, together with the reformation in astronomy by Copernicus and Galileo, instituted a new era in geographical knowledge; the earlier charts of this period, however, were still grossly inaccurate, especially as regards geographical positions, and many of the isolated islands of the Pacific Ocean, seen and described by the early Spanish voyagers, have been searched for at later periods in vain, until islands in positions differing hundreds of miles from those given to them, but answering their description completely, have been adopted for them; many of the islands shown on the present charts with queries, in regions not yet sufficiently explored, will prove to have been similarly misplaced at that early date.

The science of hydrography, by which the correct establishment of positions and exact delineations of the shores are attained, remained meagre until the middle of the eighteenth century, when it may be said to have fairly commenced with the expeditions of Captain James Cook under the auspices of Great Britain, which were soon followed by similar undertakings by other nations, especially by France and Russia, and at a later period by the United States. Almost all these voyages of discovery and explorations were of circumnavigation, and, though many localities were examined more or less in detail, in general they could only result in skeleton charts to be filled in by systematic surveys, at a future period, conducted under the direction of organized institutions. In the first quarter of the present century hydrographic offices were established by the principal maritime nations for the survey of their waters at home and in their colonies. To the hydrographic office of Great Britain, which has been liberally provided with means by the Government, belongs the credit of having taken the lead in extending systematic surveys into almost every water traversed by vessels, and to its zeal and energy all navigators and commercial communities will ever be deeply indebted. At present almost every nation having a seaboard has it hydrographic office for the survey of its own coast, and to participate in the survey of such waters as are considered the common possession of nations, and of the coasts of countries which do not provide for surveys. Almost every European nation has provided for the trigonometrical survey of its entire domain.

The British Ordnance Survey, commenced in 1783, will probably take ten years yet to complete; the trigonometrical surveys of France, Germany, the Netherlands, Belgium, and the European portion of Russia, are in course of completion; in other countries they are in progress. The several governments have also agreed on measures for the careful connection of the triangulations across the borders of their states. Where such rigid geodetic operations were instituted previous to the hydrographic survey of the coasts and waters, they furnish the hydrographic surveyor, not only with the correct outlines of the coast, but also with the precise position of the landmarks upon which he may base his work, or, in other words, a skeleton for the same. But, when such surveys are not existing, he is compelled to lay down the coast-line also, with its detail as far inland as there are landmarks auxiliary to navigation, thus performing the labors of the topographer as well as those of the hydrographer. Both require the greatest care, for on the precise establishment of the landmarks depend in a great measure the delineation of the shore-line, the establishment of outlying dangers, and the exact location of the soundings, by which the profile of the bottom is represented on the chart.

Sudden elevations, shoals, and especially submerged rocks, the great dangers to navigation, sometimes escape the lead as well as the eye, even in the most careful survey, and are only discovered by accident, often from disaster. Such dangers are found from time to time in the most frequented harbors, which have been surveyed with the greatest care. While the land, with the present means, can be laid down absolutely correct, the hydrographic surveyor can never be certain that he has thus represented the most essential portion of his chart.

The hydrographic features of coasts, not rock-bound, are subject to changes, gradual by the action of the sea, and sudden by natural phenomena, as great gales, etc.; volcanic activity also affects at times the rock-bound coasts. The mouths of rivers and the embouchures of inland waters are especially subject to changes by the wash of the discharging waters, and the sediment and *débris* carried along by them, which mostly accumulate on the bars, and are shifted to and fro by the force of the sea before they settle firmly; the depth of water in the channels, and even the course of the latter, does not remain the same for any great length of time, and some bars change with every shift of the wind. The surveys of such localities will only hold good in their general features; in the shore-lines and in the landmarks by which a vessel may approach and feel her way in; the more frequented harbors of this nature require reëxamination from time to time.

Several nations have provided for a trigonometrical survey of their coasts only, in advance of geodetical operations embracing their entire domain.

The United States Coast Survey was first organized by act of Congress in 1807, which provided for surveying the coasts of the United States, but the first labors in this field did not commence until 1817, and were shortly after interrupted; in 1832 they were resumed, and have since been carried on, with energy and but little interruption, to the present date.

The United States Hydrographic Office, for the purpose of constructing and publishing charts, sailing directions, and all hydrographic information relating to the coasts and waters outside of the boundaries of the United States, for the use of its marine, both naval and commercial, and for directing the examination and survey of the channels of commerce in foreign waters, was established under the Navy Department in 1866.

Connected trigonometrical surveys have also been instituted for the waters of the more important of the European colonies, especially in the West and East India waters and in Australia, but for far the greater part of the navigated portions of the globe the navigator will for a long time have nothing but reconnoissances and running surveys, of which the earlier are more or less rough and unconnected, and even some of later dates cannot be entirely relied upon.

Running surveys, more or less in detail, are generally the precursors of the more strict geodetic survey, but, in order to answer the wants of navigation, these should always be based upon a triangulation between natural landmarks, checked at reasonable distances by very careful shore observations for latitude and longitude, and the latter carried directly from a central position to the most prominent points of the thus surveyed area and back again, and the central position connected in the same manner with the nearest satisfactorily determined position, to which the longitudes of that locality are generally referred.

The telegraph-cables which already connect many of the most important places will soon gird the globe in several belts, and will afford the means for ascertaining great meridional distances with almost absolute correctness. There will thus be furnished a great number of primary positions from which the longitude may be carried in coördinate lines to secondary places. In this manner a network of points spread over the globe will be attained, corresponding to the primary and second triangle points of great geodetical operations.

The completeness and correctness of a running survey depend upon the time devoted to it and the difficulties encountered; frequently the coast-line is only traced in from point to point, or from the shore-ends of the lines of soundings by the eye; the points of land, however, especially the salient ones, should always be fixed by angles to or from the established landmarks, as should also all outlying dangers and all features bearing directly upon or assisting navigation.

The surveys of harbors and anchorages should be as complete as possible; if time permits, beacons should be erected for triangulation, and the plane-table employed for obtaining the shore-line. The parts of the latter which are merely traced in approximately should be distinguished on the chart by a broken line.

The soundings should always be numerous enough to show the configuration of the bottom of harbors, and off a seacoast the gradual rise from great depths to the shore, islands, and banks, so that the characteristic curves of the depths may be shown with precision on the charts; for harbors generally the one, two, three, and five fathom curves are marked; on coast-charts, those of three, five, ten, twenty, fifty, and one hundred fathoms.

When sounding from a vessel in motion or from a boat, the lead should be tried at intervals, even when it is anticipated that the bottom will not be reached, not only on account of the possibility of the discovery of a sudden elevation, but for the purpose of placing the negative soundings on the chart, which show conclusively the absence of danger and that the ground has been examined.

For such negative soundings, as much line should be used as the speed of the vessel will permit, and at reasonable distances the deep-sea lead should be employed to obtain actual depths. Positive soundings exceeding 100 fathoms should be obtained as far to seaward as circumstances will permit the survey to be extended.

A difficult task of the hydrographic surveyor is, to search for the islands and dangers shown on the charts, or enumerated in nautical guides as uncertain in position or of doubtful existence.

Many facts show that the origin of a great number of these may be traced to deceptive appearances, to misplacement from faulty observations or reckoning, or to typographical errors in the reports published.

Reports of new dangers grow more frequent, as the sea-routes extend into regions heretofore but little traversed, and as the commercial navigator manifests a greater interest in hydrography. All these obstructions to navigation are placed on the charts, usually with queries, until they are verified and correctly located, or their non-existence proved by professional authority through local search. Such dangers have frequently been found to exist at considerable distance from the positions given, from indifferent astronomical observations, or from reckoning referred to observations taken several days before or after their discovery; the search must, therefore, be extended over a considerable area. The search for islands is naturally less difficult than that for submerged dangers, which on the broad ocean can in some instances hardly be detected but by chance.

In causing reported dangers of this nature to be erased from the charts, on the strength of a search which has not been thorough in every particular, the hydrographer incurs a grave responsibility; there are a number of instances on record where dangers which had been searched for most carefully and by very competent authority, have been replaced exactly in the position from which they were erased, after they have been assured by the loss of a vessel on them, and the reëxamination of the position in consequence of it.

A correct representation of the character of the bottom of the waters is very important, not only for the selection of anchorages, but also as a guide to the navigator when he cannot otherwise obtain the position of his vessel, especially when approaching a coast in fogs and thick weather, or when passing through channels not bordered by good landmarks; for this purpose specimens of the bottom should be brought up for examination, and every change of it noted.

The tidal relations, tidal hour, and the rise and fall at the various stages of the moon, and in the various seasons, the influence of the winds upon the tides, etc., can be deduced accurately only by observations continued through a longer period than the limited time of a running survey will generally permit. Observers should, if possible, be left for this purpose at the important points. A lunation is the shortest period in which approximate data can be arrived at, but observations for a shorter time, and by rough means, may prove of some value, and such should be made daily.

Meteorological observations, the direction and force of the winds, the appearance of the sky and clouds, temperature, the pressure and humidity of the atmosphere, etc., should be made at the stations occupied for tidal observations; they can then be made with more precision than those usually made on board ship.

Every opportunity should be availed of for gathering information from intelligent residents in regard to the local, tidal, and meteorological relations, in order to complete deficient observations. Permanent currents are correctly ascertained in places where a vessel can anchor, by various methods of observation, on the deep sea generally by the difference between the position by observation and that by the dead-reckoning.

The active hydrographic surveyor will not, while on the ocean, neglect to aid in the labor of the physicist, by examining into the condition of the water, its temperature at the surface and at various depths, its specific gravity and salinity, its fauna and flora, and by contributing to the natural sciences, general geography, geology, and ethnology, while in regions which may be not at all, or but little, explored.

The hydrographic part of the information thus obtained is laid down for the use of the navigator in charts and text-books in such a manner as to be rendered complete without interfering with clearness and ready comprehension.

Charts must contain with distinctness every feature upon which the navigator relies, coast-line, out-lying dangers, peaks of mountains, with their height, conspicuous objects, etc. Sea-charts are constructed for publication on Mercator's projection, although this projection distorts the relative size of the several areas and the bearings of points; the more so the farther the chart is extended toward the poles. Navigators, however, prefer it to the more correct conic projections, as it represents the meridians and parallels of latitude in straight lines, thereby facilitating the laying down positions and bearings. The careful hydrographer will plot his work on a conic projection, and thence transfer it to that of the Mercator. The gnomonic projection—projecting areas on a plane tangent to the earth from the earth's centre—represents the great circles, the shortest distances between two points by straight lines, and in this has advantages for charts of entire oceans. As yet, this projection has not been used to any extent. All conspicuous objects on which the navigator depends should be given preference in distinctness of delineation over that of mere detail.

Upon the intricacy of the configuration, especially that of dangerous passages, will depend the scale to be adopted, which should not be so large as to render the chart unhandy, and not so small as to interfere with clearness. Usually the work is first laid down on a scale large enough to show at a glance any fault in the projection, and then reduced to the scale decided on for publication. On the latter, objects of importance, especially dangers to navigation, should be exaggerated in preference to their not being sufficiently conspicuous. The soundings obtained, especially in harbors, will be far too numerous to represent them all, even upon the working-sheet; care must be taken in selecting the characteristic soundings, which must be reduced to a certain state of the tide, usually to low water, and they must be placed on the exact spot representing that in which they were obtained. Heretofore these were expressed in the standard measure of the country in which the chart was published, but recently the French metre has been adopted by all maritime nations, excepting Great Britain and the United States, who use the English fathom and foot. It is preferable to use on the same chart but one unit, either fathoms or feet, as the use of both, even with the shading, frequently leads to error. In order to show better the structure of the bottom, and to make irregularities more conspicuous, curves of equal depths—fathom-curves—are laid down. The denomination of the curves depends upon the depth of water that can be carried into the harbor or along the coast. Harbor charts generally show the five, three, two, and one fathom curves, the latter three often distinguished by shades of sanding (dots to represent sand); the five-fathom curve is expressed by rows of five dots on the line of the curve. Coast-charts generally show in addition a ten, fifty, and one-hundred fathom curve.

The character of the bottom is represented by the first letter, or an abbreviation of the word, expressing it; currents by arrows, with the force in knots per hour or per day placed along them; buoys and beacons are shown by conventional signs.

Lines of bearing point out the courses to be steered, and guide also in avoiding dangers. Views, placed so as not to interfere with the sailing-ground, show the appearance of the land on the bearings on which they are taken.

An important feature of the chart is the compass, placed in such positions as are most convenient for taking off the courses. On harbors and special coast-charts the compass-points are generally laid off from the magnetic north line; on general ocean-charts, on which the variation changes rapidly with the lateral distances from the direction of the magnetic curves, they are laid off from the true north.

General charts, and frequently harbor-charts, have the projection drawn over them, from which the latitude and longitude of any point represented on it can be ascertained minutely; where the projection is not thus drawn, the astronomical position of a well-defined point is given, usually under the title, with the mention of the primary position to which it has been referred. The title also embraces the tidal hour, with rise and fall of tide, at the full and change; the unit of measure in which soundings and elevations are expressed; the scale on which the chart has been constructed, and an explanation of the conventional signs used on it; these latter, however, are generally supposed to be known.

General notes regarding the winds, currents, tides, harbor facilities, etc., are frequently added, as also sometimes sailing-directions; but generally these are left for text-books, which, under the titles of "Directions," "Memoirs," "Manuals," or "Pilots," give to the navigator the information obtained by the hydrographer, with the general results arrived at, which cannot be engrossed on charts.

By a judicious arrangement and a complete index, these should be made as intelligible and as ready for reference as possible, and should contain all the points within the area treated on that are of interest to navigation.

The first treatise on marine surveying, published in a practical form, was by Alexander Dalrymple, in 1771. This was followed by the work of M. Beautemps Beaupré, in 1808; since which time there have been published many valuable works on marine surveying, adapted both to running surveys and to greater geodetical operations.

In hydrographic surveys and exploration, England has always been foremost. Her Hydrographic Office, dating from 1795, under Alexander Dalrymple, was not firmly established until 1828, when Captain Francis Beaufort became the hydrographer to the British Admiralty; since which time, under the administration of the line of distinguished navy officers his successors, it has steadily advanced, to the inestimable benefit of commerce, both British and foreign. At the present date the charts of this office number two thousand nine hundred and eighteen, and yet about one-half of the coasts and navigable waters of the world remain unsurveyed, a great part not even examined.

An interesting skeleton chart of the world, compiled at the British Hydrographic Office and attached to a paper delivered by Commander Hull, R. N., superintendent of the Admiralty charts, before the Royal United Service Institution, showed the portions of the coasts of the world surveyed, partially surveyed, and only explored. Taking this continent alone, between the parallels of 60° north and 60° south, beyond which whaling-vessels only generally go, it will be found by rough measurement that about 12,000 miles of the seacoast have been surveyed, 20,000 miles partially surveyed, and that 8,000 have been only explored. Coasts partially surveyed or only explored require the utmost caution for safe navigation; and, even with this, vessels are constantly in peril. For the remainder of the globe, with exception of Europe, the proportion of the inadequately-surveyed and almost unknown coasts and waters is much greater. This should demonstrate clearly the vast field of labor awaiting the maritime surveyor.

England perseveres in this work, and her hydrographic parties are found in every quarter of the globe, opening new channels to commerce, and defining the dangers of navigation. France, in her publications issuing from her Department des Cartes et Plans, is hardly behind Great Britain; from the time of the father of French hydrography, M. Beautemps Beaupré, to that of its present distinguished director, Vice-Admiral Jurien de la Gravière, this office has not ceased to assert its prominence and usefulness. France, however, though constantly and systematically prosecuting foreign hydrographic surveys, has not carried this work to the same extent as England. Spain, of late years, has rested on her laurels of the past, and with other maritime nations, with exception of casual foreign surveys, has restricted herself to the shores of her own possessions, and to issuing from time to time valuable publications and information for the benefit of navigation. The United States Hydrographic Office, though yet in its infancy, has made rapid progress, and now issues a respectable number of publications; no permanent system, however, of hydrographic surveys has ever been successfully instituted under the Navy Department. On its own coast, in its waters and harbors, the work of the United States Coast Survey is extensive, scientific, and thorough, and many years will yet be required for its completion.

All attempts to inaugurate a system of foreign surveys have failed, though, with intervals of many years, spasmodic efforts have been made and expeditions sent from her shores, which have done good service to hydrography and geographical science, though many and powerful attempts have been made by those interested in commerce and navigation to induce legislators to appropriate the small amounts requisite for this service; yet, even when such have been organized, and the hydrographic work was beginning to yield its fruit, the want of interest and legislation has crushed it out, and necessitated the withdrawal of the work, leaving only the hope that in time to come the United States may assist the other great maritime nations in making more smooth the course of the mariner through the paths of the great deep. Millions of property have been lost, with thousands of valuable lives, from the lamentable neglect of continued hydrographic surveys.

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## LACE AND LACE-MAKING.[1]

By ELIZA A. YOUMANS.

To think of lace merely as a symbol of vanity is quite to miss its deeper significance. If the feeling that prompts to personal decoration be a proper one—and it is certainly a natural and universal sentiment—then lace has its defense, and we may agree with old

[1] We cannot give a complete account of lace in a magazine article, but readers who desire more information are referred to Mrs. Palliser's excellent history of the subject, to which we are largely indebted, and from which our illustrations are mostly taken.

Fuller of the seventeenth century, when he says: "Let it not be condemned for superfluous wearing, because it doth neither hide nor heat, seeing that it doth adorn." But the subject has also its graver aspects; for, as science is said to obliterate all difference between great and small, so the history of lace may be said to efface the distinction between the frivolous and the serious. Though good for nothing but decoration, the most earnest elements of humanity have been enlisted in connection with it. Lace-making, a product of the first rude beginnings of art, though complex, and involving immense labor, was yet early perfected. As a source of wealth, it has been the envy of nations and has shaped state policy; as a local industry, it has enriched and ruined provinces; and, as a provocative of invention, it has given rise to the most ingenious devices of modern times, which have come into use only with tragic social accompaniments. The subject has, therefore, various elements of interest which will commend it to the readers of the MONTHLY.

Lace, made of fine threads of gold, silver, silk, flax, cotton, hairs, or other delicate fibres, has been in use for centuries in all the countries of Europe. But long before the appearance of lace, properly so called, attempts of various kinds were made to produce open, gauzy tissues resembling the spider's web. Specimens of primitive needle-work are abundant in which this openness is secured in various ways. The "fine-twined linen," the "nets of checker-work," and the "embroidery" of the Old Testament, are examples. This ornamental needle-work was early held in great esteem by the Church, and was the daily employment of the convent. For a long time the art of making it was a church secret, and it was known as nuns'-work. Even monks were commended for their skill in embroidery.

A kind of primitive lace, in use centuries ago in Europe, and specimens of which are still abundant, is called cut-work. It was made in many ways. Sometimes a network of threads was arranged upon a small frame, beneath which was gummed a piece of fine cloth, open, like canvas. Then with a needle the network was sewed to the cloth, and the superfluous cloth was cut away; hence the name of cut-work. Another lace-like fabric of very ancient date, and known as drawn-work, was made by drawing out a portion of the warp and weft threads from linen, and leaving a square network of threads, which were made firm by a stitch at each corner of the mesh. Sometimes these netted grounds were embroidered with colors.

Still another ancient lace, called "darned-netting," was made by embroidering figures upon a plain net, like ordinary nets of the present day. Lace was also formed of threads, radiating from a common centre at equal distances, and united by squares, triangles, rosettes, and other geometrical forms, which were worked over with a button-hole stitch, and the net thus made was more or less ornamented with embroidery. Church-vestments, altar-cloths, and grave-cloths, were elaborately decorated with it. An eye-witness of the disinterment of St. Cuthbert in the twelfth century says: "There had been put over him a sheet which had a fringe of linen thread of a finger's length; upon its sides and ends was woven a border of the thread, bearing the figures of birds, beasts, and branching trees." This sheet was kept for centuries in the cathedral of Durham as a specimen of drawn or cut work. Darned-netting and drawn and cut work are still made by the peasants in many countries.

The skill and labor required in the production of these ornamental tissues gave them immense value, and only kings and nobles were able to buy them. But, as this kind of manufacture was encouraged and rewarded by the courts, it reached great perfection centuries ago. A search among court records, and a study of old pictures and monumental sculptures, show that it was much worn in the fifteenth century; but it was not known as lace. The plain or figured network which we call lace was for a long time called *passement*, a general term for gimps and braids as well as lace, and this term continued in use till the middle of the seventeenth century.

Lace was not only known and worn in the fifteenth century, but its manufacture at that time was an important industry in both Italy and Flanders (Belgium); while in the sixteenth and seventeenth centuries it was extensively made in all the leading countries of Europe. Two distinct kinds of lace were made by two essentially different methods. One was called point-lace, and was made with the needle, while the other was made upon a stuffed oval board, called a pillow, and the fabric was hence called pillow-lace. "On this pillow a stiff piece of parchment is fixed, with small holes pricked through to work the pattern. Through these holes pins are stuck into the cushion.[1] The threads with which the lace is made are wound upon 'bobbins,' small, round pieces of wood, about the size of a pencil, having around their upper ends a deep groove on which the thread is wound, a separate bobbin being used for each thread. By the twisting and crossing of these threads the ground of the lace is formed." The pattern is made by interweaving a much thicker thread than that of the ground, according to the design pricked out on the pattern.

The making of plain lace-net upon the pillow is thus described: "Threads are hung round the pillow in front, each attached to a bobbin, from which it is supplied and acting as a weight. Each pair of adjacent threads is twisted three half-turns by passing the bobbins over each other. Then the twisted threads are separated and crossed over pins on the front of the cushion in a row. The like twist is then made by every adjacent pair of threads not before twisted, whence the threads become united sideways in meshes. By repeating the process the fabric gains the length and width required."

[1] Sometimes lace-makers who were the wives of fishermen, not being able to buy pins, used the bones of fish as substitutes. Hence the term bone-lace.

FIG. 1—VALENCIENNES LAPPET. Eighteenth Century.

Lace consists of two parts: a network called the *ground*, and the *pattern* traced upon it, sometimes called the flower, or gimp (Fig. 1). In modern lace we may easily distinguish the ground and pattern, but in the older laces the flowers are not wrought upon a network

FIG. 2.—HONITON GUIPURE.

ground, but are connected by irregular threads, overcast with button-hole stitch, and sometimes fringed with loops. These connecting-threads, called "*brides*," are shown in Fig. 2.

The network ground is known by the French term *réseau*. It is sometimes called *entoilage*, on account of its containing the *toile* flower or ornament, which resembles linen, and is often made of linen thread. The terms *fond* and *champ* are also applied to it.

The ornamental pattern is sometimes made with the ground as n Fig. 3, or separately, and then worked in or sewed on (*appliqué*), Fig. 4. The open-work stitches seen in the pattern are called *modes*, *jours*, or "fillings."

All lace has two edges, the "footing," a narrow lace which serves to keep the stitches of the ground firm that it may be sewed to the garment upon which it is to be worn (Fig. 3); and the "pearl," *picot*, *couronne*, a row of little points or loops at equal distances at the free edge as shown in the figures.

The manufacture of point-lace was brought to the highest perfection by the Venetians as early as the sixteenth century. The pattern-

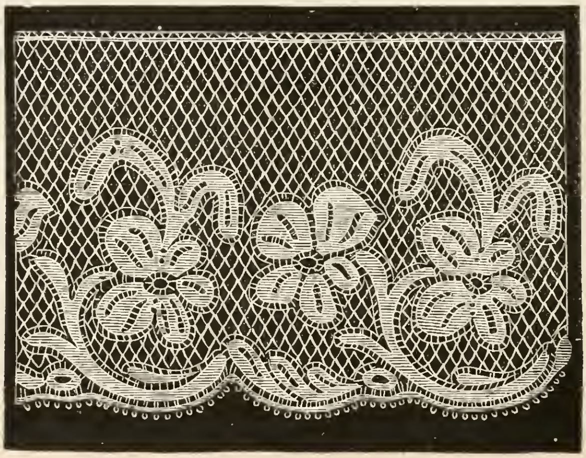

Fig. 3.—Valenciennes Lace of Yprès.

books of that time contain examples of more than a hundred varieties of this costly lace. Some of these points were world-renowned for their fineness and exquisite beauty. *Point de Venice, en relief*, is the richest and most complicated of all laces. It is so strong, with its tiers upon tiers of stitches, that some of it has lasted for centuries. All the outlines are in high-relief, and innumerable beautiful stitches are introduced into the flowers. Italian influence under the Valois and Medicis spread the fashion for rich laces, and the Venetian points were in great demand in foreign countries, particularly in France. The exportation of costly laces was a source of great wealth to Venice. The making of lace was universal in every household, and the secret of the manufacture of her finest points she jealously guarded. Although both point and pillow lace were made at this time in all the leading countries of Europe, Flanders was the only rival of Italy in the markets of the world.

During the sixteenth century there was the most extravagant use of lace by the court of France. In 1577, on a state occasion, the king wore four thousand yards of pure gold lace on his dress, and the wardrobe accounts of the queen are filled with entries of point-lace. Such was the prodigality of the nobility at this period in the purchase of lace that sumptuary edicts were issued against it, but edicts failed to put down Venetian points; profusion in the use of lace only increased. The consumption of foreign lace and embroidery was unbounded. Immense sums of money found their way annually from France to Italy and Flanders for these costly fabrics. As royal commands were powerless against the artistic productions of Venice, Genoa, and Brussels, it was determined by Colbert, the French minister, to develop the lace-manufacture in France, that the money spent upon these luxuries might be kept within the kingdom. Skillful workmen were suborned from Venice and the Low Countries, and placed around in the existing manufactories and in towns where new ones were to be established.

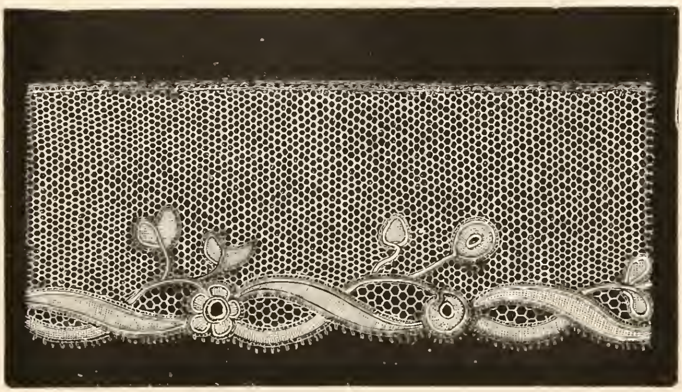

Fig. 4.—Old Honiton Application.

A declaration of August 5, 1665, orders "the manufacture of all sorts of works of thread, as well of the needle as on the pillow, in the manner of the points which are made at Venice and other foreign countries, which shall be called 'points de France.'" In a few years a lucrative manufacture was established which brought large sums into the kingdom. Point de France supplanted the points of Venice and Flanders, and France became a lace-making as well as a lace-wearing country.

The manufacture of the most sumptuous of the points de France was established by the minister at the town of Alençon, near his residence. Venetian point in relief was made in perfection in this place before his death, 1683. In all the points of this century the flowers are united *à bride* (Fig. 2), but in the eighteenth century the net-work ground was introduced, and soon became universal. The name point de France for French point-lace was after a time dropped, and the different styles took the name of the towns at which they were made, as point d'Alençon and point d'Argentan.

"Point d'Alençon is made entirely by hand with a fine needle, upon a parchment pattern, in small pieces, afterward united by invisible seams. Each part is executed by a special workman. The design, engraved upon a copperplate, is printed off in divisions upon pieces of parchment ten inches long, and numbered in their order. Green parchment is now used, the worker being better able to detect faults in her work than on white. The pattern is next pricked upon the parchment, which is stitched to a piece of very coarse linen folded double. The outline of the pattern is then formed by two flat threads, which are guided along the edge by the thumb of the left hand, and fixed by minute stitches, passed with another thread and needle through the holes of the parchment. When the outline is finished, the work is given over to the maker of the ground, which is of two kinds, *bride* and *réseau*. The delicate *réseau* is worked backward and forward from the footing to the *picot*. For the flowers the worker supplies herself with a long needle and a fine thread; with these she works the button-hole stitch (*point noué*) from left to right, and, when arrived at the end of the flower, the thread is thrown back from the point of departure, and she works again from left to right over the thread. This gives a closeness and evenness to the work unequaled in any other point. Then follow the *modes* and other operations, so that it requires twelve different hands to complete it. The threads which unite linen, lace and parchment are then severed, and all the segments are united together by the head of the establishment. This is a work of the greatest nicety." From its solidity and durability Alençon has been called the Queen of Lace.

The manufacture of Alençon lace had greatly declined even before the Revolution, and was almost extinct when the patronage of Napoleon restored its prosperity. On his marriage with the Empress Marie Louise, among other orders executed for him was a bed furniture—tester, curtains, coverlet, and pillow-cases, of great beauty and richness. The pattern represented the arms of the empire surrounded by bees. Fig. 5 is a piece of the ground powdered with bees. The differences of shading seen in the ground show where the separate bits of lace were joined in the finishing. With the fall of Napoleon this manufacture again declined, and, when in 1840 attempts were made to revive it, the old workers, who had been specially trained to it, had passed away, and the new workers could not acquire the art of making the pure Alençon ground. But they made magnificent lace, and Napoleon III. was magnificent in his patronage of the revived manufacture. One flounce worth 22,000 francs, which had taken thirty-six women eighteen months to finish, appeared among the wedding-presents of Eugénie. In 1855 he presented the empress with a dress of

Alençon point which cost 70,000 francs ($14,000). Among the orders of the emperor in 1856 were the curtains of the imperial infant's cradle, of needle-point, and a satin-lined Alençon coverlet; christening robe, mantle, and head-dress, of Alençon; twelve dozen embroidered frocks profusely trimmed with Alençon; and lace-trimming for the aprons of the imperial nurses. The finest Alençon point is now made at Bayeux.

Argentan is another town in France celebrated for its point-lace, which was not inferior in beauty to that of Alençon. The flowers of

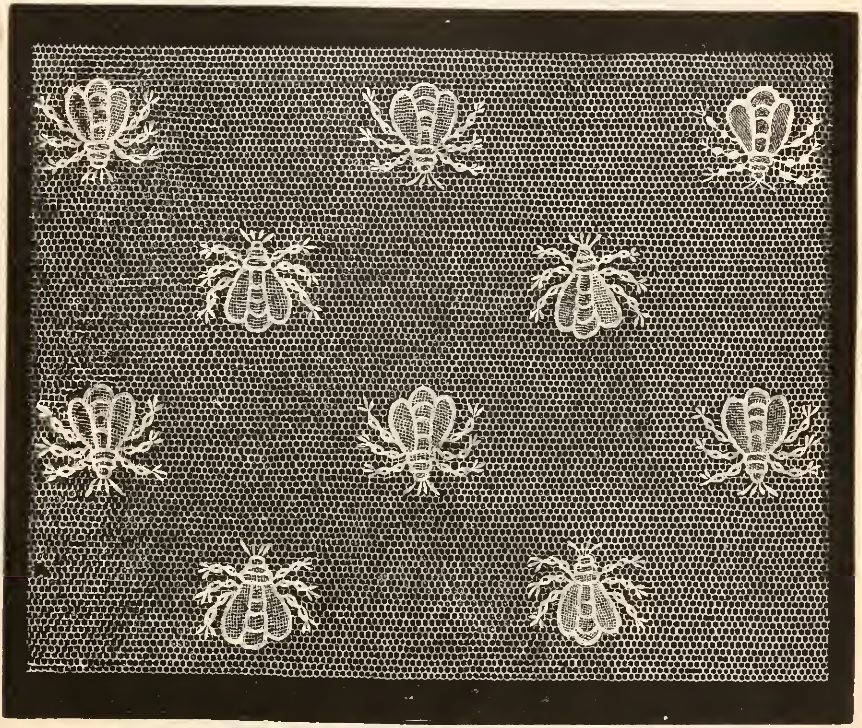

Fig. 5.—Alençon Bed made for Napoleon I.

point d'Argentan, as seen in Fig. 6, are large and bold, in high-relief, on a clear compact ground, with a large, six-sided mesh. This ground was made by passing the needle and thread around pins pricked into a parchment pattern, and the six sides were worked over with seven or eight button-hole stitches on each side. It is called the *grande bride* ground, and is very strong.

While it is clear that France derived the art of making Alençon point from Italy, yet, along with all the countries of Northern Europe, Germany, and England, she is in the main indebted to Flanders for her knowledge of the art of lace-making. Flanders, as well as Italy,

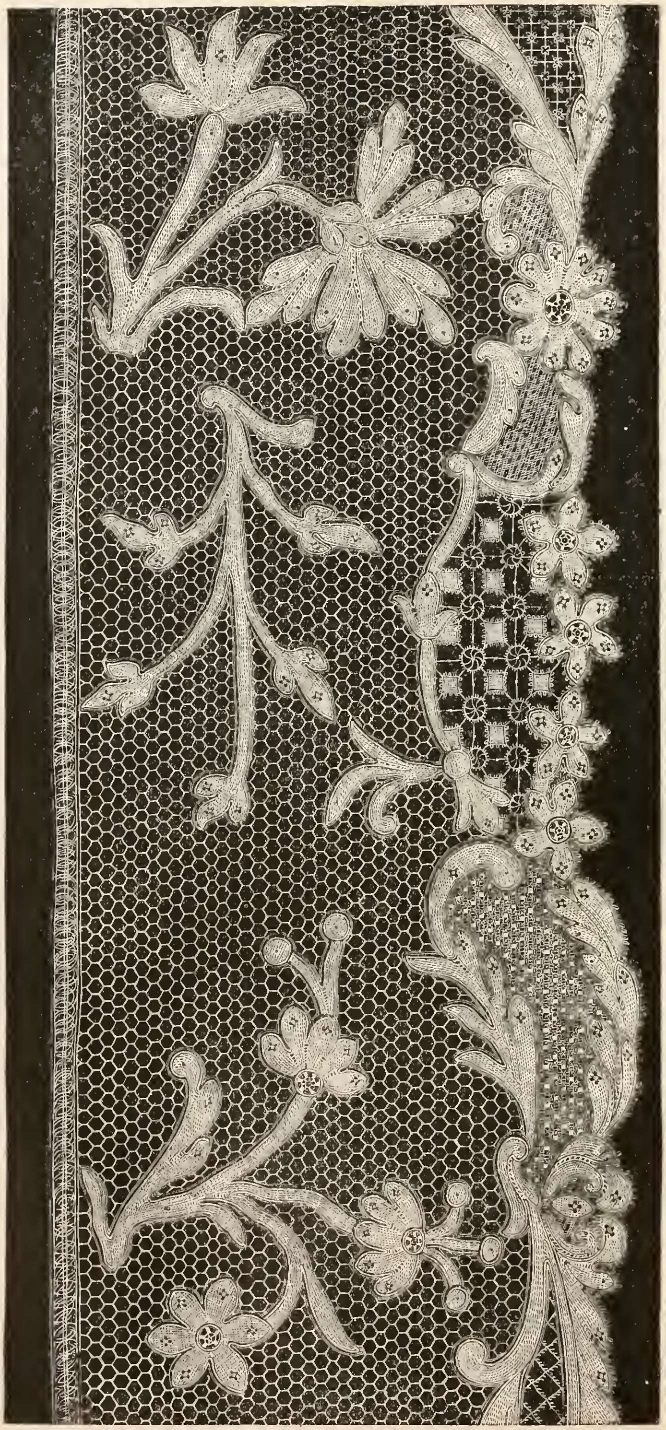

Fig. 6.—Point d'Argentan.

claims the invention of lace, and, notwithstanding its glorious past, the lace-trade of Belgium is now as flourishing as at any former pe-

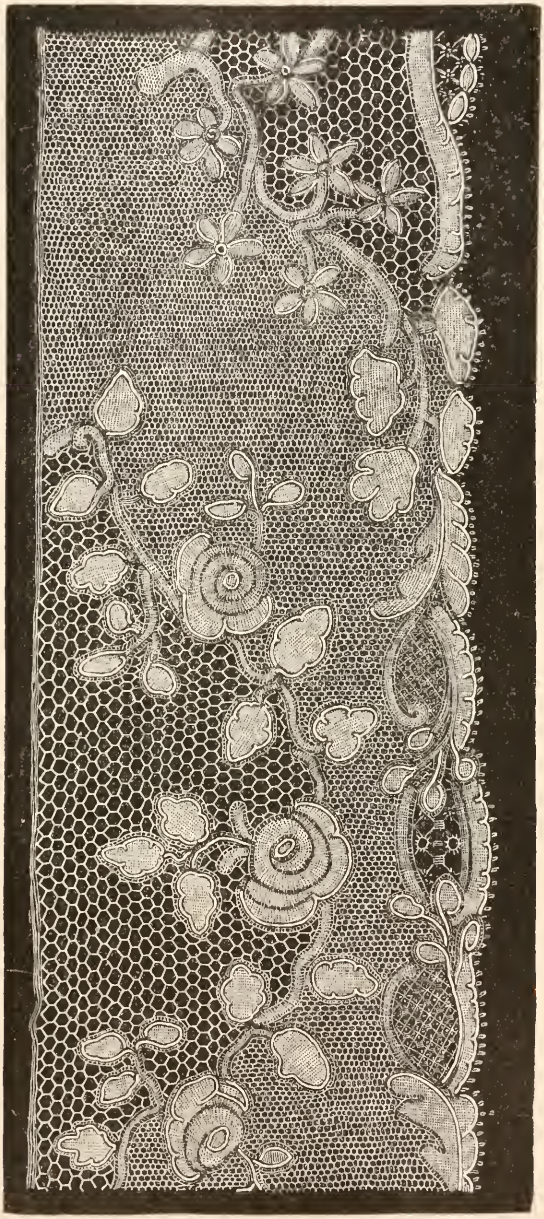

FIG. 7.

riod. Brussels lace is widely known as *point d'Angleterre*, for the reason, it is said, that in the seventeenth century the English, after vainly attempting to establish its manufacture at home, bought up the finest laces of the Brussels market, smuggled them over to England, and sold them as English point (Figs. 7 and 8).

The smuggling of lace is a very important and interesting feature in its history. From 1700 downward we are told that in England the prohibition of lace went for nothing. Ladies would have foreign lace, and if they could not smuggle it themselves the smuggler brought it to them. "Books, bottles, babies, boxes, and umbrellas, daily poured out their treasures." Everybody smuggled.

"At one period much lace was smuggled into France from Belgium by means of dogs trained for the purpose. A dog was caressed and petted at home, fed on the fat of the land, then, after a season, sent across the frontier where he was tied up, half starved, and ill-treated. The skin of a bigger dog was then fitted to his body, and the intervening space filled with lace. The dog was then allowed to escape, and make his way home, where he was kindly welcomed, with his contraband charge. These journeys were repeated till the French custom-house, getting scent, by degrees put an end to the traffic. Between 1820 and 1836, 40,278 dogs were destroyed, a reward of three francs being given for each."

The thread used in Brussels lace is of the first importance. It is of extreme fineness, and the best quality, spun in underground rooms to avoid dryness of the air, is so fine as to be almost invisible. The room is darkened, and a background of dark paper is arranged to throw out the thread, while only a single ray of light is admitted, which falls upon it as it passes from the distaff. The exquisite fineness of this thread made the real Brussels ground so costly as to prevent its production in other countries. A Scotch traveler, in 1787, says that "at Brussels, from one pound of flax alone, they can manufacture to the value of seven hundred pounds sterling."

In former times, the ground of Brussels lace was made both by needle and on the pillow. The needle-ground was worked from one flower to another, while the pillow-ground was made in small strips an inch wide, and from seven to forty-five inches long. It required the greatest skill to join the segments of shawls and large pieces of lace. The needle-ground is three times as expensive as the pillow, for the needle is passed four times into each mesh, but in the pillow it is not passed at all. Machinery has now added a third kind of ground, called tulle, or Brussels-net. Since this has come into use, the hand-made ground is seldom used except for royal trousseaux. The flowers of Brussels lace are also both needle-made *point à l'aiguille* and those of the pillow "point plat." In the older laces the plat flowers were worked in along with the ground, as *lace appliqué* was unknown (Figs. 7 and 8).

Each process in the making of Brussels lace is assigned to a different hand. The first makes the *vrai réseau;* the second the footing; the third makes the point *à l'aiguille* flowers ; the fourth, the plat flowers; the fifth has charge of the open-work (*jours*) in the plat; the sixth unites the different pieces of the ground; and the seventh sews

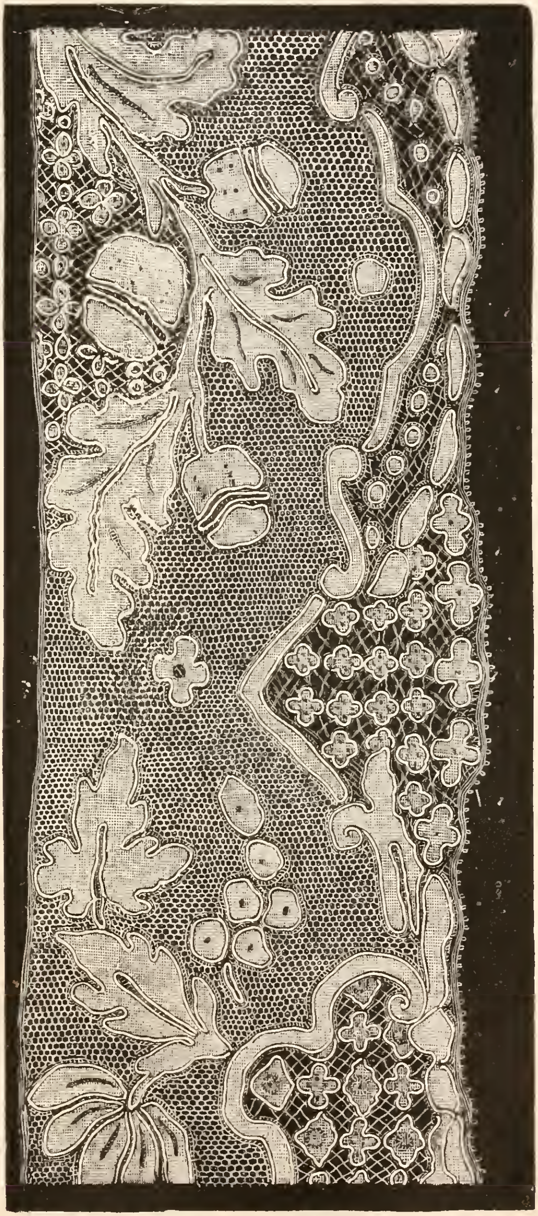

Fig. 8.—Old Brussels (Point d'Angleterre). Middle of Eighteenth Century.

the flowers upon the ground (application). The master prepares the pattern, selects the ground, and chooses the thread, and hands all over to the workman, who has no responsibility in these matters. "The lace industry of Brussels is now divided into two branches, the making of sprigs, either point or pillow, for application upon the net-ground, and the modern *point gaze*. The first is the Brussels lace, *par excellence*, and more of it is produced than of any other kind. Of late years it has been greatly improved by mixing point and pillow-made flowers.

*Point gaze* is so called from its gauze-like needle-ground, *fond gaze*, comprised of very fine, round meshes, with needle-made flowers, made simultaneously with the ground, by means of the same thread, as in the old Brussels. It is made in small pieces, the joining concealed by sprigs or leaves, like the old point, the same lace-worker making the whole strip from beginning to end. *Point gaze* is now brought to the highest perfection, and is remarkable for the precision of the work, the variety and richness of the *jours*, and the clearness of the ground. It somewhat resembles point d'Alençon, but the work is less elaborate and less solid. Alençon lace, it is said, could not compete with Brussels in its designs, which are not copied from Nature, while the roses and honeysuckles of the Brussels lace are worthy of a Dutch painter. When flowers of both pillow and needle-lace are marked upon the "*fond gaze* it is erroneously called point de Venice."

Lace-making is at present the chief source of national wealth in Belgium. It forms a part of female education, and one-fortieth of the entire population (150,000 women) are said to be engaged upon it.

But some of the pillow-laces have had immense popularity as well as those of the needle. Fig. 1 is a beautiful example of the pillow-lace made at Valenciennes in the eighteenth century.

This kind of lace was first made in the city of Valenciennes, and the manufacture reached its height in that town about 1780, when there were some 4,000 lace-makers employed upon it; but fashion changed, lighter laces came into vogue, and in 1790 the lace-workers had diminished to 250. Napoleon made an unsuccessful attempt to revive the manufacture, and in 1851 only two lace-makers remained, and they were over eighty years old. At one time this manufacture was so peculiar to the place that it was said, "if a piece of lace were begun at Valenciennes and finished outside the walls, the part not made at Valenciennes would be visibly less beautiful and less perfect than the other, though done by the same lace-maker with the same thread and pillow." The city-made lace was remarkable for its richness of design, evenness, and solidity. It was known as the "beautiful and everlasting Valenciennes," and was bequeathed from mother to daughter like jewels and furs. It was made by young girls in underground rooms, and many of these workers are said to have become almost blind before they were thirty years of age When the whole piece was done by the same hand the lace was thought much more valuable.

Valenciennes lace was made in other towns of the province, but "vraie Valenciennes" only at Valenciennes. The Lille makers, for instance, would make from three to five ells a day (an ell is forty-eight inches), while those of Valenciennes would make not more than an inch and a half in the same time. Some lace-makers made only twenty-four inches in a year; hence the costliness of the lace. Modern Valenciennes is far inferior in quality to that made in 1780.

The manufacture is now transferred to Belgium, to the great commercial loss of France, for it is the most widely consumed of any of the varieties of lace. It is the most important of the pillow-laces of Belgium. Yprês, which is the chief place of its manufacture, began to make this lace in 1656. In 1684 it had only three forewomen and 63 lace-makers, while in 1850 it numbered from 20,000 to 22,000. The Valenciennes of Yprès (Fig. 3) is the finest and most elaborate of any that is now made. On a piece not two inches wide, from 200 to 300 bobbins are employed, and for greater widths 800 bobbins are sometimes used on the same pillow. The large, clear squares of the ground contrast finely with the even tissue of the patterns. The Yprês manufacture has greatly improved since 1833, and has reached a high degree of perfection. Irish Valenciennes closely resembles the Yprês lace. Valenciennes lace as fine as that of France was at one time made in England (Fig. 9).

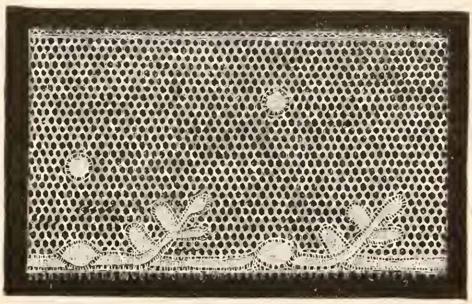

Fig. 9.—Valenciennes, Northampton, England.

*Mechlin* is a fine, beautiful lace, made in one piece on the pillow, and is distinguished by the flat thread which forms its flower. Before 1665 all pillow-lace, of which the pattern was relieved by a flat thread, was known as Mechlin lace. "It is essentially a summer lace, not becoming in itself, but charming when worn over color."

Silk laces were first made about 1745. At first this new fabric was manufactured from silk of the natural color brought from Nanking and it was hence called *blonde.* After a time, however, it was prepared from the purest and most brilliant white silk. "Not every woman can work at the white lace. Those who have what is locally termed the *haleine grasse* (greasy breath) are obliged to confine themselves to black." To preserve purity of color it is made in the open air in summer, and in winter in the lofts over cow-houses, as the warmth of the animals enables the workers to dispense with fire, which makes more or less smoke. The most beautiful blondes were once made at Caen, but competition with the machine-made blondes of Calais and Nottingham has caused the manufacture of white blonde to be abandoned at this place, and its lace-makers now confine themselves to making black lace.

The manufacture of black-silk lace was first established in the town of Chantilly, near Paris, and hence, wherever this fabric is now made, it is called "Chantilly lace." It is always made of a lustreless silk, called "grenadine," which is commonly mistaken for thread. As it was only consumed by the nobility, its unfortunate producers became the victims of the Revolution of 1793, and perished with their patrons on the scaffold. This put an end to the manufacture for many years; but in 1835 black lace again became fashionable, and Chantilly was once more prosperous. But the nearness of Chantilly to Paris has, of late, increased the price of labor so much that the lace-manufacturers have been driven away. The so-called Chantilly shawls are now made at Bayeux. The shawls, dresses, and scarfs, that are still made at Chantilly are mere objects of luxury.

The black laces of Caen, Bayeux, and Chantilly, are identical. The shawls, dresses, flounces, veils, etc., are made in strips and united by a peculiar stitch. Great pains are taken in Bayeux in the instruction of lace-makers, so that the town now leads in the manufacture of large pieces of black lace. Fig. 10 represents a sample of this lace of the finest quality and of rich design.

Each country has furnished its special style of lace—Italy its points of Venice and Genoa; Flanders its Brussels, Mechlin, and Valenciennes; France its point d'Alençon and its black lace of Bayeux. England has also produced its unique Honiton, and Spain its silk blondes. Each of these laces is made in other countries, but in its characteristic lace each nation is unrivaled.

Honiton lace, the only original English lace of importance, was first made at Honiton, in Devonshire, in the seventeenth century. The art of lace-making is said to have been brought into England by Flemish refugees, and Honiton lace long preserved an unmistakable Flemish character. It is to its sprigs that it owes its reputation. They are made separately, and at first they were worked in with the pillow-ground; afterward they were sewed on, as shown in Fig. 4, which is a sample of the Honiton of the last century. The net is very beautiful and regular. It is made of the finest thread, brought from Antwerp at a cost of $350 per pound. There was no thread to be found in the British Islands fit for the purpose. Cotton thread, perhaps, might be had, but not the linen thread necessary in a work requiring so much labor, which alone would make it very costly.

The manufacture of a piece of net like this, eighteen inches square, cost $75, and a Honiton veil often cost a hundred guineas.

At the time of the marriage of Queen Victoria, the manufacture of Honiton lace was so depressed that it was with difficulty the necessary number of lace-workers could be found to execute the wedding

Fig. 10.—Black Lace of Bayeux

lace. Her dress cost £1,000, and was composed entirely of Honiton sprigs, connected on the pillow by a variety of open-work stitches. Fig. 11 is one of the honeysuckle sprigs from a flounce afterward made for her Majesty. "The bridal dresses of their royal highnesses the Princess Royal, the Princess Alice, and the Princess of

Wales, were all of Honiton lace, the patterns consisting of the national flowers, the latter with prince's-feathers intermixed with ferns, and introduced with the most happy effect." These sprigs are joined with the needle by various stitches, forming Honiton guipure, Fig. 2, which, in richness and delicacy, is by many thought to surpass the fine

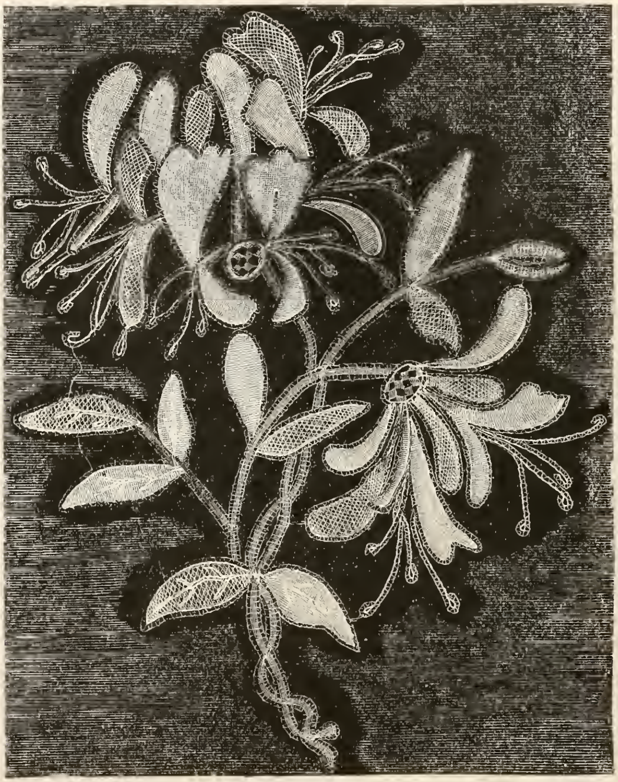

Fig. 11.—Honeysuckle Sprig of Modern Honiton.

guipure of Belgium, known as *duchesse* lace. "The reliefs are embroidered with the greatest delicacy, and the beauty of the workmanship is exquisite."

Valenciennes and Mechlin were the first laces in which the ground was wrought in one piece with the design. Until this time all lace had been *guipure*—that is, it had consisted of open embroidery, in which the figures were connected by *brides* without any thing like a background. The network ground, which we now take to be the essential thing in lace, was not thought of till the end of the seventeenth century. The word *guipure* means a thick cord over which silk, gold, or silver thread, is twisted. In the seventeenth century this guipure, or *guipé*, was introduced into lace to imitate the high-reliefs of needle-made points. These were guipure laces. The name has since been applied to all laces without grounds that have the patterns united by brides. The bold, flowing figures of Belgium and Italy, joined by a coarse network ground (Fig. 12), are also called guipure.

The *guipure* called Cluny, with its geometrical patterns, is a recent lace which derives its name from the circumstance that the first patterns were copied from specimens of old lace in the Musée de Cluny.

Thus far we have only spoken of hand-made lace, which, in Italy, was a purely domestic industry. It was made by women at home,

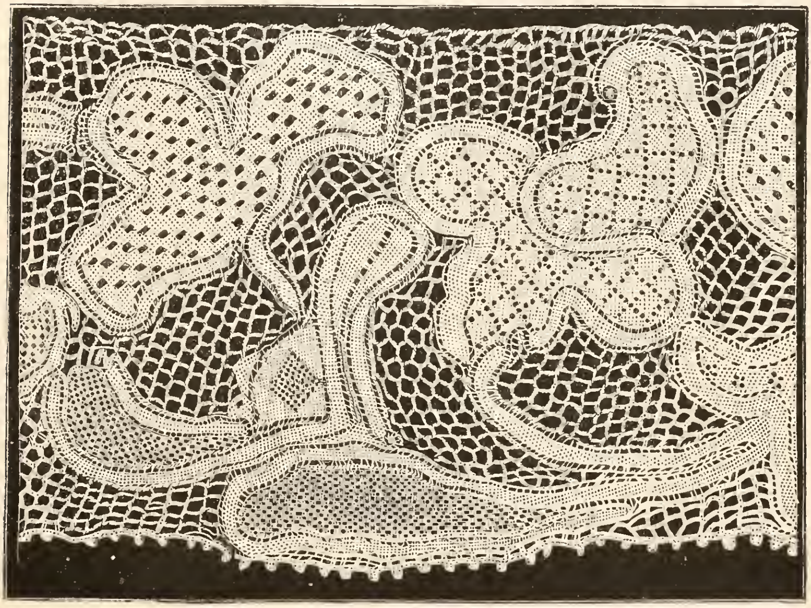

Fig. 12.—Guipure. Seventeenth Century.

and each piece of work was begun and finished by the same hand. But, when the statesman Colbert introduced the manufacture into France, the principle of the division of labor was adopted, and the work was done in large factories. By degrees, as we have seen, fine needle-made net replaced the bride-ground in costly laces, and cheaper laces of the same style were made upon the pillow. The sprigs were at first worked into the net; but at length, in the Valenciennes and Mechlin laces, the figure was made along with the ground, and it was the immense success of these laces which led to the invention and perfection of lace-machines, so that now almost every kind of lace is made by machinery, and often so perfect that it is difficult for experts to detect the difference.

"The number of new mechanical contrivances to which this branch of manufacture has given rise is altogether unparalleled in any other department of the arts." It was in 1764, a little more than a hundred years ago, that pillow-made net was first imitated by machinery. It was called frame-looped net, and was made by using one thread, as in hosiery, and, like hosiery, the lace would ravel when this thread was broken. The machine was, in fact, a modification of the stocking-frame. It was so much improved from time to time that net with six-sided meshes could be made, which, when stiffened, looked like cushion-net, but when damp it would shrink like crape.

Another machine was devised for making lace, called the warp-frame. The lace made by it, like the former, consisted of looped stitches, but a solid web was produced, which could be cut and sewed like cloth. In 1795 lace open-work was made by this machine, and soon afterward durable and cheap figured laces, in endless variety. "The lightest gossamer blond silk laces, cotton tattings and edgings, antimacassars and d'oyleys, threaded and pearled, are finished in this loom, and are the pioneers of higher-priced lace articles throughout the world. In 1810 there were four hundred warp-looms at work making the lace called Mechlin-net, and using cotton yarn costing fifteen guineas the pound."

But the most important step ever taken in the making of lace was the invention of the bobbin-net machine. Until this invention machine-lace was, for the most part, only a kind of knitting that had to be gummed and stiffened to give it the solidity of net. The great problem of the time was how to imitate pillow-made net by machinery. Numerous attempts to do this were made by smiths, weavers, and lace-makers. Much inventive talent was vainly spent, and many men of genius fell into poverty through their prolonged and unrequited efforts to construct the required machine. Insanity and self-destruction had ended the careers of some, and disappointment and misfortune befell them all, until at last the idea of such a machine was regarded as visionary—it was classed with the perpetual motion.

John Heathcote, the inventor of the bobbin-net machine, was born in 1783. In youth he was remarkable for his quick acquisition of knowledge, his thoughtful intelligence, and quiet deportment. He was early placed at the hosiery manufacture, and at the age of sixteen he conceived the idea of constructing a machine to make lace. In 1804 he was at work as a journeyman at Nottingham, and is thus described by his employer: "Heathcote showed that he had already attained to a thorough knowledge of mechanical contrivances; was inventive and persevering; undaunted by difficulties or mistakes and consequent ill-success; patient, self-denying, and very taciturn. But he expressed surprising confidence that, by the application of mechanical principles to the construction of a twist-net machine, his efforts would be crowned with success." Being determined to construct a machine for making twisted and traversed net,[1] he removed to a place where he could secure privacy and the constant sight of lace-making upon the pillow. During the time between 1805 and 1808 he perfected and patented his first machine, by which he could make a breadth of traversed and twisted net three inches wide. It was pronounced by Lord Lyndhurst "the most extraordinary machine ever invented; but he at once broke it up, and in 1809 patented another, which would make a wider net and had many other advantages.

"Cushion-made net had half the threads proceeding in wavy lines from end to end of the piece, and may be represented by warp-threads. The other threads, lying between the former, pass from side to side by an oblique course to the right and left, and may be called weft-threads. If the warp-threads could move relatively to the weft-threads so as to effect the twisting and crossing, but without deviating to the right or left hand, and if the weft-threads could be placed so that all of them should effect the twisting at the same time, and one-half of them should proceed at each operation to the left and the other half to the right hand (a substitute being also provided for the cushion-pins), lace would be made exactly as on the cushion." The machine patented by

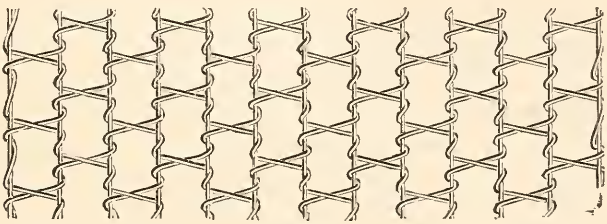

Fig. 13.

Heathcote secured these results, and increased the production over the pillow-worker a thousand-fold. The courses of the threads forming the meshes of the bobbin-net frame may be seen in Fig. 13. When taken off and extended to their proper shape the meshes have the appearance shown in Fig. 14.

This wonderful machine was produced by the unaided mechanical skill of Heathcote; but in constructing it he met with such difficulties as led him long after to say that, "if it were to be done again, he should probably not attempt to overcome them." He was only twenty-six years old when he took the second patent. In 1813 he patented various improvements upon it and reduced the number of movements necessary to make a row of meshes. The machine of 1809 employed sixty movements to make one mesh, which is now done by twelve. It made one thousand meshes a minute, and only five or six could be made by hand. A machine of the present day produces thirty thou-

[1] Net in which great numbers of threads were made to twist with or wrap round each other, and to traverse, mesh by mesh, through a part or the entire width of the frame.

sand in the same time. This industry is said to surpass all others in the complex ingenuity of its machinery.

One of the machines used in its production is said by Dr. Ure to be as much beyond the most curious chronometer in multiplicity of mechanical device as that is beyond a common roasting-jack.

In 1811, when prices had fallen, a Vandal association at Loughborough paraded the streets at night with their faces covered, and armed with swords and pistols, and, entering the workshops, they broke the machines with hammers; twenty-seven machines were destroyed in Heathcote's factory. In 1816 fifty-five more were destroyed

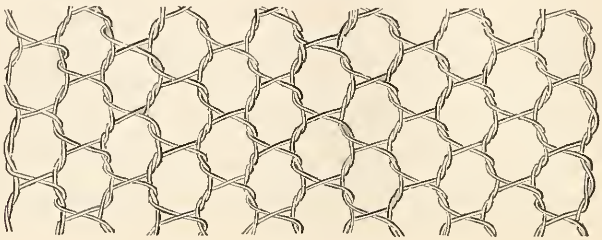

Fig. 14.

by the same society. Of the eight men who conspired in the attack on Heathcote's factory, six were convicted and hung and two transported for life. Heathcote's loss was estimated at $50,000, which the authorities offered to make up to him if he would reëxpend the money in the county. This he refused to do, and the result was that he left Loughborough and settled at Tiverton, where he remained until his death in 1861. Heathcote employed his mechanical skill with unwearied energy in improving the lace-manufacture. From 1824 to 1843 he was constantly busy with inventions, and he represented Tiverton in Parliament from 1834 to 1859.

"Bobbin-net and lace are cleaned from the loose fibres of the cotton by the ingenious process of gassing, as it is called, invented by the late Mr. Samuel Hall, of Nottingham. A flame of gas is drawn through the lace by means of a vacuum above. The sheet of lace passes to the flame opaque and obscured by loose fibre, and issues from it bright and clear, not to be distinguished from lace made of the purest linen thread, and perfectly uninjured by the flame." The progressive value of a square yard of plain cotton bobbin-net is thus stated: In 1809, $25; 1813, $10; 1815, $7.50; 1818, $5; 1821, $3; 1824, $2; 1827, $1; 1830, 50 cents; 1833, 32 cents; 1836, 20 cents; 1842, 12 cents; 1850, 8 cents; 1856, 6 cents; 1862, 6 cents.

In 1823, when Heathcote's patent expired, water and steam power had already begun to take the place of hand-labor, and lace-machines rapidly increased in numbers. Men of all ranks and professions, clergymen, lawyers, and doctors, embarked capital in the business, and all Nottingham went mad. Mechanics flocked to the scene, dwellings could not be had, and building-ground sold for $20,000 an acre. "Thousands of pounds were paid in wages to men who had not seen a twist-machine, and tens of thousands for machinery that could never repay the outlay. Improvident men rode to their work, stopping for drinks of port and claret by the way, and were seen years afterward receiving parish pay. When the national frenzy of 1825 collapsed, the effect of this local inflation was fearful. Visions of wealth were at once dissipated; many in and out of the trade fell into poverty, or became exiles, and some destroyed themselves."

The extent of the manufacture of lace by machinery in England is immense. In 1866 there were 3,552 bobbin and 400 warp machines, yielding £5,130,000. There has been no actual census since then, but in 1872 the returns were certainly not less than £6,000,000.

In France, in 1851, there were 235,000 cushion-lace makers, producing annually £3,000,000, the whole European production in hand-made lace being £5,500,000. The bobbin-net machines and warp frames are extensively used in France, and twenty years ago there were 50 bobbin-net machines in Belgium, making very fine extra twist-net on which cushion sprigs are applied.

The invention of machinery for lace-making, however, has not diminished the consumption of costly hand-made laces. The rich seem more eager than ever to obtain the finer products of the needle and pillow, insisting that the touch, finish, and beauty, of such laces can never be attained by the products of the lace-frame. On the contrary, the writer was recently assured, by the foreman of a leading lace establishment in London, that no hand-made ground could compare in beauty and perfection of workmanship with some of the exquisite grounds now made by machinery.

## OUR GREAT AMERICAN UNIVERSITY.

ABOUT five years ago we decided to found a new college. At that time our denomination had but seven in the State, not one of them first class, all beggarly, and the nearest fifty miles away. Brother A—— alone demurred to the project, but, as he was more noted for mere abstract scholarship than for practical attainments, his objections were easily set aside. He thought it would be very unwise to establish another institution of learning, on the ground that the prevalent division of forces tended to lower educational standards; and he held that we ought rather to concentrate our energies upon schools already in existence and struggling to get along. We, on the other hand, urged the desirability of multiplying means of education. If one college is a good thing, surely two must be twice as good, and so on, indefinitely. Why, then, should we not have a college of our own, and train up our young men at home, instead of sending them away to institutions established in distant places for the gratification of wretched local pride? Besides, the nearest university to us was that hot-bed of infidelity founded by the State, and there was great danger lest our youth should go there and become corrupted. Such a catastrophe must be prevented at all hazards.

But one argument influenced us above all others, and was, in fact, unanswerable: we had in our midst a very prominent man, the Hon. Magnus Virtue, who, after accumulating a large fortune in the management of a distillery, had lately retired from business, and joined my church. Out of the goodness of his heart, and encouraged by my exhortations, he decided to become a public benefactor, and accordingly offered us $20,000 for the foundation of a great college to be called by his ever-to-be-revered name. Here, then, was an opportunity which we ought not to neglect. Twenty thousand dollars was a most munificent gift, and would found an institution better endowed at the start than any of our near rivals, except perhaps the political abomination already mentioned. Twenty thousand dollars meant a fine building; and surely students' fees would suffice for the expenses of running. As for libraries, apparatus, etc., we could easily rely upon donations and bequests which would, of course, come pouring in upon us as soon as we were well established.

So we organized a board of trustees, procured a charter, and set to work under the title of "Virtue University." This, we thought, had a grander sound than "Virtue College," and we well knew how much the public is influenced by names. Shakespeare's absurd statement about the odor of a rose is contradicted by universal experience.

The first great task before us was, plainly, the erection of a building; and this involved the choice of a site. Here we were very fortunate. One of my parishioners, a noted real-estate broker, happened to own a worn-out farm some two miles from town, and was anxious to bring it into market. He was a man who clearly recognized the duty of casting his bread upon the waters whenever a fair prospect of speedy return with interest was discernible; and so he presented us with five acres of said land, situated on the top of a steep bluff a quarter of a mile from the nearest road. The gift, of course, advertised the rest of his estate, which he at once cut up into building-lots, and sold at a handsome profit. He got his money, and we got our site, so both were satisfied. Far be it from me to impugn or even to suspect his motives. Of course, our building was begun without delay.

Meanwhile we went vigorously to work manipulating the newspapers, both secular and religious. Every week we caused some item to appear concerning the progress and prospects of "Our Great American University." Rumors of expected bequests, and speculations about the Faculty were continually finding their way into print. Our university was to be a model to all other institutions. Although controlled by our denomination, it was to have no sectarian bias; its policy should be conservatively liberal; morally, intellectually, and æsthetically, it might be regarded as the culmination of our American school-system. Men of national reputation and the greatest ability were to fill professors' chairs; thorough instruction could be expected in every department; languages, literatures, sciences, philosophy, and art, would occupy the time of the students who were sure to flock in from all parts of the country. We hoped to eclipse all the colleges of America, and even to rival the greatest universities of the Old World. Statements like these, capable as they were of great latitude in interpretation, served the double purpose of interesting the general public, and of keeping up our own enthusiasm.

At last our building was finished—a splendid brick structure with a French roof, a tower, and a belfry. Even a New York architect, who visited our town, expressed his wonderment and surprise at it. Of course we were proud of our work, but that pride was lessened when we discovered that the $20,000 was all expended. The building had absorbed it completely, and half as much again; so here we were, at the end of our tether, with a fine pile of brick-and-mortar, no money, and a very handsome debt. What was to be done? Our trustees met, and, since most of them were clergymen, this question was promptly answered. We must appeal to the public. We did so—begged vigorously on week-days, took up a collection on Sundays, and, in the course of a month, managed to raise about $3,000. This went to the builder, who, for the rest of his claim, generously accepted a mortgage bearing eight per cent. interest.

This unfortunate matter rather cast a damper upon our spirits, but still we were determined to go along. Here was a debt upon which interest must be paid, and how could we pay it except by opening the university and deriving some income from students? We expected 500 students at $50 per annum each, making $25,000 a year to begin with, exclusive of gifts and bequests. We could allow $2,000 a year for interest and sinking-fund, $8,000 for incidental expenses, and all the rest might go to pay instructors. Seven professors, at $1,800 apiece, with a president at $2,500, would give us indeed a strong Faculty. So we went bravely ahead on the strength of these calculations. Adversity only seemed to make our anticipations more glowing than ever. Such is the power of faith.

All this time Brother A——, who had, unfortunately, become a member of the board, was a thorn in our flesh, and a stumbling-block in our path. Not a step was taken without opposition from him; indeed, he seemed to consider himself a monitor over all our official actions. The conceit of these scholars is amazing! He opposed the erection of our building as an extravagance, urging that a university needed brains more than mere brick-and-mortar. When we decided to get brains, he again annoyed us, saying that we ought not to employ professors until we were sure of our ability to pay them. Such inconsistencies were naturally self-destructive; so we listened politely to his wild and extravagant ideas, then quietly ignored whatever he said, and did as we had previously determined. Other colleges had fine buildings, contracted debts, and worked on the sure foundations of faith, hope, and (to be received) charity. We would follow the common example, and succeed. To this Brother A—— added that other colleges sometimes failed, and so might ours; but I, for one, could not understand the relevancy of the remark.

So the board agreed, with but one dissenting voice, to appoint a Faculty. The next step led to squabbles. Every member had some *protégé* to provide for; each one desired that certain chairs should be established and others omitted—no two could agree altogether. First, of course, we decided to choose a president, for a college without a president would be like a house without a roof. We would, therefore, appoint a president, and then let him advise us what to do next; although taking his advice might be quite another matter. As was to be expected, Brother A—— again interfered, saying that a president would be a useless expense; that he would merely draw the highest salary and do the least work of any member of the Faculty. To sustain his arguments he called our attention to the fact that the German universities have no presidents, whereupon I jocosely remarked that "they could afford no precedent for us." With their infidel tendencies they are indeed bad exemplars, and it would be a great pity if any free American institution should ever copy after them.

After a long and tedious discussion we at last fixed our choice upon a prominent Eastern clergyman, and offered him the splendid salary of $2,500 dollars a year. His parish, however, paid him $6,000, and so he gratefully declined our proposition. Several other ventures resulted in the same way, and thus three months passed with nothing accomplished. Finally, the lightning struck in a most unexpected quarter, and I, the humble writer of these pages, was really chosen President of Virtue University. This choice was opposed by Brother A—— with more than his usual bitterness; why, I never could quite understand. He disclaimed all personal feeling in the matter, professed great esteem for me, and all that sort of thing, but thought I was hardly qualified for the place. He pointed out that I had had no experience in educational affairs; that I was a graduate, not of a college, but only of a theological seminary; and stoutly maintained that we ought to choose either a thoroughly-trained educator or nobody at all. Now, it was well known that I had successfully, not to say brilliantly, served several terms upon the school committee; and also that I had once been chaplain of a small college in the northern part of the State. These facts, coupled with the shrewd suspicion that Brother

A—— would like the appointment for himself, gave me the election. I at once entered upon my duties, and began to draw salary. This was in May, and the university was to open in September. Meanwhile, I was to raise money; so, after first giving my views concerning the Faculty, I started for New York, begging. In two months I contrived to secure $1,500 over my expenses, and then returned in only a very moderate state of jubilation. Why is it that rich men care so little for the cause of education?

At last the composition of our Faculty was determined, as follows: I, as president, was to teach mental and moral philosophy, logic, and finance. Brother A—— ironically suggested that perhaps I had better undertake five or six other branches in addition to these, but I did not feel like being overworked. For professors we were to have one of Latin, a second of Greek, a third of mathematics, a fourth of history, a fifth of English literature and rhetoric, a sixth of modern languages, and a seventh of chemistry and natural philosophy. As was to have been expected, Brother A—— bothered us again, urging that, as long as we were determined to appoint professors, we ought to do fuller justice to the sciences. But these are comparatively unimportant, as well as rather unsafe, branches of knowledge (if, indeed, they can be called true knowledge at all), and therefore we adhered to the scheme given above. We did, however, draw up a long plan of studies, including every prominent subject we ever heard of, and in it relegated astronomy, botany, natural history, and geology to the senior year of the college course. They could be taught at the proper time without special professors. This plan or programme we constructed in the most thorough manner, arranging hours for each professor, fixing text-books, and stating in which rooms given recitations should be heard. One of our members—it is easy to guess who—broached the subject of elective studies, but the rest of us discountenanced all such experiments. We felt able to arrange a better course of studies than any student could devise, and held firmly to the idea that what was best for one was best for all. With the needs of students after graduation we had nothing to do. As for text-books, not a new one appeared on our list; we chose only such as were old and well tried; that on chemistry, for instance, was the same which I had studied in the Sleepyville High-School thirty years before. When our professors arrived they annoyed us a good deal about changing, but we firmly adhered to our early decisions. The scheme of hours, however, we did have to rearrange, for in practice it would not work. We had planned it in such a way that sometimes one professor would have to hear two different classes in different rooms at once; and in other instances the students were required to be similarly ubiquitous.

I have already mentioned the fact that the election of professors was attended by much dissension in our board. This began, as usual, with Brother A——, whose notions were always of the most unpractical kind. He wanted us to employ specialists; men who understood thoroughly the branches they professed to teach, and who would be independent of text-books. According to his extravagant ideas, every department of knowledge is in rapid growth, and only a man who devotes himself assiduously to one study is able to teach that study in accordance with the requirements of modern times. Such nonsense as this we repudiated. Anybody of ordinary education and intelligence ought to be able to teach any subject by simply taking a text-book and keeping a lesson or two ahead of the class. As for "advanced knowledge," the "requirements of modern times," and all that sort of thing, we distrusted it totally; under such disguises, specious and pleasing, dangerous ideas would be sure to creep in and sap the foundations of our university. We must have nothing rash nor novel in our institution; only well-tried and approved knowledge should be taught by the professors. These must be, first, men of trained moral character and good denominational standing; mere familiarity with this, that, or the other study, should be a purely secondary matter.

At last, after much ill-feeling all round, our professors were appointed. Four of them were esteemed clergymen of our denomination, who, having failed at preaching, were glad to find some occupation. Thus, in divers ways, does a great university benefit the human race. Another member of the Faculty was a recent graduate of our leading theological seminary, who accepted a chair until he could find a pulpit; two others were lay brethren. We had our greatest difficulty in selecting a professor of chemistry. Several gentlemen applied, were discussed, and rejected, before we made our final choice. One, the special *protégé* of Brother A——, had just returned from Germany, where for three years he had been studying at Heidelberg under a certain Prof. Bunsen, who was reputed to be a very great man, but of whom we had never before heard. This young man brought strong recommendations, but appeared to be dangerous; so, as he was not a member of our sect, we rejected him. Another we were about to elect, when we discovered that he was a Darwinian and a reader of Tyndall; so he could not by any means be chosen. At last we found an apparently harmless young gentleman who had just graduated from an Eastern scientific school, and him we made our professor. Now a notable event happened. Brother A—— made a suggestion which was actually followed; namely, that we should buy some apparatus and chemicals. We at once voted to spend three hundred dollars (recently begged) for fitting up a laboratory, and appointed a committee to look after the matter. At the next meeting of the board they reported the purchase of an air-pump, an electrical machine, some acids, a little phosphorus, a large gas-bag, and several retorts. These being the appliances most frequently mentioned in general literature, they were undoubtedly the proper things to have; and we considered the professor lucky in having them. Brother A—— was, of course, dissatisfied with the whole proceeding. He thought that the money should have been placed at the disposal of our professor, who knew best how to expend it; and he also grumbled because our committee had not bought something called a spectroscope. Such an instrument was never heard of in my days, so I suspected it of some occult connection with spiritualism, and expressed myself accordingly. What has science to do with spectres? The instrument was never bought.

Before the university opened, all the moneys collected during my Eastern trip, together with minor sums contributed at home, were expended. All sorts of unforeseen expenses kept rising before us. There was furniture to buy, of course, and maps, and stationery, and books. Indeed, a library was indispensable, so we voted to invest a thousand dollars in books, and placed this sum in the hands of a committee, of which I was chairman. I think few committees could have done better than we did. Many valuable works we obtained very cheaply from a second-hand dealer in New York; scarcely a new book was purchased. We were especially careful not to get any thing which might prove injurious to our young men; not a volume of Darwin, Tyndall, or Spencer (except the "Faery Queene"), has to this day found its way upon our shelves. No, indeed! we bought good editions of the old pagan authors, and the works of the early fathers, and full sets of the sermons published by the leading lights in our own denomination. We had also a few histories, some of the poets, and two or three worn-out schoolbooks upon chemistry and natural philosophy. I doubt whether any college in the world could show a more respectable and less dangerous library than the one which we collected.

At length all was ready for opening. Our professors were on hand, our building furnished, our money spent. Now for the rush of students eager to partake of the intellectual feast so cheaply offered to them. We had all been very busy drumming up recruits, and confidently expected a large class; but only thirty appeared. Out of these, twelve were studying for the ministry, and expected tuition free. Only eighteen paying students, yielding us an income of $900 a year; and this when we had calculated upon $25,000! Why, it would pay little more than the interest on our debt, to say nothing of professors' salaries. In this terrible emergency, the Hon. Magnus Virtue again became our benefactor. I myself went boldly to him, and told how we were situated. Said I: "The university bears your name; if it fails, your reputation will suffer; 'he that giveth to the poor lendeth to the Lord.'" He grumbled a good deal at what he called our "wretched mismanagement," and especially at our extravagance in the matter of teachers' wages. "Why should we pay a professor nearly $2,000 a year, when he had always been able to get plenty of clerks to work in his office for $600?" Finally, after much argument, he gave us $10,000, unaccompanied by his blessing. This relieved our embarrassments for the time being, and we went along quite swimmingly for the rest of the year.

I wonder if there was ever a college whose professors and trustees did not occasionally disagree? We certainly had now and then a squabble to vary the monotony of our labors, and were obliged in the board more than once to reverse decisions of the Faculty. But our chief difficulty was with the chemist, whose ideas upon some subjects were, to say the least, extravagant. To begin with: he wanted more apparatus, said he could do nothing with the "meagre" supply we had given him, and spoke rather disrespectfully of the committee which bought it; he actually referred to certain trustees as "idiots" (perhaps meaning Brother A——), which may have been true, but was unquestionably uncivil. It was in vain that I tried to convince the young man of his unreason; I urged my superior age and experience, and finally was obliged to crush him by saying, in my most polite and dignified manner, that I had probably studied chemistry before he was born, and that my teacher had succeeded brilliantly with no apparatus at all. He also bothered us for more books; so we gave him twenty-five dollars to buy them with, and thus silenced him for a while. That money he actually spent for works in foreign languages which neither I nor any student could read. Such is a result of trusting to the judgment of a professor. In the spring our chemist again broke out in the most absurd manner. It so chanced that some of our students had entered in advanced classes, a circumstance for which we failed to provide beforehand, and upon the list of studies framed by us they found certain branches which they wished to pursue. Among these were the treacherous and valueless natural sciences, for which we had no professors. It was at once found necessary that these things should be taught: and who was to teach them but the Professor of Chemistry and Natural Philosophy? We intimated to that gentleman that such work devolved upon him, and he objected most irrationally. He claimed that his business was to teach chemistry and physics (as he called natural philosophy, though what that branch has to do with medicine I never could see), and refused to undertake any thing else. How unreasonable! We only asked him to hear a few extra recitations in astronomy, natural history, physiology, botany, and geology, and he must needs object! He said that he was a chemist, and knew nothing of these other sciences; that each of them was the life-work of a specialist; and that no man living was competent to undertake even the tenth part of such a task. As we knew perfectly well that twenty other colleges in the State employed men who did precisely what he said no man could do, we insisted; and the upshot was that he resigned. Then the trustees passed an ordinance to the effect that any professor in the university could be called upon to teach any branch, upon penalty of dismissal if he refused. We were determined that our teachers should be men of broad general culture, and not mere narrow specialists. Of course, every one of them had studied a variety of branches at school or college, and surely any man ought to be able to teach any thing which he himself had ever learned. Brother A—— objected to our entire proceeding, but we paid no attention to him. Still, his remarks about "smatterers" and "educational fraud" could not but be somewhat offensive.

In the course of the year our university received a few minor gifts, and at commencement we found ourselves with the debt not very much increased. Our teachers were nearly paid, but the treasury was again empty. Two students graduated; and for them we had grand public exercises, which closed with an appeal to the people for support. This meant money, and brought in about $500. Upon such driblets our institution was obliged to run. We must evidently retrench, and we did so by reducing the number of professors and cutting down salaries. My own salary was untouched, however; but then, instruction in rhetoric and English literature was added to my former duties. The professors were to receive $1,000 per annum each, instead of the $1,800 paid hitherto, and were to be only three in number. These three were of course selected from among the unfortunate ex-clergymen who served in our original Faculty. One was to teach ancient languages and history; another modern languages and history; the third gave instruction in mathematics, political economy, and Oriental tongues. The latter item we thought would look well in our catalogue, and, as the professor had learned Turkish and Arabic when a missionary during his youth, we put it in. To be sure, he had about forgotten both languages, but, as he was never actually called upon to teach them, that made little difference. As for the "natural sciences," we decided to pass them around. For instance: I would teach chemistry the first year; then the professor of mathematics was to take it; and so on in order through the Faculty until it came my turn again. Thus we avoided the confusion and annoyance due to the presence of a scientific specialist upon our working staff. Now and then, of course, trifling difficulties arose in consequence of our unfamiliarity with the minor details of science. For example: our classical professor undertook to teach botany the other day, and attempted to show his students how a flower might be analyzed. He selected a buttercup for purpose of illustration, went through his analysis, as he thought, according to the book, and made the flower out to be a water-lily. His students would have lost confidence in him had he not dexterously attributed his error to misprints in the botany! But what are such trivial matters in comparison with the great essentials of education?

This reorganization of the Faculty meant the reorganization of the entire university, and two entirely new features were introduced into it. We established a preparatory department under a lady teacher, and we voted to admit female students to all of our classes. The latter measure was adopted rather hesitatingly, having been in a sense forced upon us by stress of circumstances. We must have students at any rate, and if we could not get young men we would take young ladies. The impropriety of thus mingling the sexes was evident to all except Brother A——, who alone really favored the step taken; and the uselessness of higher education to women was also obvious. How can women apply Latin and Greek to their household duties, I should like to know? What business have they with mathematics? My own wife never learned these things, and she has been certainly none the worse wife to me. But, notwithstanding my apprehensions, the dangerous move was made, and in consequence I have had tribulation ever since. Not that any scandal has resulted; not that any wrong has been done; our troubles come from a totally different source. These pestilent girls are teasing us to teach them all sorts of out-of-the-way things: one wants to learn the calculus, of which our mathematical professor is ignorant; another asks for a laboratory course in chemistry such as we are unable to give, and so on. Unhappy for us was the day that we permitted our thirteen young women to enter the university. They tell tales about us outside, and thus injure our reputation. We cannot get rid of them, and what *are* we to do?

But troubles like these were trifling in comparison with our anxiety upon pecuniary matters. Counting in our new preparatory department we had a few more students than before, but not enough to yield us the income we needed. The money-question, then, kept staring us in the face, and no measure we could devise ever quieted it more than just temporarily. One move was taken at commencement-time—a move due to my remarkable executive genius—which seemed to tide us over several months of our trials. We gave the degree of LL. D. to every millionaire in our county, and made a number of our popular clergymen doctors of divinity. The millionaires took the bait readily, and all save one gave us handsome sums, varying from $500 to $2,000. The single exception was a retired coal-dealer, who refused to accept the proffered degree, saying that he knew nothing about laws and did not want to doctor them. Shortly afterward he gave $50,000 to a distant college, which was already rich, and claimed to be undenominational. As for the new D. D.'s, they all exerted themselves in our behalf, and raised for us a considerable sum of ready money. All told, these honorary degrees brought us in nearly $6,000, which, together with our student-fees, was all we had to sustain our university through its second college-year.

We are now just entering upon our third season of actual collegiate work, and troubles accumulate over us. Our money is gone, our students are deserting to other institutions, and, if we had not faith in our grand enterprise the future would seem dark indeed. Some of the trustees advocate closing temporarily. Brother A—— has withdrawn from the board; Mr. Virtue refuses to do any thing more for us; our creditors are proving to be most inveterate duns, and no way seems to be open for going on. Still, we must go on; inaction would be fatal. Some rich friend ought to endow us liberally—a great university like ours cannot be permitted to die. In our two opening years we have done as much work as did either Yale or Harvard in the corresponding periods of their youth; why should we not rise as they have risen? We appeal to the public at large for support—to all friends of true education, of high culture, of moral civilization. Let it not be said in despotic Europe that Americans cared so little for intellectual advancement that they allowed their most promising university to fail. Let the rich give us money liberally for the glory of the denomination which we represent; others who cannot give should send us their sons and daughters to be educated in the true principles of life and the faith of the early fathers. No matter how dark the present may appear, the future is bright before us; great success must eventually attend our labors; unborn generations will one day look back and say, "Our ancestors sustained that university in its hour of trial, and have transmitted to us the inheritance of its greatness." Statesmen, poets, and chieftains, shall hail our university as their *alma mater*, and contribute gladly to its glory and its support.

# THE WARFARE OF SCIENCE.[1]

By ANDREW D. WHITE, LL. D.,
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## II.

I PASS, now, to fields of more immediate importance to us—to Anatomy and Medicine.

It might be supposed that the votaries of sciences like these would be suffered to escape attack; unfortunately, they have had to stand in the thickest of the battle.

As far back as the latter part of the thirteenth century, Arnold de Villa Nova was a noted physician and chemist. The missile usual in such cases was hurled at him. He was charged with sorcery and dealings with the devil; he was excommunicated and driven from Spain.[1]

Such seemed the fate of men in that field who gained even a glimmer of new scientific truth. Even men like Cardan, and Paracelsus, and Porta, who yielded much to popular superstitions, were at once

[1] Draper, "Int. Dev. of Europe," p. 421. Whewell, "Hist. of the Induct. Sciences," vol. i., p. 235; vol. viii., p. 36. Frédault, "Hist. de la Médecine," vol. i., p. 204.

set upon if they ventured upon any other than the path which the Church thought sound—the insufficient path of Aristotelian investigation.

We have seen that the weapons used against the astronomers were mainly the epithets infidel and atheist. We have also seen that the missiles used against the chemists and physicians were the epithets "sorcerer" and "leaguer with the devil," and we have picked up on various battle-fields another effective weapon, the epithet "Mohammedan."

On the heads of the anatomists and physicians were concentrated *all* these missiles. The charge of atheism ripened into a proverb: "*Ubi sunt tres medici, ibi sunt duo athei.*"[1] Magic seemed so common a charge that many of the physicians seemed to believe it themselves. Mohammedanism and Averroism became almost synonymous with medicine, and Petrarch stigmatized Averroists as "men who deny Genesis and bark at Christ."[2]

Not to weary you with the details of earlier struggles, I will select a great benefactor of mankind and champion of scientific truth at the period of the Revival of Learning and the Reformation—Andreas Vesalius, the founder of the modern science of anatomy. The battle waged by this man is one of the glories of our race.[3]

The old methods were soon exhausted by his early fervor, and he sought to advance science by truly scientific means—by patient investigation and by careful recording of results.

From the outset Vesalius proved himself a master. In the search for real knowledge he braved the most terrible dangers. Before his time the dissection of the human subject was thought akin to sacrilege. Occasionally some anatomist, like Mundinus, had given some little display with such a subject; but, for purposes of *investigation*, such dissection was forbidden. Even such men in the early Church as Ter-

[1] Honorius III. forbade medicine to be practised by archdeacons, deacons, priests, etc. Innocent III. forbade surgical operations by priests, deacons, or sub-deacons. In 1243 Dominicans banished books on medicine from their monasteries. *See* Daunou cited by Buckle, "Posthumous Works," vol. ii., p. 567. For thoughtful and witty remarks on the struggle at a recent period, *see* Maury, "L'Ancienne Académie des Sciences," Paris, 1864, p. 148. Maury says: "La faculté n'aimait pas à avoir affaire aux théologiens qui procèdent par anathèmes beaucoup plus que par analyses."

[2] Renan, "Averroés et l'Averroisme," Paris, 1867, pp. 327, 333, 335. For a perfectly just statement of the only circumstances which can justify the charge of "atheism," *see* Dr. Deems's article in Popular Science Monthly, February, 1876.

[3] Whewell, vol. iii., p. 328, says, rather loosely, that Mundinus "dissected at Bologna in 1315." How different his idea of dissection was from that introduced by Vesalius, may be seen by Cuvier's careful statement that the entire number of dissections by Mundinus was three. The usual statement is that it is two. *See* Cuvier, "Hist. des Sci. Nat.," tome iii., p. 7; also, Sprengel, Frédault, and Hallam; also, Littré, "Médecine et Médecins," chap. on anatomy. For a very full statement of the agency of Mundinus in the progress of anatomy, *see* Portal, "Hist. de l'Anatomie et de la Chirurgérie," vol. i., pp. 209–216.

tullian and St. Augustine held anatomy in abhorrence.[1] Boniface VIII. interdicted dissection as sacrilege.[2]

Through this sacred conventionalism Vesalius broke without fear. Braving ecclesiastical censure and popular fury, he studied his science by the only method that could give useful results. No peril daunted him. To secure the material for his investigations, he haunted gibbets and charnel-houses; in this search he risked alike the fires of the Inquisition and the virus of the plague. First of all men he began to place the great science of human anatomy on its solid, modern foundations—on careful examination and observation of the human body. This was his first great sin, and it was soon aggravated by one considered even greater.

Perhaps the most unfortunate thing that has ever been done for Christianity is the tying it to forms of science which are doomed and gradually sinking. Just as in the time of Roger Bacon, excellent but mistaken men devoted all their energies to binding Christianity to Aristotle; just as in the time of Reuchlin and Erasmus, they insisted on binding Christianity to Thomas Aquinas—so in the time of Vesalius, such men made every effort to link Christianity to Galen.

The cry has been the same in all ages; it is the same which we hear in this age for curbing scientific studies—the cry for what is called "sound learning." Whether standing for Aristotle against Bacon, or Aquinas against Erasmus, or Galen against Vesalius, or making mechanical Greek verses at Eton instead of studying the handiwork of the Almighty, or reading Euripides with translations instead of Lessing and Goethe in the original, the cry always is for "sound learning." The idea always is that these studies are *safe*.

At twenty-eight years of age Vesalius gave to the world his great work on human anatomy. With it ended the old and began the new. Its researches, by their thoroughness, were a triumph of science; its illustrations, by their fidelity, were a triumph of art.

To shield himself as far as possible in the battle which he foresaw must come, Vesalius prefaced the work by a dedication to the Emperor Charles V. In this dedicatory preface he argues for his method, and against the parrot repetitions of the mediæval textbooks; he also condemns the wretched anatomical preparations and specimens made by physicians who utterly refused to advance beyond the ancient master.

The parrot-like repeaters of Galen gave battle at once. After the

[1] For Tertullian and Augustine against anatomical investigation, *see* Blount's "Essays," cited in Buckle's "Posthumous Works," vol. ii., pp. 107, 108. The passage from St. Augustine is in "Civ. Dei," xxii., p. 24. *See* Abbé Migne, "Patrologia," vol. xl., p. 791.

[2] For Boniface VIII. and his interdiction of dissections, *see* Buckle's "Posthumous Works," vol. ii., p. 567. For injurious effects of this ecclesiastical hostility to anatomy upon the development of art, *see* Woltman, "Holbein and His Time," pp. 266, 267. For an excellent statement of the true relation of the medical profession to religious questions, *see* Prof. Acland, "General Relations of Medicine in Modern Times," Oxford, 1868.

manner of their time, their first missiles were epithets; and, the almost infinite magazine of these having been exhausted, they began to use sharper weapons—weapons theologic.

At first the theologic weapons failed. A conference of divines having been asked to decide whether dissection of the human body is sacrilege, gave a decision in the negative. The reason is simple; Charles V. had made Vesalius his physician, and could not spare him. But, on the accession of Philip II. of Spain, the whole scene changed. That most bitter of bigots must of course detest the great innovator.

A new weapon was now forged. Vesalius was charged with dissecting living men,[1] and, either from direct persecution, as the great majority of authors assert, or from indirect influences, as the recent apologists for Philip II. allow, Vesalius became a wanderer. On a pilgrimage to the Holy Land to atone for his sin, he was shipwrecked, and in the prime of his life and strength he was lost to this world.

And yet not lost. In this century he again stands on earth. The painter Hamann has again given him to us. By the magic of Hamann's pencil, we look once more into Vesalius's cell. Its windows and doors, bolted and barred within, betoken the storm of bigotry which rages without; the crucifix, toward which he turns his eyes, symbolizes the spirit in which he labors. The corpse of the plague-stricken, over which he bends, ceases to be repulsive; his very soul seems to send forth rays from the canvas which strengthen us for the good fight in this age.[2]

He was hunted to death by men who conscientiously supposed that he was injuring religion. His poor, blind foes destroyed one of religion's greatest apostles. What was his influence on religion? He substituted for repetition, by rote, of worn-out theories of dead men, conscientious and reverent searching into the works of the living God. He substituted for representations of the human structure—pitiful and unreal—truthful representations, revealing the Creator's power and goodness in every line.[3]

I hasten now to the most singular struggle and victory of medical science between the sixteenth and nineteenth centuries.

Early in the last century, Boyer presented Inoculation as a preventive of small-pox, in France; thoughtful physicians in England, led by Lady Montagu and Maitland, followed his example.

Theology took fright at once on both sides of the Channel. The

[1] For a similar charge against anatomical investigations at a much earlier period, *see* Littré, "Médecine et Médecins," chapter on anatomy.

[2] The original painting of Vesalius at work in his cell, by Hamann, is now at Cornell University.

[3] For a curious example of weapons drawn from Galen and used against Vesalius, *see* Lewes, "Life of Goethe," p. 343, note. For proofs that I have not over-estimated Vesalius, *see* Portal, *ubi supra*. Portal speaks of him as "*le génie le plus droit qu'eut l'Europe*," and again, "*Vesale me paraît un des plus grands hommes qui ait existé.*"

French theologians of the Sorbonne solemnly condemned the practice. English theologians were most loudly represented by the Rev. Edward Massy, who, in 1722, preached a sermon in which he declared that Job's distemper was probably confluent small-pox, and that he had been doubtless inoculated by the devil—that diseases are sent by Providence for the punishment of sin, and that the proposed attempt to prevent them is "a diabolical operation." This sermon was entitled "The Dangerous and Sinful Practice of Inoculation." Not less absurd was the sermon of the Rev. Mr. Delafaye, entitled "Inoculation an Indefensible Practice." Thirty years later the struggle was still going on. It is a pleasure to note one great churchman, Maddox, Bishop of Worcester, giving battle on the side of right reason; but as late as 1753 we have the Rector of Canterbury denouncing inoculation from his pulpit in the primatial city, and many of his brethren following his example. Among the most common weapons hurled by churchmen at the supporters of inoculation, during all this long war, were charges of sorcery and atheism.[1]

Nor did Jenner's blessed discovery of Vaccination escape opposition on similar grounds. In 1798 an anti-vaccine society was formed by clergymen and physicians, calling on the people of England to suppress vaccination as "bidding defiance to Heaven itself—even to the will of God"—and declaring that "the law of God prohibits the practice." In 1803 the Rev. Dr. Ramsden thundered against it in a sermon before the University of Cambridge, mingling texts of Scripture with calumnies against Jenner; but Plumptre in England, Waterhouse in America, and a host of other good men and true, press forward to Jenner's side, and at last science, humanity, and right reason, gain the victory.[2]

But I pass to one typical conflict in our days. In 1847 James Young Simpson, a Scotch physician of eminence, advocated the use of Anæsthetics in obstetrical cases.

Immediately a storm arose. From pulpit after pulpit such a use of chloroform was denounced as impious. It was declared contrary to Holy Writ, and texts were cited abundantly. The ordinary declaration was, that to use chloroform was "to avoid one part of the primeval curse on woman." [3]

[1] *See* Sprengel, "Histoire de la Médecine," vol. vi., pp. 39–80. For the opposition of the Paris Faculty of Theology to inoculation, *see* the "Journal de Barbier," vol. vi., p. 294. For bitter denunciations of the inoculation by English clergy, and for the noble stand against them by Maddox, *see* Baron, "Life of Jenner," vol. i., pp. 231, 232, and vol. ii., pp. 39, 40. For the strenuous opposition of the same clergy, *see* Weld, "History of the Royal Society," vol. i., p. 464, note. Also, for the comical side of this matter, *see* Nichols's "Literary Illustrations," vol. v., p. 800.

[2] For the opposition of conscientious men in England to vaccination, *see* Duns, "Life of Sir James Y. Simpson, Bart.," London, 1873, pp. 248, 249; also Baron, "Life of Jenner," *ubi supra*, and vol. ii., p. 43; also "Works of Sir J. Y. Simpson," vol. ii.

[3] *See* Duns, "Life of Sir J. Y. Simpson," pp. 215–222.

Simpson wrote pamphlet after pamphlet to defend the blessing which he brought into use; but the battle seemed about to be lost, when he seized a new weapon. "My opponents forget," said he, "the twenty-first verse of the second chapter of Genesis. That is the record of the first surgical operation ever performed, and that text proves that the Maker of the universe, before he took the rib from Adam's side for the creation of Eve, caused a deep sleep to fall on Adam."

This was a stunning blow; but it did not entirely kill the opposition. They had strength left to maintain that "the deep sleep of Adam took place before the introduction of pain into the world—in the state of innocence." [1] But now a new champion intervened—Thomas Chalmers. With a few pungent arguments he scattered the enemy forever, and the greatest battle of science against suffering was won.[2]

But was not the victory won also for religion? Go to yonder monument, in Boston, to one of the discoverers of anæsthesia. Read this inscription from our sacred volume: "This also cometh from the Lord of hosts which is wonderful in counsel and excellent in working."

I now ask you to look at another part of the great warfare, and I select it because it shows more clearly than any other how Protestant nations, and in our own time, have suffered themselves to be led into the same errors that have wrought injury to religion and science in other times. We will look very briefly at the battle-fields of Geology.

From the first lispings of this science there was war. The prevailing doctrine of the Church was, that "in the beginning God made the heavens and the earth," that "all things were made at the beginning of the world," and that to say that stones and fossils have been made since "the beginning," is contrary to Scripture. The theological substitutes for scientific explanations ripened into such as these—that the fossils are "sports of Nature," or "creations of plastic force," or "results of a seminal air acting upon rocks," or "models" made by the Creator before he had fully decided upon the best manner of creating various beings. But, while some latitude was allowed among these theologico-scientific explanations, it was held essential to believe that they were placed in all the strata, on one of the creation-days, by the hand of the Almighty; and that this was done for some mysterious purpose of his own, probably for the trial of human faith.

In the sixteenth century Fracastoro and Palissy broached the true idea, but produced little effect. Near the beginning of the seventeenth century De Clave, Bitaud, and De Villon, revived it; straightway the Theologic Faculty of Paris protested against the doctrine as unscriptural, destroyed the offending treatises, banished the authors

[1] *See* Duns, "Life of Sir J. Y. Simpson," pp. 256–259.

[2] "Ibid.," p. 260; also "Works of Sir J. Y. Simpson," *ubi supra*.

from Paris, and forbade them to live in towns or enter places of public resort.[1]

At the middle of the eighteenth century, Buffon made another attempt to state simple and fundamental geological truths. The theological faculty of the Sorbonne immediately dragged him from his high position, forced him to recant ignominiously and to print his recantation.

It required a hundred and fifty years for Science to carry the day fairly against this single preposterous theory. The champion who dealt it the deadly blow was Scilla, and his weapons were facts revealed by the fossils of Calabria.

But the advocates of tampering with scientific reasoning now retired to a new position. It was strong, for it was apparently based on Scripture, though, as the whole world now knows, an utterly false interpretation of Scripture. The new position was that the fossils were produced by the deluge of Noah.

In vain had it been shown, by such devoted Christians as Bernard Palissy, that this theory was utterly untenable; in vain did good men protest against the injury sure to result to religion by tying it to a scientific theory sure to be exploded: the doctrine that fossils were the remains of animals drowned at the flood continued to be upheld by the great majority as "sound doctrine," and as a blessed means of reconciling science with Scripture.[2]

To sustain this "scriptural view," so called, efforts were put forth absolutely herculean, both by Catholics and Protestants. Mazurier declared certain fossil remains of a mammoth, discovered in France, to be bones of giants mentioned in Scripture. Father Torrubia did the same thing in Spain. Increase Mather sent similar remains, discovered in America, to England, with a similar statement. Scheuchzer made parade of the bones of a great lizard discovered in Germany, as the *homo diluvii testis*, the fossil man, proving the reality of the deluge.[3]

In the midst of this appears an episode very comical but very instructive; for it shows that the attempt to shape the deductions of science to meet the exigencies of theology may mislead heterodoxy as absurdly as orthodoxy.

[1] Morley, "Life of Palissy the Potter," vol. ii., p. 315, *et seq.*

[2] Audiat, "Vie de Palissy," p. 412. Cantu, "Hist. Universelle," vol. xv., p. 492.

[3] For ancient beliefs regarding giants, *see* Leopardi, "Saggio sopra gli errori popolari," etc., chapter xv. For accounts of the views of Mazurier and Scheuchzer, *see* Büchner, "Man in Past, Present, and Future," English translation, pp. 235, 236. For Increase Mather's views, *see* "Philosophical Transactions," xxiv., 85. For similar fossils sent from New York to the Royal Society as remains of giants, *see* Weld, "History of the Royal Society," vol. i., p. 421. For Father Torrubia and his *Gigantologia Española*, *see* D'Archiac, "Introduction à l'Etude de la Paléontologie stratiographique," Paris, 1864, p. 202. For admirable summaries, *see* Lyell, "Principles of Geology," London, 1867; D'Archiac, "Géologie et Paléontologie," Paris, 1866; Pictet, "Traité de Paléontologie," Paris, 1853; Vezian, "Prodrome de la Géologie," Paris, 1863; Haeckel, "History of Creation," New York, 1876, chapter iii.

About the year 1760 news of the discovery of marine fossils in various elevated districts of Europe reached Voltaire. He too had a theologic system to support, though his system was opposed to that of the sacred books of the Hebrews. He feared that these new discoveries might be used to support the Mosaic accounts of the Deluge. All his wisdom and wit, therefore, were compacted into arguments to prove that the fossil fishes were remains of fishes intended for food, but spoiled and thrown away by travelers; that the fossil shells were accidentally dropped by Crusaders and pilgrims returning from the Holy Land; and that the fossil bones of a hippopotamus found between Paris and Étampes were parts of a skeleton belonging to the cabinet of some ancient philosopher. Through chapter after chapter Voltaire, obeying the supposed necessities of his theology, fights desperately the growing results of the geologic investigations of his time.[1]

But far more wide-spread and disastrous was the effort on the other side to show that the fossils were caused by the Deluge of Noah.

No supposition was too violent to support a theory which was considered vital to the Bible. Sometimes it was claimed that the tail of a comet had produced the deluge. Sometimes, by a prosaic rendering of the expression regarding the breaking up of the fountains of the great deep, a theory was started that the earth contained a great cistern, from which the waters came and to which they retired. By taking sacred poetry as prose, and by giving a literal interpretation of it, Thomas Burnet in his "Sacred Theory of the Earth," Whiston in his "Theory of the Deluge," and others like them, built up systems which bear to real geology much the same relation that the "Christian Topography" of Cosmas bears to real geography. In vain were exhibited the absolute geological, zoölogical, and astronomical proofs that no universal deluge, or deluge covering any great extent of the earth, had taken place within the last six thousand or sixty thousand years; in vain did Bishop Clayton declare that the deluge could not have taken place save in that district where Noah lived before the flood; in vain was it shown that, even if there had been a universal deluge, the fossils were not produced by it; the only answers were the citation of the text—"and all the high mountains which were under the whole heaven were covered"—and denunciation of infidelity. In England, France, and Germany, belief that the fossils were produced by the Deluge of Noah was insisted upon as part of that faith essential to salvation.[2] It took a hundred and twenty

[1] *See* Voltaire, "Dissertation sur les Changements arrivés dans notre Globe," also Voltaire, "Les Singularités de la Nature," chapter xii., near close of vol. v. of the Didot edition of 1843; also Jevons, "Principles of Science," vol. ii., p. 328.

[2] For a candid summary of the proofs from geology, astronomy, and zoölogy, that the Noachian Deluge was not universally or widely extended, *see* McClintock and Strong, "Cyclopædia of Biblical Theology and Ecclesiastical Literature," article "Deluge." For general history *see* Lyell, D'Archiac, and Vezian. For special cases showing bitterness of the conflict, *see* the Rev. Mr. Davis's "Life of Rev. Dr. Pye Smith," *passim*.

years for the searchers of God's truth, as revealed in Nature—such men as Buffon, Linnæus, Whitehurst, and Daubenton—to push their works under these mighty fabrics of error, and, by statements which could not be resisted, to explode them.

Strange as it may at first seem, the war on geology was waged more fiercely in Protestant countries than in Catholic; and, of all countries, England furnished the most bitter opponents to geology at first, and the most active negotiators in patching up a truce on a basis of sham science afterward.[1]

You have noted already that there are, generally, two sorts of attack on a new science. First, there is the attack by pitting against science some great doctrine in theology. You saw this in astronomy, when Bellarmin and others insisted that the doctrine of the earth revolving about the sun is contrary to the doctrine of the incarnation. So now, against geology, it was urged that the scientific doctrine that the fossils represented animals which died before Adam, was contrary to the doctrine of Adam's fall and that "death entered the world by sin."

Then there is the attack by literal interpretation of texts, which serves a better purpose generally in rousing prejudices.

It is difficult to realize it now, but within the memory of many of us the battle was raging most fiercely in England, and both these kinds of artillery were in full play and filling the civilized world with their roar.

About thirty years ago the Rev. J. Mellor Brown, the Rev. Henry Cole, and others, were hurling at all geologists alike, and especially at such Christian divines as Dr. Buckland, and Dean Conybeare, and Pye Smith, and such religious scholars as Prof. Sedgwick, the epithets of "infidel," "impugner of the sacred record," and "assailant of the volume of God."

Their favorite weapon was the charge that these men were "attacking the truth of God," forgetting that they were simply opposing the mistaken interpretations of Messrs. Brown, Cole, and others like them, inadequately informed.

They declared geology "not a subject of lawful inquiry," denouncing it as "a dark art," as "dangerous and disreputable," as "a forbidden province," as "infernal artillery," and as "an awful evasion of the testimony of revelation."[2]

This attempt to scare men from the science having failed, various other means were taken. To say nothing about England, it is humiliating to human nature to remember the annoyances, and even trials, to which the pettiest and narrowest of men subjected such Christian

[1] For a philosophical statement of reasons why the struggle was more bitter, and the attempt at deceptive compromises more absurd in England than elsewhere, *see* Maury, "L'Ancienne Académie des Sciences," second edition, p. 152.

[2] *See* Pye Smith, D. D., "Geology and Scripture," pp. 156, 157, 168, 169.

scholars in our own country as Benjamin Silliman and Edward Hitchcock and Louis Agassiz.

But it is a duty and a pleasure to state here that one great Christian scholar did honor to religion and to himself by standing up for the claims of science, despite all these clamors. That man was Nicholas Wiseman, better known afterward as Cardinal Wiseman. The conduct of this pillar of the Roman Catholic Church contrasts nobly with that of timid Protestants who were filling England with shrieks and denunciations.[1]

And here let me note that one of the prettiest skirmishes in this war was made in New England. Prof. Stuart, of Andover, justly honored as a Hebrew scholar, virtually declared that geology was becoming dangerous; that to speak of six periods of time for the creation was flying in the face of Scripture; that Genesis expressly speaks of six days, each made up of an evening and a morning, and not six periods of time.

To him replied a professor in Yale College, James Kingsley. In an article admirable for keen wit and kindly temper, he showed that Genesis speaks just as clearly of a solid firmament as of six ordinary days, and that if Prof. Stuart had got over one difficulty and accepted the Copernican theory, he might as well get over another and accept the revelations of geology. The encounter was quick and decisive, and the victory was with science and our own honored Yale.[2]

But perhaps the most singular attempt against geology was made by a fine specimen of the English Don—Dean Cockburn, of York—to *scold* its champions out of the field. Without, apparently, the simplest elementary knowledge of geology, he opened a battery of abuse. He gave it to the world at large, by pulpit and press; he even inflicted it upon leading statesmen by private letters.[3]

From his pulpit in York Minster, Mary Somerville was denounced coarsely, by name, for those studies in physical geography which have made her honored throughout the world.[4]

But these weapons did not succeed. They were like Chinese gongs and dragon-lanterns against rifled cannon. Buckland, Pye

[1] Wiseman, "Twelve Lectures on the Connection between Science and Revealed Religion," first American edition, New York, 1837.

[2] *See Silliman's Journal*, vol. xxx., p. 114.

[3] Prof. Goldwin Smith informs me that the papers of Sir Robert Peel, yet unpublished, contain very curious specimens of these epistles.

[4] *See* "Personal Recollections of Mary Somerville," Boston, 1874, pp. 139 and 375. Compare with any statement of his religious views that Dean Cockburn was able to make, the following from Mrs. Somerville: "Nothing has afforded me so convincing a proof of the Deity as these purely mental conceptions of numerical and mathematical science which have been, by slow degrees, vouchsafed to man—and are still granted in these latter times, by the differential calculus, now superseded by the higher algebra—all of which must have existed in that sublimely omniscient mind from eternity."—*See* "Personal Recollections," pp. 140, 141.

Smith, Lyell, Silliman, Hitchcock, Murchison, Agassiz, Dana, and a host of noble champions besides, press on, and the battle for truth is won.

And was it won merely for men of science? The whole civilized world declares that it was won for religion—that thereby was infinitely increased the knowledge of the power and goodness of God.

Did time permit, we might go over other battle-fields no less instructive than those we have seen. We might go over the battle-fields of Agricultural Progress, and note how, by a most curious perversion of a text of Scripture, great masses of the peasantry of Russia were prevented from raising and eating potatoes,[1] and how in Scotland at the beginning of this century the use of fanning-mills for winnowing grain was denounced as contrary to the text "the wind bloweth where it listeth," etc., as leaguing with Satan, who is "prince of the powers of the air," and as sufficient cause for excommunication from the Scotch Church.[2]

We might go over the battle-fields of Industrial Science, and note how the introduction of railways into France was declared, by the Archbishop of Besançon, an evidence of the divine displeasure against country innkeepers who set meat before their guests on fast-days, and now were punished by seeing travelers carried by their doors; and how railroad and telegraph were denounced from a noted pulpit as "heralds of Antichrist." And then we might pass to Protestant England and recall the sermon of the Curate of Rotherhithe at the breaking in of the Thames Tunnel, so destructive to life and property, declaring that "it was but a just judgment upon the presumptuous aspirations of mortal man."[3]

We might go over the battle-fields of Ethnology and note how a few years since an honored American investigator, proposing in a learned society the discussion of the question between the origin of the human race from a single pair and from many pairs, was called to order and silenced as atheistic, by a Protestant divine whose memory is justly dear to thousands of us.[4]

Interesting would it be to look over the field of Meteorology—beginning with the conception, supposed to be scriptural, of angels opening and shutting "the windows of heaven" and letting out "the waters that be above the firmament" upon the earth—continuing

[1] *See* Haxthausen, "Études sur la Russie."

[2] Burton, "History of Scotland," vol. viii., p. 511. *See* also Mause Headrigg's views in Scott's "Old Mortality," chapter vii. For the case of a person debarred from the communion for "raising the devil's wind" with a winnowing-machine, *see* works of Sir J. Y. Simpson, vol. ii. Those doubting the authority or motives of Simpson may be reminded that he was, to the day of his death, one of the strictest adherents of Scotch orthodoxy.

[3] *See* Journal of Sir I. Brunel, for May 20, 1827, in "Life of I. K. Brunel," p. 30.

[4] This scene will be recalled, easily, by many leading ethnologists in America, and especially by Mr. E. G. Squier, formerly minister of the United States to Central America.

through the battle of Fromundus and Bodin, down to the onslaught upon Lecky, in our own time, for drawing a logical and scientific conclusion from the doctrine that Meteorology is obedient to laws.[1]

We might go over the battle-fields of Cartography and see how at one period, on account of expressions in Ezekiel, any map of the world which did not place Jerusalem in the centre, was looked on as impious.[2]

We might go over the battle-fields of Political Economy and note how a too literal interpretation of scriptural texts regarding taking interest for money wrought fearful injury, not only to the material interests, but also to the moral character of hosts of enterprising and thrifty men, during ages.[3]

We might go over the battle-fields of Social Science in Protestant countries, and note the opposition of conscientious men to the taking of the census, in Sweden and in the United States, on account of the terms in which the numbering of Israel is spoken of in the Old Testament.[4]

And we might also see how, on similar grounds, religious scruples have been avowed against so beneficial a thing as Life Insurance.[5]

I now come to the warfare on Scientific Instruction. I shall not take time for a sketch of the earlier phases of this warfare, but shall simply present a few typical conflicts that have occurred within the last ten years.

During the years 1867 and 1868 war was commenced against certain leading professors of the Medical School of Paris, especially against Profs. Vulpian and See, and against the Department of Pub-

[1] The meteorological battle is hardly fought out yet. Many excellent men seem still to entertain views almost identical with those of over two thousand years ago, depicted in "The Clouds" of Aristophanes.

[2] These texts are Ezekiel v. 5 and xxxviii. 12. The progress of geographical knowledge, evidently, caused them to be softened down somewhat in our King James's version; but the first of them reads, in the Vulgate, "Ista est Hierusalem, in medio gentium posui eam et in circuitu ejus terras;" and the second reads in the Vulgate "in medio terræ," and in the Septuagint ἐπι τὸν ὀμφαλὸν τῆς γῆς. That the literal centre of the earth was meant, *see* proof in St. Jerome, Commentar. in Ezekiel, lib. ii., and for general proof, *see* Leopardi, "Saggio sopra gli errori popolari degli antichi," pp. 207, 208. For an idea of orthodox geography in the middle ages, *see* Wright's "Essay on Archæology," vol. ii., chapter "On the Map of the World in Hereford Cathedral."

[3] For a very complete history of this opposition of the Church to one of the fundamental doctrines of political economy, *see* Murray, "History of Usury," Philadelphia, 1866; also, Lecky, "History of Rationalism," vol. ii., chapter vi. For collateral information as to effect of similar doctrines on Venetian commerce, *see* Lindsay, "History of Merchant Shipping," London, 1874, vol. ii.

[4] *See* Michaelis, "Commentaries on the Laws of Moses," 1874, vol. ii., p. 3. The writer of the present article himself witnessed the reluctance of a very conscientious man to answer the questions of a census marshal, Mr. Lewis Hawley, of Syracuse, N. Y., and this reluctance was based upon the reasons assigned in II. Samuel, chapter xxiv. 1, and I. Chronicles, chapter xxi. 1, for the numbering of the children of Israel.

[5] *See* De Morgan, "Paradoxes," pp. 214–220.

lic Instruction, having at its head the Minister of State, Duruy. The storming party in the French Senate was led by a venerable and conscientious prelate, Cardinal de Bonnechose.

It was charged by Monseigneur de Bonnechose and his party, that the tendencies of the teachings of these professors were fatal to religion and morality. A heavy artillery of phrases was hurled, such as "sapping the foundations," etc., "breaking down the bulwarks," etc., etc., and withal a new missile was used with much effect, the epithet of "materialist."

The result can be easily guessed. Crowds came to the lecture-rooms of these professors, and the lecture-room of Prof. See, the chief offender, was crowded to suffocation.

A siege was begun in due form. A young physician was sent by the cardinal's party into the heterodox camp as a spy. Having heard one lecture of Prof. See, he returned with information that seemed to promise easy victory to the besieging party. He brought a terrible statement, one that seemed enough to overwhelm See, Vulpian, Duruy, and the whole hated system of public instruction in France.

Good Cardinal Bonnechose seized the tremendous weapon. Rising in his place in the Senate he launched a most eloquent invective against the Minister of State who could protect such a fortress of impiety as the College of Medicine; and, as a climax, he asserted, on the evidence of his spy fresh from Prof. See's lecture-room, that the professor had declared, in his lecture of the day before, that so long as he had the honor to hold his professorship he would combat the false idea of the existence of the soul (*idée de l'ame*). The weapon seemed resistless, and the wound fatal; but M. Duruy rose and asked to be heard.

His statement was simply that he held in his hand documentary proofs that Prof. See never made such a declaration. He held the notes used by Prof. See in his lecture. Prof. See, it appeared, belonged to a school in medical science which combated the idea of an art (*idée d'un art*) in medicine. The real expression used was *l'idée d'un art*—the idea of an *art;* the expression which the imagination of the cardinal's eager emissary made of it was *l'idée d'une ame*—the idea of a *soul.*

The forces of the enemy were immediately turned. They retreated in confusion amid the laughter of all France; and a well-meant attempt to check what was feared might be dangerous in science simply ended in bringing ridicule on religion, and thrusting still deeper into the minds of thousands of men that most mistaken of all mistaken ideas—the conviction that religion and science are enemies.[1]

[1] For general account of the Vulpian and See matter, *see Revue des Deux Mondes*, 31 Mai, 1868. "Chronique de la Quinzaine," pp. 763–765. As to the result on popular thought may be noted the following comment on the affair by the *Revue* which is as free as possible from any thing like rabid anti-ecclesiastical ideas: "*Elle a été vraiment curieuse, instructive, assez triste et même un peu amusante.*"

But justice forbids our raising an outcry against Roman Catholicism alone for this. In 1864 a number of excellent men in England drew up a declaration to be signed by students in the natural sciences, expressing "sincere regret that researches into scientific truth are perverted by some in our time into occasion for casting doubt upon the truth and authenticity of the Holy Scriptures." Nine-tenths of the leading scientific men of England refused to sign it. Nor was this the worst. Sir John Herschel, Sir John Bowring, and Sir W. R. Hamilton, administered, through the press, castigations which roused general indignation against the proposers of the circular, and Prof. De Morgan, by a parody, covered memorial and memorialists with ridicule. It was the old mistake, and the old result followed in the minds of multitudes of thoughtful young men.[1]

And in yet another Protestant country this same wretched mistake was made. In 1868, several excellent Churchmen in Prussia thought it their duty to meet for the denunciation of "Science falsely so called." Two results followed. Upon the great majority of these really self-sacrificing men—whose first utterances showed crass ignorance of the theories they attacked—there came quiet and wide-spread contempt; upon Pastor Knak, who stood forth and proclaimed views of the universe which he thought scriptural, but which most schoolboys knew to be childish, came a burst of good-natured derision from every quarter of the German nation.[2]

Warfare of this sort against Science seems petty indeed; but it is to be guarded against in Protestant countries not less than Catholic; it breaks out in America not less than in Europe. I might exhibit many proofs of this. Do conscientious Roman bishops in France labor to keep all advanced scientific instruction under their own control—in their own universities and colleges; so do very many not less conscientious Protestant clergymen in our own country insist that advanced education in science and literature shall be kept under control of their own sectarian universities and colleges, wretchedly one-sided in their development, and miserably inadequate in their equipment: did a leading Spanish university, until a recent period, exclude professors holding the Newtonian theory; so does a leading American college exclude professors holding the Darwinian theory: have Catholic colleges in Italy rejected excellent candidates for professorships on account of "unsafe" views regarding the Immaculate Conception; so are Protestant colleges in America every day rejecting excellent candidates on account of "unsafe" views regarding the Apostolic Succession, or the Incarnation, or Baptism, or the Perseverance of the Saints.

And how has all this system resulted. In the older nations, by a natural reaction, these colleges under strict ecclesiastical control

[1] De Morgan, "Paradoxes," pp. 421–428; also Daubeny's "Essays."

[2] *See* the Berlin newspapers for the summer of 1868, especially *Kladderadatsch.*

have sent forth the most bitter enemies the Christian Church has ever known—of whom Voltaire and Renan and St. Beuve are types; and there are many signs that the same causes are producing the same result in our own country.

I might allude to another battle-field in our own land and time. I might show how an attempt to meet the great want, in the State of New York, of an institution providing scientific instruction, has been met with loud outcries from many excellent men, who fear injury thereby to religion. I might picture to you the strategy which has been used to keep earnest young men from an institution, which, it is declared, cannot be Christian because it is not sectarian. I might lay before you wonderful lines of argument which have been made, to show the dangerous tendencies of a plan which gives to scientific studies the same weight as to classical studies, and which lays no less stress on modern history and literature than on ancient history and literature.

I might show how it has been denounced by the friends and agents of denominational colleges and in many sectarian journals, how the most preposterous charges have been made and believed by good men, how the epithets of "godless," "infidel," "irreligious," "unreligious," "atheistic," have been hurled against a body of Christian trustees, professors, and students, and with little practical result save arousing a suspicion in the minds of large bodies of thoughtful young men, that the churches dread scientific studies untrammeled by sectarianism.

You have now gone over the greater struggles in the long war between Ecclesiasticism and Science, and have glanced at the lesser fields. You have seen the conflicts in Physical Geography, as to the form of the earth; in Astronomy, as to the place of the earth in the universe; in Chemistry and Physics; in Anatomy and Medicine; in Geology; in Meteorology: in Cartography; in the Industrial and Agricultural Sciences; in Political Economy and Social Science; and in Scientific Instruction.

In every case, whether the war has been long or short, forcible or feeble, you have seen this same result—Science has at last gained the victory.

In every case too, you have seen that while this ecclesiastical war, during its continuance, has tended to drive multitudes of thoughtful men away from religion, the triumph of science has been a blessing to religion—ennobling its conceptions and bettering its methods.

May we not, then, hope that the greatest and best men in the Church, the men standing at centres of thought, will insist with power, more and more, that religion be no longer tied to so injurious a policy as that which this warfare reveals; that searchers for truth, whether in theology or natural science, work on as friends, sure that, no matter how much at variance they may at times seem to be, the truths they reach shall finally be fused into each other?

No one needs fear the result. No matter whether Science shall complete her demonstration that man has been on the earth not merely six thousand years, or six millions of years; no matter whether she reveals new ideas of the Creator or startling relations between his creatures; no matter how many more gyves and clamps upon the spirit of Christianity she destroys, the result, when fully thought out, will serve and strengthen religion not less than science.[1]

The very finger of the Almighty has written on history that science must be studied by means proper to itself, and in no other way. That history is before us all. No one can gainsay it. It is decisive, for it is this: There has never been a scientific theory framed from the use of scriptural texts, wholly or partially, which has been made to stand. Such attempts have only subjected their authors to derision, and Christianity to suspicion. From Cosmas finding his plan of the universe in the Jewish tabernacle, to Increase Mather sending mastodon's bones to England as the remains of giants mentioned in Scripture; from Bellarmin declaring that the sun cannot be the centre of the universe, because such an idea vitiates the whole scriptural plan of salvation, to a recent writer declaring that an evolution theory cannot be true, because St. Paul says that "all flesh is not the same flesh," the result has always been the same.[2]

[1] In an eloquent sermon, preached in March, 1874, Bishop Cummins said, in substance: "The Church has no fear of Science; the persecution of Galileo was entirely unwarrantable; but Christians should resist to the last Darwinism; for that is evidently contrary to Scripture." The bishop forgets that Galileo's doctrine seemed to such colossal minds as Bellarmin, and Luther, and Bossuet, "evidently contrary to Scripture." Far more logical, modest, sagacious, and full of faith, is the attitude taken by his former associate, Dr. John Cotton Smith. "For geology, physiology, and historical criticism, have threatened or destroyed only particular forms of religious opinion; while they have set the spirit of religion free to keep pace with the larger generalizations of modern knowledge."—(Picton, "The Mystery of Matter," London, 1873, p. 72.)

[2] In the *Church Journal*, New York, May 28, 1874, a reviewer praising Rev. Dr. Hodge's book against Darwinism, says: "Darwinism, whether Darwin knows it or not, whether the clergy, who are half prepared to accept it in blind fright as 'science,' know it or not, is a denial of every article of the Christian faith. It is supreme folly to talk as some do about accommodating Christianity to Darwinism. Either those who so talk do not understand Christianity, or they do not understand Darwinism. If we have all, men and monkeys, women and baboons, oysters and eagles, all 'developed' from an original monad and germ, then St. Paul's grand deliverance—'All flesh is not the same flesh. There is one kind of flesh of men, another of beasts, another of fishes, and another of birds. There are bodies celestial and bodies terrestrial'—may be still very grand in our funeral-service, but very untrue to fact." This is the same dangerous line of argument which Caccini indulged in in Galileo's time. Dangerous, for suppose "Darwinism" *be proved true!* For a soothing potion by a skillful hand, *see* Whewell on the consistency of evolution doctrines with teleological ideas; also Rev. Samuel Houghton, F. R. S., "Principles of Animal Mechanics," London, 1873, preface and page 156, for some interesting ideas on teleological evolution.

Such facts show that the sacred books of the world were not given for any such purpose as that to which so many men have endeavored to wrest them.[1]

Such facts show, too, that scientific hypotheses will be established or refuted by scientific men and scientific methods alone, and that no conscientious citation of texts or outcries as to consequences of scientific truths, from any other quarter, can do any thing save retard truth and cause needless anxiety.[2]

Is skepticism feared? All history shows that the only skepticism which does permanent harm is skepticism as to the value and safety of truth as truth. No skepticism has proved so corrosive to religion, none so cancerous in the human brain and heart.

Is faith cherished? All history shows that the first article of a saving faith, for any land or time, is faith that there is a Power in this universe strong enough to make truth-seeking safe, and good enough to make truth-telling useful.

What Science can do for the world is shown, not by those who have labored to concoct palatable mixtures of theology and science —men like Cosmas, and Torrubia, and Burnet, and Whiston—but by men who have fought the good fight of faith in truth for truth's sake —men like Roger Bacon, and Vesalius, and Palissy, and Galileo.

What Christianity can do for the world is shown, not by men who have stood on the high places screaming in wrath at the advance of science—not by men who have retreated in terror into the sacred caves and refused to look out upon the universe as it is, but by men who have preached and practised the righteousness of the prophets, and the aspirations of the Psalmist, and the blessed Sermon on the Mount, and "the first great commandment and the second which is like unto it," and St. James's definition of "pure religion and undefiled."

It is shown in the Roman Church, not by Tostatus and Bellarmin, but by St. Carlo Borromeo, and St. Vincent de Paul, and Fénelon, and Eugénie de Guérin; in the Anglican Church, not by Dean Cockburn, but by Howard, and Jenner, and Wilberforce, and Florence Nightingale; in the German Church, not by Pastor Knak, but by Pastor Harms; in the American Church, not by the Mathers and Stuarts, but by such as Bishop Whatcoat, and Channing, and Muhlenberg, and Father De Smet, and Samuel May, and Harriet Stowe.

Let the warfare of science, then, be changed. Let it be a warfare in which Religion and Science shall stand together as allies, not against each other as enemies. Let the fight be for truth of every

[1] To all who are inclined to draw scientific conclusions from biblical texts, may be commended the advice of a good old German divine of the Reformation period: "Seeking the milk of the Word, do not press the teats of Holy Writ too hard."

[2] For some excellent remarks on the futility of such attempts and outcries, *see* the Rev. Dr. Deems, in Popular Science Monthly for February, 1876.

kind against falsehood of every kind—for justice against injustice—for right against wrong—for the living kernel of religion rather than the dead and dried husks of sect and dogma; and the great powers whose warfare has brought so many sufferings shall at last join in ministering through earth God's richest blessings.

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# ON FALLACIES OF TESTIMONY RESPECTING THE SUPERNATURAL.

By WILLIAM B. CARPENTER, LL.D., F.R.S.

No one who has studied the history of science can fail to recognize the fact that the rate of its progress has been in great degree commensurate with the degree of *freedom from any kind of prepossession* with which scientific inquiry has been conducted. And the chapters of Lord Bacon's "Novum Organum," in which he analyzes and classifies the prejudices that are apt to divert the scientific inquirer from his single-minded pursuit of truth, have rightly been accounted among the most valuable portions of that immortal work. To use the felicitous language of Dr. Thomas Brown, "the temple which Lord Bacon purified was not that of Nature herself, but the temple of the mind; in its innermost sanctuaries were the idols which he overthrew; and it was not till these were removed, that Truth would deign to unveil herself to adoration."

Every one, again, who watches the course of educated thought at the present time, must see that it is tending toward the exercise of that trained and organized common-sense which we call "scientific method," on subjects to which it is legitimately applicable within the sphere of religious inquiry. Science has been progressively, and in various ways, undermining the old "bases of belief;" and men in almost every religious denomination, animated by no spirit but that of reverent loyalty to truth, are now seriously asking themselves, whether the whole fabric of what is commonly regarded as authoritative revelation must not be carefully reëxamined under the searching light of modern criticism, in order that what is sound may be preserved and strengthened, and that the insecurity of some parts may not destroy the stability of the whole.

I notice, further, among even "orthodox" theologians of the present time, indications of a disposition to regard the New Testament miracles rather as incumbrances, than as props, to what is essential in Christianity; of a feeling that they are rather to be explained away,[1] than adduced as authoritative attestations of the teachings of

[1] Thus theologians of the "philosophic" school argue that miracles are not to be regarded as departures from the divine order, but are parts of the order originally settled

Jesus; and of a perception that to attempt to enforce a belief in them, on the part of the rising generation, will be either to alienate from the acceptance of those teachings many of the most cultured and most earnest young people of our time, or to reduce their minds to that state of unreasoning subservience to authority which finds its only logical basis in the Roman Catholic Church. And, moreover, I observe it to be among those, in various religious denominations, who are converging to the conclusion that the "authority" of Christianity most surely consists in the direct appeal it makes to the hearts and consciences of mankind, who most fully recognize in the life, teaching, and death of Christ, that manifestation of the Divine (*ἀπαύγασμα τῆς δόξης καὶ χαρακτὴρ τῆς ὑποστάσεως αὐτοῦ*[1]) which constitutes him their Master and Lord, and who most earnestly and constantly aim to fashion their own lives on the model of his—that there is the greatest readiness to admit that the records of that life are tinged by the prepossessions, and subject to the inaccuracies, to which all human testimony is liable.

It was nobly said thirty years ago[2] (I believe by Francis Newman) that "every fresh advance of certain knowledge apparently sweeps off a portion of (so-called) religious belief, *but only to leave the true religious element more and more pure; and in proportion to its purity will be its influence for good, and for good only;*" and that, "little as many are aware of it, faithlessness is often betrayed in the struggle to retain in the region of faith that which is already passing into the region of science, for it implies doubt of the value of truth." Thoroughly sympathizing with this view—in no spirit of hostility to what is commonly regarded as revealed truth—but with a desire to promote the discriminating search for what really constitutes revealed truth, I offer the following suggestions, arising out of the special studies which have occupied a large part of my life, to the consideration of such as may deem them worthy of attention.

That the whole tendency of recent scientific inquiry has been to strengthen the notion of "continuity" as opposed to "cataclysms" and "interruptions," and to substitute the idea of progressive "evolution" for that of "special creations," cannot but be obvious to every one who is familiar with the progress of inquiry in astronomy, physical geology, paleontology, and biology. But the scientific theist who regards the so-called "laws of Nature" as nothing else than man's expressions of so much of the divine order as it lies within his power to discern, and who looks at the uninterruptedness of this

in the divine mind—as typified by the well-known illustration supplied by Mr. Babbage from his calculating-machine. But this obviously puts altogether on one side the notion of miracles as extraordinary interpositions, involving a more direct personal agency than the ordinary uniformity.

[1] "The brightness of his glory, and the express image of his person."

[2] *Prospective Review*, vol. i., p. 53.

order as the highest evidence of its original perfection, need find (as it seems to me) no abstract difficulty in the conception that the author of Nature can, if he will, occasionally depart from it. And hence, as I deem it presumptuous to deny that there might be occasions which in his wisdom may require such departure, I am not conscious of any such scientific "prepossessions" against miracles as would prevent me from accepting them as facts, if trustworthy evidence of their reality could be adduced. The question with me, therefore, is simply, "Have we any adequate historical ground for the belief that such departure has ever taken place?"

Now, it can scarcely be questioned that, while the scientific probability of uniform sequence has become stronger, the value of testimony in regard to departures from it has been in various ways discredited by modern criticism. It is clear that the old arguments of Lardner, and the modern reproduction of them by Prof. Andrews Norton (Boston, New England), which in my early days were held as demonstrating the "genuineness of the Gospels," no longer possess their former cogency. For the question has now passed into a phase altogether different from that which it presented a century or two ago. It was then, "Are the narratives genuine or fictitious? Did the narrators intend to speak the truth, or were they constructing a tissue of falsehoods? Did they really witness what they narrate, or were they the dupes of ingenious story-tellers?" It is now, "Granting that the narrators wrote what they firmly believed to be true, as having themselves seen (or thought they had seen) the events they recorded, or as having heard of them from witnesses whom they had a right to regard as equally trustworthy with themselves, is *their* belief a sufficient justification for *ours?* What is the extent of allowance which we are to make for 'prepossession'—1. As modifying their conception of each occurrence at the time; and 2. As modifying their subsequent remembrance of it? And 3. In cases in which we have not access to the original records, what is the amount of allowance which we ought to make for the accretion of other still less trustworthy narratives around the original nucleus?"

Circumstances have led me from a very early period to take a great interest in the question of the value of testimony, and to occupy myself a good deal in the inquiry as to what is scientifically termed its "subjective" element. It was my duty for many years to study and to expound systematically to medical students the probative value of different kinds of evidence; and my psychological interest in the curious phenomena which, under the names of mesmerism, odylism, electro-biology, psychic force, and spiritual agency, have been supposed to indicate the existence of some new and mysterious force in Nature, led me, through a long series of years, to avail myself of every opportunity of studying them that fell within my reach. The general result of these inquiries has been to force upon me the conviction that, as to all which concerns the "supernatural" (using that term in its generally understood sense, without attempting a logical definition of it), the allowance that has to be made for "prepossession" is so large as practically to destroy the validity of any testimony which is not submitted to the severest scrutiny according to the strictest scientific methods. Of the manner in which, within my own experience, what seemed the most trustworthy testimony has been completely discredited by the application of such methods, I shall give some examples hereafter.

I would by no means claim for myself or any other scientific man an immunity from idolatrous prepossessions; for we must all be guided in our researches by *some* notion of what we expect to find; and this notion may be very misleading. Thus, when no metal was known that is not several times heavier than water, it was not surprising that Dr. Pearson, as he poised upon his finger the first globule of potassium produced by the battery of Davy, should have exclaimed, "Bless me, how heavy it is!" though, when thrown into water, the metal floated upon it. But while the true disciple of Bacon is on his guard against "idolatry," and is constantly finding himself rudely handled (as Dr. Pearson was) by "the irresistible logic of facts" if he falls into it, the pledged upholder of any religious system can be scarcely other than, in some degree, an "idolater." The real philosopher, says Schiller, is distinguished from the "trader in knowledge" by his "always loving truth better than his system."

Bacon's classification of "idols" is based on the *sources* of our prepossessions; and, although his four types graduate insensibly into each other, yet the study of them is very profitable. Sir John Herschel is, I think, less successful when he classifies them as—1. Prejudices of opinion, and 2. Prejudices of sense; because an analysis of any of his "prejudices of sense" shows that it is really a "prejudice of opinion." My first object is to show that we are liable to be affected by our prepossessions at every stage of our mental activity, from our primary reception of impressions from without, to the highest exercise of our reasoning powers; and that the value of the testimony of any individual, therefore, as to any fact whatever, essentially depends upon his freedom from any prepossessions that can affect it.

That our own states of consciousness constitute what are, to each individual, the most certain of all truths—in a philosophical sense (as J. S. Mill says) the only certain truths—will, I suppose, be generally admitted; but there is a wide *hiatus* between this and the position that every state of consciousness which represents an external object has a real object answering to it. In fact, although we are accustomed to speak of "the evidence of our senses" as worthy of the highest credit, nothing is easier than to show that the evidence of any one sense, without the check afforded by comparison with that of another, is utterly untrustworthy.

I might pile up instances of visual illusion, for example, in which the subject would be ready to affirm without the slightest hesitation that he sees something which greatly differs from the object that actually forms the picture on his retina; his erroneous interpretation of that picture being the result of a prepossession derived from antecedent experience. I could show, too, that the same picture may be interpreted in two different modes: a skeleton-diagram, for example, suggesting two dissimilar solid forms, according as the eyes are fixed on one or another of its angles; and a photograph of a coin or fossil being seen as a cameo or as an intaglio, according as the position of the light affects the interpretation of its lights and shadows. Again, I have before me two pieces of card, A and B, of similar form: when A is placed *above* B, the latter is unhesitatingly pronounced the larger; if their relative positions be reversed, A is pronounced, with equal conviction, to be the larger; yet, when one is laid *upon* the other, they are found to be precisely equal in size.

So, again, in those more complex combinations of natural objects which the pictorial artist aims to represent, the different modes in which the very same scene shall be treated, by two individuals working at the same time and from the same point of view, show how differently they interpret the same visual picture, according to their original constitution and subsequent training. As Carlyle says, "The eye sees what it brings the power to see."

But mental prepossessions do much more than this; they *produce* sensations having no objective reality. I do not here allude to those "subjective sensations" of physiologists which depend upon physical affections of nerves in their course, the circulation of poisoned blood in the brain (as in the delirium of fever), and the like; but I refer to the sensations produced by *mental expectancy*, a most fertile source of self-deception. The medical practitioner is familiar with these in the case of "hysterical" subjects; whose pains are as real experiences to them as if they originated in the parts to which they are referred. And I have no reason to doubt that the "sensitives" of Reichenbach really saw the flames they described as issuing from magnets in the dark—as a very honest and highly-educated gentleman assured me that he did, not only when the magnet was there, but when he believed it to be still there (in the dark), after it had been actually withdrawn. So there are "sensitives" in whom the drawing of a magnet along the arm will produce a sensible *aura* or a pricking pain; and this will be equally excited by the belief that the magnet is being so used, when nothing whatever is done.

Now, the phenomena of which these are simple examples appear to me to have this physiological signification—that changes in the cerebrum which answer to the higher mental states act *downward* upon the sensorium at its base, in the same manner as changes in the organs of sense act *upward* upon it; the very same state of the sensorium being producible through the nerves of the *internal* and of the *external* senses, and the very same affection of the sensational consciousness being thus called forth by impressions *ab extra* and *ab intra*. Thus, individuals having a strong pictorial memory can reproduce scenes from Nature, faces, or pictures, with such vividness that they may be said to see with their "mind's eye" just as distinctly as with their bodily eye; and there is an instance on record (which Mr. Ruskin fully accredits, as well from having seen the two pictures as from his own similar experiences) in which a painter at Cologne accurately reproduced from memory a large altar-piece by Rubens, which had been carried away by the French. Those, again, who possess a strong pictorial imagination, can thus *create* distinct visual images of what they have never seen through their bodily eyes. And, although this power of voluntary representation is comparatively rare, yet we are all conscious of the phenomenon as occurring involuntarily in our dreams.

Now, there is a very numerous class of persons who are subject to what may be termed "waking dreams," which they can induce by placing themselves in conditions favorable to reverie; and the course of these dreams is essentially determined by the individual's prepossessions, brought into play by suggestions conveyed from without. In many who do not spontaneously fall into this state, fixity of the gaze for some minutes is quite sufficient to induce it; and the "mesmeric mania" of Edinburgh in 1851 showed the proportion of such susceptible individuals to be much larger than was previously supposed. Those who have had adequate opportunities of studying these phenomena find no difficulty in referring to the same category many of the "spiritualistic" performances of the present time, in which we seem to have reproductions of states that were regarded in ancient times, under the influence of religious prepossession, as results of divine inspiration. I have strong reason to believe (from my conviction of the honesty of the individuals who have themselves narrated to me their experiences) that they have really seen, heard, and felt what they describe, where intentional deception was out of the question; that is, that they had the same distinct consciousness, in states of expectant reverie, of seeing, touching, and conversing with the spirits of departed friends, that most of us occasionally have in our dreams. And the difference consists in this—that while one, in the exercise of his common-sense, dismisses these experiences as the creation of his own brain, having no objective reality, the other, under the influence of his prepossession, accepts them as the results of impressions *ab extra* made upon him by "spiritual" agencies.

The faith anciently placed, by the heathen as well as the Jewish world, in dreams, visions, trances, etc., has thus its precise parallel in the present day; and it is not a little instructive to find a very intelligent religious body, the Swedenborgians, implicitly accepting as authoritative revelation the visions of a man of great intellectual ability and strong religious spirit, but highly imaginative disposition, the peculiar feature of whose mind it was to dwell upon his own imaginings. These he seems to have so completely separated from his worldly life, that the Swedenborg who believed himself to hold intercourse with the spiritual world and Swedenborg the mechanician and metallurgist may almost be regarded as two distinct personalities.

If, then, the high scientific attainments of some of the prominent advocates of "spiritualism," and our confidence in their honesty, be held to require our assent to what they narrate as their experiences, in regard to a class of phenomena which they declare that they have witnessed, but which they cannot reproduce for the satisfaction of other men of science who desire to submit them to the rigorous tests which they regard as necessary to substantiate their validity, then we must, in like manner, accept the records of Swedenborg's revelations as binding on our belief. That they were *true to him* I cannot doubt; and, in the same manner, I do not question that Mr. Crookes is thoroughly honest when he says that he has repeatedly witnessed the "levitation of the human body." But I can regard his statements in no other light than as evidence of the degree in which certain minds are led, by the influence of strong "prepossession," to believe in the creations of their own visual imagination.

All history shows that nothing is so potent as religious enthusiasm, in fostering this tendency; the very state of enthusiasm, in fact, being the "possession" of the mind by fixed ideas, which overbear the teachings of objective experience. These, when directed to great and noble ends, may overcome the obstacles which deter cooler judgments from attempting them; but, on the other hand, may also move not only individuals but great masses of people to extravagances at which sober common-sense revolts; as the history of the Flagellants, the Dancing Mania, and other religious epidemics of the middle ages, forcibly illustrates. And nothing is more remarkable, in the history of these epidemics, than the vividness with which people who were not asleep saw visions that were obviously inspired by the prevalent religious notions of their times. Thus, some of the dancers saw heaven opened, and the Saviour enthroned with the Virgin Mary; while others saw hell yawning before their feet, or felt as if bathed in blood; their frantic leaps being prompted by their eagerness to reach toward the one or to escape from the other.

In the next place, I would briefly direct attention to the influence of prepossessions on those *interpretations* of our sensational experiences which we are prone to substitute for the statement of the experiences themselves. Of such misinterpretations, the records of science are full; the tendency is one which besets every observer, and to which the most conscientious have frequently yielded; but I do not know any more striking illustrations of it than I could narrate from my own inquiries into mesmerism, spiritualism, etc. The most diverse accounts of the *facts* of a *séance* will be given by a believer and a skeptic. One will declare that a table rose in the air, while another (who had been watching its feet) is confident that it never left the ground; a whole party of believers will affirm that they saw Mr. Home float out of one window and in at another, while a single honest skeptic declares that Mr. Home was sitting in his chair all the time. And in this last case we have an example of a fact, of which there is ample illustration, that during the prevalence of an epidemic delusion the honest testimony of any number of individuals on one side, if given under a "prepossession," is of no more weight than that of a single adverse witness—if so much. Thus I think it cannot be doubted by any one who candidly studies the witchcraft trials of two centuries back, that, as a rule, the witnesses really believed what they deposed to as facts; and it further seems pretty clear that in many instances the persons incriminated were themselves "possessed" with the notion of the reality of the occult powers attributed to them. No more instructive lesson can be found, as to the importance of the "subjective" element in human testimony, than is presented in the records of these trials. Thus, Jane Brooks was hung at Chard assizes in 1658, for having bewitched Richard Jones, a sprightly lad of twelve years old; he was seen to rise in the air and pass over a garden-wall some thirty yards; and nine people deposed to finding him, in open daylight, with his hands flat against a beam at the top of the room, and his body two or three feet from the ground? If this "levitation of the human body," confirmed as it is in modern times by the testimony of Mr. Crookes, Lord Lindsay, and Lord Adair, to say nothing of the dozen witnesses to Mrs. Guppy's descent through the ceiling of a closed and darkened room, has a valid claim on our belief, how are we to stop short of accepting, on the like testimony, *all* the marvels and extravagances of witchcraft? If, on the other hand, we put these witnesses out of court, as rendered untrustworthy by their "prepossession," what credit can we attach to the testimony of any individuals or bodies dominated by a strong religious "prepossession;" that testimony having neither been recorded at the time, nor subjected to the test of judicial examination?

Though I have hitherto spoken of "prepossessions" as ideational states, there are very few in which the emotions do not take a share; and how strongly the influence of these may pervert the representations of actual facts, we best see in that early stage of many forms of monomania, in which there are as yet no fixed delusions, but the occurrences of daily life are wrongly interpreted by the emotional coloring they receive. But we may recognize the same influence in matters which are constantly passing under our observation; and a better illustration of it could scarcely be found than in the following circumstance, mentioned to me as having recently occurred in the practice of a distinguished physician: The head of a family having been struck down by serious illness, this physician was called in to consult with the ordinary medical attendant; and, after examining the patient and conferring with his colleague, he went into the sitting-room where the family were waiting in anxious expectation for his judgment on the case. This he delivered in the cautious form which wise experience dictated: "The patient's condition is very critical, but I see no reason why he should not recover." One of the daughters screamed, "Dr. —— says papa will die!" another cried out, in a jubilant tone, "Dr. —— says papa will get well." If no explanation had been given, the two ladies would have reported the physician's verdict in *precisely opposite terms*, one being under the influence of *fear*, the other of *hope*.

I shall now give a few illustrative examples, from recent experiences, of the contrast between the two views taken of the same phenomena (1) by such as are led by their "prepossessions" at once to attribute to "occult" influences what they cannot otherwise explain, and (2) by those who, under the guidance of trained and organized common-sense, apply themselves, in the first instance, to determine whether there be any thing in these phenomena which "natural" agencies are *not* competent to account for:

1. When, in 1853, the "table-turning" epidemic had taken so strong a hold of the public mind that Prof. Faraday found himself called upon to explain its supposed mystery, he devised a very simple piece of apparatus for testing the fundamental question, whether there is any evidence that the movements of the table are due to *any thing else* than the muscular action of the performers who place their hands upon it. And having demonstrated by its means (1) that the table never went round unless the "indicator" showed that lateral pressure had been exerted in the direction of the movement, while (2) it always did go round when the "indicator" showed that such lateral pressure was adequately exerted, he at once saw that the phenomenon was only another manifestation of the involuntary "ideo-motor" action which had been previously formulated, on other grounds, as a definite physiological principle; and that there was, therefore, not the least evidence of any other agency. Yet it is still asserted that the validity of Faraday's test is completely disproved by the conviction of the performers that they do not exert any such agency; all that this proves being that they are *not conscious* of such exertion—which, to the physiologist, affords no proof whatever that they are not making it.

2. So, again, Profs. Chevreul and Biot, masters of experimental science worthy to be placed in the same rank with Faraday, had been previously applying the same principles and methods to the systematic investigation of the phenomena of the divining-rod and the oscillations of suspended buttons; the former of which were supposed to depend upon some "occult" power on the part of the performer, while the latter were attributed to an hypothetical "odylic" force. And they conclusively proved that in both cases the results are brought about (as in table-turning) by the involuntary action of mental expectancy on the muscles of the performer; the phenomena either not occurring at all, or having no constancy whatever, when he neither knows nor guesses *what to expect*.—The following

instance of the application, to the phenomena of the divining-rod, of the very simple test of *closing the eyes*, has lately been sent me by an American friend, who was apparently unaware of its former application by Chevreul and Biot: "An aged clergyman, of thorough integrity, has for many years enjoyed the reputation of being specially skilled in the finding of places to dig wells by means of the 'divining-rod.' His fame has spread far; and the accounts that are given by him, and of him, must be, to those who place an implicit reliance on human testimony, overwhelmingly convincing. He consented to allow me to experiment with him, and I found that only a few moments were required to prove that his fancied gift was a delusion. In his own yard there was known to be a stream of water running a few feet below the surface, through a small pipe. As he marched over and near this, the rod continually pointed strongly downward, and several times turned clear over. These places I marked, and then blindfolded him, and marched him about until he knew not where he was, taking him over the same ground over and over again; and although the rod went down a number of times, *it did not once point to or near the places indicated.*"

3. About twenty-five years ago, when the old phenomena of the oscillations of suspended buttons, developed by Dr. H. Mayo into a pseudo-scientific theory of od-force, were strongly exciting public attention, a medical friend of great intelligence, then residing in the south of France, wrote me long letters giving the results of his surprising experiences, and asking what I regarded as their *rationale.* My reply was simply, "Shut your eyes, and let some one else observe the oscillations." In a short time I heard from him again, to the effect that his reinvestigation of the matter under this condition had satisfied him that there was no other agency concerned than his own involuntary muscular movement, directed by his *mental expectancy* of the results which would ensue.

In the foregoing cases, the honest beliefs of the agents themselves brought about the results; in the following these beliefs were taken up by the witnesses to the performances of others, in spite of all common-sense probability to the contrary, under the influence of their own strong "prepossessions."

4. At a spiritualistic *séance* at which I was present, at an early stage of the present epidemic, the "medium" pressed down one side of a large loo table supported on a pedestal springing from three spreading feet, and left it resting on only two of its feet, with its surface at an angle of about 45°. Having been admitted to this *séance* under a promise of non-interference, I waited until its conclusion; and then, going over to the table, *set it up and left it in the same position.* For I had observed, when this was done by the "medium," that the edge of the broad claw of each foot, and the edge of its castor, bore on the ground together, so as to afford a base which, though narrow, was sufficient for the table to rest on, its weight happening to be balanced when thus tilted half over. Several persons of great intelligence who were present at this *séance* (Mr. Robert Chambers among the rest) assured me that, if it had not been for my exposure of this trick, they should have gone away in the belief that the table was sustained by "spiritual" influence, as in no other way could they suppose it to have kept its position against the force of gravity.

5. So strong was the impression made by the rope-tying and other performances of the Davenport brothers, about twenty years ago, upon those who were already prepossessed in favor of their "spiritualistic" claims, that I was pressed by men of distinguished position to become a member of a committee

for their "scientific" investigation. Having a strong prepossession, however, in favor of the common-sense view that these performances were but the tricks of not very clever jugglers, and learning that this inquiry was to take place in a darkened room, and that the members of the committee must form a circle with joined hands, I at once declined to have any thing to do with it; on the ground that, to exclude the use of the eyes and hands, which the scientific investigator uses as his chief instruments of research, was to render the inquiry utterly nugatory. Now that the tricks of the Davenport brothers have been not merely imitated but surpassed by Messrs. Cooke and Maskelyne, I suppose that no truly "rational" person would appeal to them as evidence of "spiritual" agency.

6. During the meeting of the British Association at Belfast in 1874, a lady-medium of great repute held spiritualistic *séances*, at which she distributed flowers, affirmed to have been brought to her then and there by the spirits, fresh from the garden, with the dew of heaven upon them. As there was nothing more in this performance than is done every day by an ordinary conjurer, only the confidence entertained in the good faith of the medium could justify a belief in the "spiritual" transport of the flowers; but this belief, aided by the general "prepossession," had been implicitly accepted by many of the witnesses on such occasions. An inquisitive young gentleman, however, who was staying in the same house, and did not share in this confidence, found a basin-full of these flowers (hollyhocks) in a garret, with a decanter of water beside it; and strongly suspecting that they had been stored there with a view to distribution at the *séance*, and that the dew would be supplied, when wanted, from the decanter, he conveyed into the water a chemical substance (ferrocyanide of potassium), in quantity so small as not to tinge it, and yet to be distinctly recognizable by the proper test. On the subsequent application of this test (a per-salt of iron) to the flowers distributed by the "medium," they were found to give *Prussian blue*.—This is no piece of hearsay, but a statement which I have in the hand of the gentleman himself, with permission to make it public.

But every form of "prepossession" has an involuntary and unsuspected action in modifying the memorial traces of past events, even when they were originally rightly apprehended. A gradual change in our own mode of viewing them will bring us to the conviction that we always so viewed them; as we recently saw in the erroneous account which Earl Russell gave of his action as Foreign Secretary in the negotiations which preceded the Crimean War. His subsequently-acquired perception of what he should have done at a particular juncture wrought him up to the honest belief that he really did it. To few persons of experience in life has it not happened to find their distinct impressions of past events in striking discordance with some contemporary narrative, as perhaps given in a letter of their own. An able lawyer told me not long since that he had had occasion to look into a deed which he had not opened for twenty years, but which he could have sworn to contain certain clauses; and, to his utter astonishment, the clauses were not to be found in it. His habitual conception of the purpose of the deed had constructed what answered to the actual memorial trace.

Now, this constructive process becomes peculiarly obvious, in a comparison of narratives given by the believers in mesmerism, spiritualism, and similar "occult" agencies, when there has been time for the building-up of the edifice, with contemporary records of the events, made perhaps by the very narrators themselves. Every thing which tends to prove the reality of the occult influence is exaggerated or distorted; every thing which would help to explain it away is quietly (no doubt quite unintentionally) dropped out. And convictions thus come to be honestly entertained which are in complete disaccordance with the original facts. This source of fallacy was specially noticed by Bacon:

"When the mind is once pleased with certain things, it draws all others to consent, and go along with them; and though the power and number of instances that make for the contrary are greater, yet it either attends not to them, or despises them, or else removes them by a distinction, with a strong and pernicious prejudice to maintain the authority of the first choice unviolated. And hence in most cases of superstition, as of astrology, dreams, omens, judgments, etc., those who find pleasure in such kind of vanities *always observe where the event answers, but slight and pass by the instances where it fails, which are much the more numerous.*"—Novum Organon.

Of the manner in which this constructive process will build up a completely ideal representation of a personality (with or without a nucleus of reality), which shall gain implicit acceptance among a whole people, and be currently accepted by the world at large, we have a "pregnant instance" in the William Tell tradition. For the progressive narrowing-down of his claims, which has resulted from the complete discordance between the actions traditionally attributed to him and trustworthy contemporary history, leaves even his personality questionable; while the turning-up of the apple-story in Icelandic sagas and Hindoo myths seems to put it beyond doubt that this, at any rate, is drawn from far older sources. The reality of this process of gradual accretion and modification, in accordance with current ideas in regard to the character of an individual or the bearing of an event, cannot now be doubted by any philosophic student of history. And the degree in which such constructions involve ascriptions of supernatural power can be shown in many instances to depend upon the prevalent notions entertained as to what the individual might be expected to do.

No figure is more prominent in the early ecclesiastical history of Scotland than that of St. Columba, "the Apostle of the Scoto-Irish," in the sixth century. Having left Ireland, his native country, through having, by his fearless independence, been brought into collision with its civil powers, and been excommunicated by its Church-synods, he migrated to Scotland in the year 563, and acquired by royal donation the island of Iona, which was a peculiarly favorable centre for his evangelizing labors, carried on for more than thirty years among the

Picts and Scots, and also among the northern Irish. No fewer than thirty-two separate religious foundations among the Scots, twenty-one among the Picts, and thirty-seven among the Irish, many of which occupied conspicuous places in the monastic history of the earlier middle ages, seem to have been planted by himself or his immediate disciples; the most celebrated of all these being the college of the Culdees, at Iona, which kept alive the flame of learning during a prolonged period of general ignorance and superstition, and became a centre of religious influence, which extended far beyond the range of its founder's personal labors, and caused his memory to be held in the deepest veneration for centuries afterward. The point on which I here desire to lay stress is *the continuity of history*, as trustworthy as any such history can be; the incidents of St. Columba's life having been originally recorded in the contemporary *fasti* of his religious foundation, and transmitted in unbroken succession to Abbot Adamnan, who first compiled a complete "Vita" of his great predecessor, of which there still exists a manuscript copy, whose authenticity there is no reason to doubt, which dates back to the early part of the eighth century, not much more than one hundred years after St. Columba's death. Now, Adamnan's "Vita" credits its subject with the possession of every kind of miraculous power. The saint prophesied events of all kinds, trivial as well as grave, from battles and violent deaths down to the spilling of an ink-horn, the falling of a book, the omission of a single letter from a writing, and the arrival of guests at the monastery. He cured numbers of people afflicted with inveterate diseases, accorded safety to storm-tossed vessels, himself walked across the sea to his island-home, drove demons out of milk-pails, outwitted sorcerers, and gave supernatural powers to domestic implements. Like other saints, he had his visions of angels and apparitions of heavenly light, which comforted and encouraged him at many a trying juncture, lasting, on one occasion, for three days and nights.

Now, it seems to me beyond all reasonable doubt that St. Columba was one of those men of extraordinary energy of character and earnest religious nature who have the power of strongly impressing most of those with whom they come into contact, moulding their wills and awakening their religious sympathies, so as to acquire a wonderful influence over them; this being aided by the commanding personal "presence" he is recorded to have possessed. And it is not surprising that, when themselves the subjects of what they regarded as "supernatural" power, they should attribute to him the exercise of the same power in other ways. In fact, to their unscientific minds it seemed quite "natural" that he should so exert it; its possession being, in their belief, a normal attribute of his saintship. That he himself believed in his gifts, and that many wonders were actually worked by the concurrent action of his own faith in himself and his followers' faith in him, will not seem unlikely to any one who has carefully studied the action of mental states upon the bodily organism. And that round a nucleus of truth there should have gathered a large accretion of error, under the influence of the mental preconception whose *modus operandi* I have endeavored to elucidate, is accordant with the teachings of our own recent experience, in such cases as that of Dr. Newton and the Zouave Jacob. In these and similar phenomena, a strong conviction of the possession of the power on the part of the healer seems to be necessary for the excitement of the faith of those operated on; and the healer recognizes, by a kind of intuition, the existence of that faith on the part of the patient. Do not several phrases in the gospel narratives point to the same relations as existing between Jesus and the sufferers who sought his aid? The cure is constantly attributed to the "faith" of the patient; while, on the other hand, we are told that Jesus did not do many mighty works in his own country "because of their unbelief"—the very condition which, if these mighty works had been performed by his own will alone, would have been supposed to call forth its exertion, but which is perfectly conformable to our own experience of the wonders of mesmerism, spiritualism, etc. So Paul is spoken of as "steadfastly beholding" the cripple at Lystra, "and seeing that he had faith to be healed."

The potency of influences of the opposite kind upon minds predisposed to them, and through their minds upon their bodies, is shown in the "Obeah practices" still lingering among the negroes of the West India colonies, in spite of most stringent legislation. A slow pining away, ending in death, has been the not unfrequent result of the fixed belief on the part of the victim that "Obi" has been put upon him by some old man or old woman reputed to possess the injurious power; and I see no reason to doubt that the Obi men or women were firm believers in the occult power attributed to them.

Every medical man of large experience is well aware how strongly the patient's undoubting faith in the efficacy of a particular remedy or mode of treatment assists its action; and, where the doctor is himself animated by such a faith, he has the more power of exciting it in others. A simple prediction, without any remedial measure, will sometimes work its own fulfillment. Thus, Sir James Paget tells of a case in which he strongly impressed a woman, having a sluggish, non-malignant tumor in the breast, that this tumor would disperse within a month or six weeks; and so it did. He perceived the patient's nature to be one on which the assurance would act favorably, and no one could more earnestly and effectually enforce it. On the other hand, a fixed belief on the part of the patient that a mortal disease has seized upon the frame, or that a particular operation or system of treatment will prove unsuccessful, seems in numerous instances to have been the real occasion of the fatal result.

Many of the so-called "miracles" of the Romish Church, such as that of the "holy thorn" (narrated in the "History of the Port-Royalists"), which stood the test of the most rigid contemporary inquiry, carried on at the prompting of a hostile ecclesiastical party, seem to me fully explicable on the like principle of the action of strongly-excited "faith" in producing bodily change, whether beneficial or injurious; and nothing but the fact that this strong excitement was called forth by religious influences, which in all ages have been more potent in arousing it than influences of any other kind, gives the least color to the assumption of their supernatural character.

I might draw many other illustrations from the lives of the saints of various periods of the Roman Catholic Church, as chronicled by their contemporaries, many of whom speak of themselves as eye-witnesses of the marvels they relate; thus, the "levitation of the human body"—i. e., the rising from the ground, and the remaining unsupported in the air for a considerable length of time—is one of the miracles attributed to St. Francis d'Assisi. But it will be enough for me to refer to the fact that some of the ablest ecclesiastical historians in the English Church have confessed their inability to see on what grounds—so far as *externæl evidence* is concerned—we are to reject these, if the testimony of the Biblical narratives is to be accepted as valid evidence of the supernatural occurrences they relate.

But the most remarkable example I have met with in recent times of the "survival" in a whole community of ancient modes of thought on these subjects (the etymological meaning of the term "superstition") has been very recently made public by a German writer, who has given an account of the population of a corner of Eastern Austria, termed the Bukowina, a large proportion of which are Jews, mostly belonging to the sect of the Chassidim, who are ruled by "Saints" or "Just Ones." "These saints," says their delineator, "are sly impostors, who take advantage of the fanaticism, superstition, and blind ignorance of the Chassidim in the most barefaced manner. They heal the sick by pronouncing magic words, drive out devils, gain lawsuits, and their curse is supposed to kill whole families, or at least to reduce them to beggary. Between the 'saint' and 'God' there is no mediator, for he holds personal intercourse with the Father of all, and his words are oracles. Woe to those who should venture to dispute these miracles in the presence of these unreasonable fanatics! They are ready to die for their superstitions, and to kill those who dispute them." [1]

Now, I fail to see what stronger external evidence there is of any of the supernatural occurrences chronicled in the Old Testament than that which is afforded by the assured conviction of this Jewish community as to what is taking place at the present time under their own eyes. And, assuming, as I suppose most of us should be ready to do, that the testimony of these contemporary wonders would break down

[1] E. Kilian, in *Fraser's Magazine* for December, 1875.

under the rigorous test of a searching examination, I ask whether we are not equally justified in the assumption that a similar scrutiny, if we had the power to apply it, would in like manner dispose of many of the narratives of old time, either as distortions of real occurrences or as altogether legendary.

In regard to the New Testament miracles generally, while failing to see in what respect the external testimony in their behalf is stronger than it is for the reality of the miracles attributed to St. Columba, I limit myself for the present to the following questions:

1. Whether the "miracles of healing" may not have had a foundation of reality in "natural" agencies perfectly well known to such as have scientifically studied the action of the mind upon the body. In regard to one form of these supposed miracles—the casting out of devils—I suppose that I need not in these days adduce any argument to disprove the old notion of "demoniacal possession," in the face of the fact that the belief in such "possession" in the case of lunatics, epileptics, etc., and the belief in the powers of "exorcists" to get rid of it, are still as prevalent among Eastern nations as they were in the time of Christ. And I suppose, too, that, since travelers have found that the pool of Bethesda is fed by an intermittent spring, few now seriously believe in the occasional appearance of an "angel" who moved its water; or in the cure of the first among the expectant sick who got himself placed in it, by any other agency than his "faith" in the efficacy of the means. I simply claim the right to a more extended application of the same critical method.

2. Whether we have not a similar right to bring to bear on the study of the Gospel narratives the same *principles* of criticism as guided the early fathers in their construction of the canon, with all the enlightenment which we derive from the subsequent history of Christianity, aided by that of other forms of religious belief. The early Christian fathers were troubled with no doubts as to the reality of miracles in themselves; and they testified to the healing of the sick, the casting out of devils, and even the raising of the dead, as well-known facts of their own time. But they rejected some current narratives of the miraculous which they did not regard as adequately authenticated, and others as considering them puerile. Looking at it not only as our right, but as our duty, to bring the higher critical enlightenment of the present day to bear upon the study of the Gospel records, I ask whether both past and contemporary history do not afford such a body of evidence of a prevalent tendency to exaggeration and distortion, in the representation of actual occurrences in which "supernatural" agencies are supposed to have been concerned, as entitles us, without attempting any detailed analysis, to believe that, if we could know *what really did happen*, it would often prove to be something very different from what is narrated.

By such a general admission, we may remove the serious difficulties to which I alluded at the outset, difficulties which must, I think, have been present to the mind of Locke, when he recorded, in the commonplace-book published by Lord King, the remarkable aphorism that "the doctrine proves the miracles, rather than the miracles the doctrine."—*Contemporary Review.*

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# THE FUNCTIONS OF ASSOCIATION IN ITS RELATION TO LABOR.

By WILLIAM B. WEEDEN.

THE writer is a member of a copartnership chiefly devoted to the business of manufacturing textile fabrics. Within twenty years this firm has divided interests in different mills with eight persons, who acted as superintendents or assistant superintendents of the mills in which they were engaged. These combinations were of the nature of industrial partnerships, and proved uniformly successful. Of these eight persons, two were originally factory accountants, two were finishing overseers, and four were weaving overseers; all were men who had served long in the factories, and were outgrowths from factory-life. If it be true that in the armies of Napoleon every private carried a marshal's *bâton* in his knapsack, or, as Sydney Smith puts it, if every English curate is a possible bishop, then these industrial combinations must have produced better cloth for the people and a better life in the makers of the cloth, or the laborers who were confined in the factories. The firm owned or controlled ample capital for their enterprises, and employed the laborers. It needs no argument to show that the business was more thoroughly done because these industrial partners were taken from among the laborers; and it is likewise evident that each rank of laborers was elevated and stimulated by these promotions.

Under that modern system of organization which unites the laborers into one mass, striving to obtain the highest price for their services, and combines employers in another assembly seeking to obtain labor at the lowest price, our industrial partnerships would have been impossible. If close combinations resulting in certain antagonism, such as has prevailed in England for a generation, had existed here, then no links could have reached across from the chain of laborers on the one side to the chain of employers and capitalists on the other. These combinations are growing in America; the life they foreshadow must differ from the industrial life described above. It was this thought which led me to consider the matter, and to try to ascertain the true functions of association. The topic is broader than my theme, and enters into all phases of civilized society, but I would consider it in the relations of organized labor, which include the so-called labor and capital (or capital and labor) disputes. The same principles of association prevail here which dominate all social action. What are the powers, the rights, and the limits of association, whether it be of the employers or the employed? I shall resolve the question of rights into that of powers. If there be a legitimate power inherent in these associations, I will not maintain any vested right against it. This is not strictly accurate, but sufficiently so for this discussion.

In treating of association we must first consider the materials which make it; the characteristics of the individuals who associate themselves together. And here we must remember that the individual is a social entity of quite recent growth. The Roman, German, Anglo-Saxon societies knew nothing of individual men and women. The Roman family, *gens*, or house and tribe, the German benefice, commendation, and guild, the Anglo-Saxon *ceorl* and *eorl* castes, with their tithings and hundreds—all these institutions, mingling in the stream of history, made each individual into a part of something other than himself. Society as well as government was classified into groups, which were further classified and subdivided. The single individual had no place; under the Saxon laws he was outlawed, and might be killed. These groups gradually broke up, under the friction of modern life. America, as we have been frequently told in the centennial reminiscences of this period, for two hundred years received the germinal ideas of Europe. We received, through immigration, the most characteristic and modern ideas, and incorporated them into a new political and social life, freed from many restraints still prevailing in the old countries. Politically, the individual was fully recognized for the first time; socially, he was raised into freer activity than any society had ever developed; yet, socially, the individual was more limited by the influence of the old grouping than he was in his political relations. These distinctions are important, because they modify all the subsequent relations of employers and employed, and control the character of associations in this country.

The associations of employers in America thus far have been loosely formed, and their action on the labor question has been indirect. The associations of laborers have been modeled after those prevailing in England, and known as trades-unions. If we would comprehend the principles of any association of laborers in America, we must first study the history of these English unions, for the results achieved by these powerful organizations govern the movements of all labor agitators, whether they are conscious of it or not. The whole principle of trades-unionism has been set forth carefully and candidly by Mr. Thornton in his work "On Labor." Mr. Thornton is neither a communist nor a socialist, but an acute and thoughtful Englishman, with large sympathies, who, whenever his sense of justice will allow, leans to the side of labor in its struggles with capital. He sees in labor, as capital, not theories, but immense and awful facts which must bruise and grind each other until they are worn into some finer social relations. The idea that some wrong principles in the first constitution of the facts might be changed, and the whole result might be ameliorated, never occurs to him. The whole affair must be fought out representatively and fairly; and, when the strongest force has manifested itself, right will prevail. He admits the many evils of trades-unionism, stating them with candor and force. But he believes the institution to be absolutely necessary. He says, on page 320:

"Laborers may, by combining, acquire an influence which, if exercised with moderation and discretion, employers will in general be willing rather to propitiate than to oppose. Among the concessions which may in consequence be obtained by unionists, the most material are those which affect the remuneration of labor, and these, it is commonly supposed, cannot, when due solely to unionist action, be of permanent operation. We have learned, however, in the course of the present chapter, that the fact of an increase in the rate of remuneration having been artificially caused, furnishes no reason why, in the great majority of cases, that increase should not be lasting. . . . Such being the efficacy of unionism, there is no difficulty in accounting for its popularity without resorting, in explanation of unionist loyalty, to any of those terrorist theories, the exaggerations of which have already been exposed, and on which no additional words need here be expended."

Mr. Thornton supports the extraordinary theory that an artificial rise of wages may be made into a permanent value by reconstructing the whole formula of supply and demand as it is enunciated by economists and men of affairs. He says, on page 108:

"The price of labor is determined, not by supply and demand, which never determined the price of any thing, nor yet by competition, which generally determines the price of everything else, but by combination among the masters. Competition in a small minority of cases, combination in a great majority, have appeared to be normally the determining causes of the rate of wages or price of labor."

It is not necessary to refute this theory in its relation to price and value—it refutes itself; common facts, occurring since he wrote, have nullified it. I am only stating the basis of trades-unionism in the words of its most intelligent advocate. It is interesting to compare these doctrines of Mr. Thornton with those of Josiah Warren, an American socialist, who approaches the question from the opposite direction. Mr. Warren works his theory of value, price, and supply and demand, out of the sovereignty of the individual, as he terms it; while Mr. Thornton's comes out of the historic organization of society, political and social, as well as economical. Mr. Warren was an earnest man, who has had and now has a great influence in forming the opinions of laborers and labor-agitators in this country. He says in his pamphlet on "True Civilization" (pages 41, 64, 100):

"It is now evident to all eyes that labor does not obtain its legitimate reward, but, on the contrary, that those who work the hardest fare the worst. . . . . At this point society must attend to the rights of labor, and settle once for all the great problem of its just reward. This appears to demand a discrimination, a disconnection, a disunion, between *cost* and *value*. . . . Making value, or 'what a thing will bring,' the limit of its price, stagnates exchange and prevents our wants from being supplied. Now, if it were not a part of our present system to get a price according to the degree of want or suffering of the community, there would long since have been some arrangement made to *adapt* the *supply* to the *demand*. . . . Cost being made the limit of price, would give to the washer-woman a greater income than the importer of foreign goods; that this would entirely upset the present system of national trade, stop all wars arising out of the scramble for the profits of trade, and demolish all tariffs, duties, and all systems of policy that give rise to them; would abolish all distinctions of rich and poor; would enable every one to consume as much as he produced, and, consequently, prevent any one from living at the cost of another without his or her consent."

The difficulty underlying these two economical theories is the same, as I understand it. Mr. Thornton, and in a certain degree the political economists also, convert supply and demand into two entities. Take his illustration (page 59):

"Suppose at each of two horse-fairs a horse to be sold valued by its owner at £50, and suppose there be in the one case two and in the other three persons, of whom each is ready to pay £50 for the horse, though no one of them can afford to pay more. In both cases supply is the same—viz., one horse at £50—but demand is different, being in the one case two and in the other three horses at £50. Yet the price at which the horse will be sold will be the same in both cases, viz., £50."

Here he assigns a metaphysical limit to supply, and yet admits only a portion of the mental process by which that limit is reached. The fact that the buyers can afford to pay only £50 has little to do with the price paid. The cause which influences their mental action is, that they know there are plenty of other horses they can buy at £50, though there is only one at hand. Economically, the absent horses enter into the supply nearly as effectively as the one present. This supply, present and absent, affects the minds of both buyer and seller, and limits the price; the limit is not a metaphysical one, imposed by the competition of sellers alone, as Mr. Thornton would have us believe, and as he directly says elsewhere. We must bear in mind that Mr. Thornton has been partially approved by Mill and Prof. Cairns, in considering the weight of his theories. In the relations of capital and labor, he assumes that capitalists have the same control of the market-price of labor which he conceives sellers to have in ordinary trade; hence the necessity of trades-unionism to resist this control, which could not be governed by the economical forces of the market; and hence the above formula of supply and demand. Mr. Warren's error is essentially the same. In his view, the price of labor is regulated by a metaphysical entity, which is not the relation of the labor-supply to the general market and demand, but is a result of "the want or suffering of the community." To overcome this entity he would revolutionize trade and production, abolish profit, and base every transaction on its cost in labor, without regard to the results of that labor.

Now, as I understand supply and demand in the market, they are not dead-weights of matter, like a rock crushing my finger; they are forces like the gravitation controlling the rock, and which I must recognize if I would keep my finger whole and escape mental distress. These forces affect laborers and capitalists, producers and consumers alike, and they are the strongest influence in fixing market-prices. In fact, we may consider them the only forces present and active when the selling price is fixed. All other forces must have been transmuted before price can be fixed. It is not easy to comprehend these forces, for Prof. Cairns, while saying [1] "demand and supply are essentially the same phenomena regarded from different points of view, consequently general demand cannot increase or diminish except in constant relation with general supply," yet says also they are "not independent economic forces." Mr. Mill says: [2]

> "Demand and supply—the quantity demanded and the quantity supplied—will be made equal. If unequal at any moment competition equalizes them, and the manner in which this is done is by an adjustment of the value."

Yet every merchant knows that competition is only one of many elements which enter into an "equation" of supply and demand. I dwell on this, not to show the differences of professional economists, but to illustrate the subtlety of these controlling influences of the market-price of labor and commodities. These influences are quite beyond the comprehension of a trades-union as such. We may say a powerful union would employ a leader of great capacity, who would construe these influences properly; but the very process which made him a union-leader would unfit him for a judge of the markets. A general can lead an army to victory; but generals, as a class, have been poor judges of national policy, in war or peace. The union-leader may extort an advance of wages through the force of his followers. But this advance in price must be converted into permanent exchange value in order to be of benefit to the laborer. One possible element of this value is the very labor of the unionists themselves while they were striking for the advance; or the advance may have carried the products out of relation to all other values. The only solvents of these delicate problems are the principles of supply and demand I have stated. They must be interpreted by social agents with the highest faculties and the best power of discrimination. If society proves one of these men and finds him trustworthy, it must

[1] "Principles of Political Econmy," p. 42.

[2] "Political Economy," vol. i., p. 551, American edition.

keep him and allow him full play. Like tea and wine tasters, they must not be argued with nor forced into unnatural decisions by the power of numbers. If it be said that a unionist can perform this delicate social duty, let us hear what Mr. Thornton [1] says in this regard:

> "They" (trades-unions) "tell us plainly what they aspire to is 'control over the destinies of labor;' that they want not merely to be freed from dictation, but to dictate—to be able to arrange the conditions of employment at their own discretion."

Mr. Applegarth, one of the most accomplished unionists, says:

> "The business of the employed is to look after their own interests, leaving employers, customers, and the rest of society, to look after theirs and to shift for themselves as they best may."

Firm associations of employers promote the highest economical ends no better when they antagonize the market, or society economically considered. The notion long prevailed in trade and manufactures, that advantages and profits should be secured through monopolies and arbitrary control of the markets. Modern society has abandoned this theory; has forced employers and sellers into a larger view of their own interests through social obligation; and it will compel labor-organizations toward the same end by irresistible social laws. Mr. Thornton admits this principle in another form, for he constantly says the close organizations of laborers are now compelling absolute combinations of the employers to oppose them, and that these latter must surely prevail. Yet he regards the struggle as necessary, and the only means of bringing order and justice out of clashing class antagonisms. However this may be in England, and it is not our business to inquire, in America the principle does not and cannot prevail. European civilization has left but one citadel to the few, in their opposition to the many. Chieftainship, social prestige, money, all pass away from a class if its individual members are not true to its instincts. One fortress remains, where, intrenched by law, the privilege of classes can hold all assailants at bay, and can repair the unthrifty ravages of reckless individuals. Land, the final reservoir of natural advantage, the sure protector of privilege, is, in Europe, practically beyond the reach of the many. In England, the country of greatest abundance, capital ventures itself commercially not below five to ten per cent., while it rests content in land at two per cent. This petty profit shows contrariwise the immense power and value of land. In our country it is practically free; the Government gives a homestead on the open prairie, or, if that be too distant and uncertain, the laborer, riding one hundred miles by rail from a crowded district in New England, can find cheap, fertile lands, with homestead buildings abandoned and decaying. It is impossible for one class to oppress another long, while these doors open freely outward to the

[1] Pp. 193, 194.

great advantages of Nature and land. If, according to Mr. Thornton's theory, employers do not compete for, but combine against labor, or, if they do not compete forcibly enough, Nature does now, and must for centuries to come, open her arms to the sons and daughters of toil. It must be remembered that the thrifty laborer is always a capitalist here. The struggle is not between labor and capital, want and plenty; it is between the employed with a little capital and the employer with more. I throw out of the estimate the improvident and reckless; if socialists or unionists have discovered a method which will give these classes an even chance, they have found a principle which Omnipotence itself has never ventured to put in practice.

If these principles be true, one may ask, Why do we have strikes or discontented laborers in America? I answer, they are the diseases of health; inflammations come from turgid arteries as well as from sluggish veins. Our abounding life has compelled an eager competition among employers. Employers have invariably tended to over-production, as capitalists know to their cost. Strikes have hardly ever advanced the price of labor; they have never long increased its exchange value, as I indicated above. There is very little communistic sentiment in the United States, but many socialistic theories of a vague sort. That astute public servant, General Butler, would hardly be found uttering such nonsense, if it were not wanted in the socio-political market. The "glittering generality" of equality has partially corrupted the good sense of the citizen; only in part, but the effect is positive. Things are free, they say; why not have a better chance for all? Not through communism; property is both new and old here; it is sacred as a treasure, and dear as a newly-born babe in Anglo-American eyes. Let there be new property; give us all a new chance; the bird of freedom is so 'tarnally strong, why not roast-beef and two dollars a day? The American love of speculation tends in the same direction.

Then there is another principle moving in harmony with this. In great emergencies, when the state or social order is threatened, every American citizen becomes great, and views the State as belonging to all. In petty affairs, and every-day political matters, the average citizen, small capitalist as well as laborer, views the State as belonging to the many considered apart from the few. "The rich have enough; let the poor of the State lean to us," they would say. This blind instinct has entered into strikes and labor-struggles.

The agitators felt that in some way the masses would win, the constable's club would wait on the bayonets, and the militia would sway with the voters for the poor and against the rich; therefore a striker might knock a peaceful laborer on the head with impunity. The common-weal feeling, the American union sentiment as Mr. Wasson puts it, "the sovereignty of rational obligation," must stamp out this atrocious delusion. I regard this issue of fact in the late Fall

River strike as the best and almost the only good principle established there. The municipal and military power promptly restored order and left the trades-unionists their peaceable and natural powers of resistance, all which any association of this sort can legitimately claim.

The fundamental truths cannot be too deeply impressed on both employers and employed. Let no employer busy himself in politics or jurisprudence, about unionist combinations or conspiracies. We have laws enough now, if we will obey and enforce them. If any striker or unionist trespasses on the rights at common law of his employer or brother laborer, punish him with humane haste and compassionate severity. One labor-leader says an employer has no more right to discharge a man than to dungeon him. That is their business individually, and can only be controlled by the larger social and nobler instincts of humanity. If laborers choose to starve rather than work for less wages, or employers choose to rust out their mills rather than take less profits, let them. It is not the business of organized associations to interfere. Not even the State, the greatest of all associations, can control this complication. The issue lies among the great seething forces of the market indicated above; they are both economical and social, any external pressure will only aggravate the difficulty.

There can be only one legitimate power in an American labor association assuming to control the employed; that, in the famous words of Adam Smith, is the power of "higgling the market." On every other side its action is hedged by great social limits which I have indicated rather than stated. This, like friction in mechanics, is a necessary function, but is attainable by other means, and is it worth the social cost involved in associations using all the methods of a despotism? The general rise in wages has been equal, in countries unvisited by trades-unions, to that obtained in England, as Mr. Brassey has shown.

Higgling prices through combination is not a creative force, it is a negative accessory to creative faculties. It involves tremendous waste of social and economical forces. To quote Thornton (pages 344–346):

"A bricklayer's assistant, who by looking on has learned how to lay bricks as well as his principal, is generally doomed nevertheless to continue a laborer for life." . . . Bricks beyond Lancashire are excluded. "To enforce the exclusion, paid agents are employed; every cart of bricks coming toward Manchester is watched, and, if the contents be found to have come from without the prescribed boundary, the bricklayers at once refuse to work. . . . A master-mason at Ashton obtained some stone ready polished from a quarry near Macclesfield. His men, however, in obedience to club rules, refused to fix it until the polished part had been defaced, and they had polished it again by hand, though not so well as at first! . . . On the importation of worked stone into Barrow, the lodge demanded first that the bases should be worked over again;

secondly, when this was refused as an impossible interference with the architects' design, that as much time as would have been required to rework them should be occupied by the Barrow masons in standing over them."

These are not mere caprices and fancies, they are the certain aberrations which misdirected, arbitrary power must cause.

This power of vagary is even more dangerous politically than it is in the industrial world. The eight-hour league lately attempted to canvass in favor of Randall for Speaker. What business has a labor league, an Odd-Fellows' lodge, or a Methodist church, as such, in the election of an officer of the United States Government? Let them consider Shay's insurrection, the slavery rebellion, and Know-Nothingism, both in its success and its failure.

Politically the genius of America welcomes every individual waif, allows him all liberty of political association or agitation; and he may make social or industrial combinations at will. Let any one of these extra-political associations lift a finger to interfere with a fold of her political garment, and she will crush it under a step heavier than the tread of Roman legions; she will smite it with an arm swifter and mightier than the embodied power of feudal or constitutional monarchies!

I would not deny the right of the individual laborer to "strike" when he is wronged beyond endurance. This inheres in him, like the right of revolution in the citizen—a dangerous power, only to be evoked in dire need, it cannot be formulated socially. As political order binds the citizen, so contract, that mystic sacrament of civilization, must ever hold the laborer fast; it can only be overcome by bitter injustice.

It may be said that trades-unionism, though vicious in direct influence, may enlarge the laborer through indirect social action. We must remember that the laborer here has social opportunities unknown in Europe. The freemasons, militia companies, Patrick's brotherhoods, and Good Templars, all found themselves on broad and benevolent ideas; higgling prices, the one effective force of a trades-union, can hardly equal these ideas in elevating the laborer. Going back to our characteristics of American citizens, it is not to be imagined that we lost all traces of old social groups because we did not represent them in our political organizations. The individual had become sufficiently socialized to be the unit of state, yet he did not lose all historic antecedents. The old groups show their traces in the American as well as in the Italian, German, and Englishman. We have not changed social laws, but given them new elasticity. Water cannot be water unless it intermingles freely with air. Society must refresh itself with new individual units, always moving, always classifying, always mingling unit and group again, like drop and stream, cloud and sea, water and air. Trades-unionism, and all socialism, in so far as it trenches on the State, is a backward step in this American progress. They clasp rigid fetters on movements which were becoming more supple and elastic. All social organisms are finally parts of the State, that tangible divine power, the right arm of God in his relations with men. There can be no true functions of association which tend to embarrass the free development of the State—the association of associations.

# MODERN PHILOSOPHICAL BIOLOGY.

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## I.

BIOLOGY, or the science of life, is so new a subject of investigation that its limits are as yet imperfectly ascertained. Metaphysical ideas have too large a place in our conception of its extent. When we ask where biology commences, we are met by the problem of the origin of living things, which very often is solved in accordance rather with preconceived opinions of the system of the universe than with an independent scientific hypothesis. When we would determine its limits, we are met by the problems of cognition, and of the causes determining man's actions; and again usually it is unscientific prejudices that decide whether these problems should be referred to another science, or treated under a subdivision of biology; whether we should range, alongside with phenomena which unquestionably belong to biology, those other phenomena which experience shows us to be closely connected with them, associated with them, and which are in such constant ratio with them in their variations that they appear to derive from them, and from no other source, the conditions of their existence. The indecision as to the limits of biology results principally from the difficulty of giving a strict definition of its subject-matter. Still, in spite of these difficulties, though we cannot say precisely what life is, where its province commences, where it ends, there exists between the two extremes—the inorganic world and the mental world—a very firm ground, imperfectly explored, it is true, but nevertheless belonging to biology alone. The various departments which constitute this domain, though they themselves are not all very clearly defined, are sufficient to give to biology a definite individuality.

Living things present themselves to the observer of Nature as individuals; and it was not long before man began to regard them from another point of view, as forming groups of similar individuals more nearly allied to one another than to individuals in other groups. At first these groups were held to be natural; next it was asked whether, like individuals, they had a history—a beginning and an ending.

This question, as being one that strikes the imagination, naturally arose even before science possessed the means of settling it, and preceded, in the historical order, that thorough study of individuals on which its solution really depends. When men of science had begun to study living things with other purposes than simply that of deriving from them knowledge that would be available for the medical art, and had gained sufficient information for inductive generalizations, they no longer contented themselves with theories of the origin of groups, but sought to reduce to general principles the structure of living bodies—a thing which previously had been considered only from the topographical point of view, and with reference to what was called the use of the parts; and on these general principles they sought to rest a scientific theory of the origin of natural groups.

A man of keen and powerful intellect, who, had he but lived in our time, would have attained the summit of fame, with marvelous acumen anticipated a doctrine which is steadily tending to become a received scientific theory, viz., that the changes which have occurred in Nature are the effects of constant natural laws. Applying this idea to the natural groups of the animal kingdom, he rejected the hypothesis which ascribed to geological catastrophes the destruction of entire faunæ, and the preparation of the earth's surface for a fresh special creation. The transformation of lower organisms into higher he referred to the action of modifications which, though in themselves inconsiderable, became important from repetition and long accumulation, under the influence of forces whose powers he exaggerated. Species and varieties he regarded as artificial groups. According to him the very simplest organisms are derived, by way of spontaneous generation, from naturally-produced plastic substances; then they mutually diverged by imperceptible differences, so as to constitute a linear series, which, but for the gaps caused here and there by lost species, would present to us the aspect of a continuous system. Under favoring circumstances the organs of an animal are modified; a change in the circumstances causes changes in the structure of the individuals belonging to a species, and is the starting-point for the formation of a new species. Crossing, by producing hybrids, still further multiplies the number of species. And species appear to be fixed, simply because the circumstances appear to be similarly fixed during the brief period embraced in our observations. Transformation is the rule, and in the regular course which it runs we can discover no indications of plan or purpose.

The ideas of Lamarck, being but ill supported by positive proofs, were looked on as mere speculations, plausible but doubtful, or even as dreams, unworthy of science; his generalizations were discredited, and even now, when they reappear, backed by a powerful array of facts, but few ever think of giving due honor to their author.

The attempts made at the same period to form generalizations with respect to the constituent parts of the living individual were more successful. It was not enough to know in a general way that the phenomena observed in living things are in the last resort the same in kind as those which are known as physico-chemical, and that they obey the same laws. Between the phenomena of living things and those of inanimate Nature there existed too wide a chasm; there was no way of passing, deductively, from physico-chemical laws to vital phenomena, and the scientific explanation of organic forms and of functions was of necessity defective. The author of the "Anatomie générale" simply recognized in organs various elements, which he grouped in families, with a view to define, under the general name of tissues, the basis of their structure. In these elements he recognized, independently of their physical and chemical properties, special properties which he justly denominated vital, inasmuch as it is by them that life manifests itself, and which are, properly speaking, the function of these elements. Bichat's generalizations were, doubtless, in his own mind, in opposition to the theory which refers vital phenomena to physico-chemical properties; in point of fact, they have established a relation between functional facts and the general properties of matter. The functional facts of organs are explained by the elementary properties of the tissues; and the latter, though we cannot as yet refer them to physico-chemical properties, are, nevertheless, brought into remarkably close relation with them through our modern ideas of the constitution of organic substances and the principle of the equivalence and transformation of forces.

Still, these relations could not be perceived prior to the discovery of the relations which connect organisms and their tissues with external forces possessed only of physico-chemical properties; and this conception dates from a time long after Bichat's day. We have reason for believing that the part assigned by Lamarck to the action of external circumstances upon organisms first suggested this conception, owing to one of those mysterious operations of the mind which, out of an idea vaguely descried, and even, perhaps, not accepted in the form in which it first presented itself, forms a nucleus around which experience and reasoning group proofs, and which the inventive faculty develops under the form of a doctrine apparently brand-new. The doctrine of the action of "general external modifiers," which Blainville sets forth summarily in his "Cours de Physiologie générale et comparée," by no means possessed, even in his own mind, all the importance it later assumed in science under the name of "doctrine of media," after Auguste Comte had given it so prominent a place in his "Biologie." But, by bringing upon the scene the action of external circumstances upon the sum total of a living organism, and by calling attention to the effects they produce therein, whether as stimulating or reviving the functions, or as suspending the same, Blainville prepared the way for a better interpretation of vital phenomena; and though he himself, with all this light, did not attain to the truest conception of life, he nevertheless broke ground for those who afterward were to do so.

In more recent times biology has been enriched with an enormous amount of facts for which we are indebted to the labors of naturalists, or even of mere breeders, as also to the labors of anatomists and clinicians, but, above all, to researches in experimental physiology, wherein the application of physical-science methods to the discovery of the laws of vital phenomena has been attended with brilliant success. Amid the extreme complexity of these phenomena it was difficult to perceive the relations of succession which unite them, and to establish positive series. But when men of science refused any longer to content themselves with observing them as they occur spontaneously, and began to vary them by calling in the action of special agents, then modifications were produced, the true causes of which were easily recognized. As in the study of inorganic bodies we learned the laws of their actions and combinations by seeking to find out with the aid of reagents—which are, in fact, special modifiers—the way in which they behave under circumstances that are well known, being fixed beforehand by the observer; so, in the study of living bodies, the introduction of experimentation which alters, according to a plan determined beforehand, the conditions under which the functions of life are to be performed, has enabled us to perceive, with an exactitude previously unknown, the organic properties underlying these functions. Even in embryogeny, a science which once seemed to belong to the domain of simple observation, it has been possible, by way of experimentation, to gain results which shed some light upon teratology. The employment, in observation, of instruments of precision, and in particular of registering apparatus, and of all those processes which suppress causes of error resulting from the personal peculiarities of the observer, gives to the results of research a degree of certitude which renders indisputable facts properly so called, the only question that remains being as to whether these results have been rightly or wrongly interpreted. In addition to an immense amount of unquestionable facts, in addition to a knowledge of the elementary properties of organic tissues and an acquaintance with the special laws which represent the action of these tissues in presence of these modifiers, this general result has followed the conquests of biology, namely, that living bodies are now known to be subject to the self-same laws which govern inorganic bodies, and that, under the hand of the experimenter, the course of things within the tissues is precisely the same as without the tissues; that in the laboratory the elements of living bodies, like those of inanimate things, have their own way of affecting the mind that observes them—that is to say, they possess fixed essential properties which can be determined; and what remains yet to be known is, above all, the mode in which those organic substances are formed which are the basis of living bodies. The belief which from day to day is gaining confirmation from the labors of physiologists is that so boldly expressed by Claude Bernard, viz., that as the chemist, starting with the knowledge of inorganic bodies, subjects them to his will and creates new bodies, so the physiologist, starting from organic matter, "by imposing upon it special conditions, will be able to produce new physiological modifications and new series of phenomena, thus modifying at will living bodies, and even creating them."

At the same time, by comparing and analyzing the different branches of biology, certain very general laws have been established, particularly in physiology proper, having a bearing upon the development of the individual and the relations of the functions to their organs. We are in possession of a certain number of very broad though purely empiric generalizations on the phenomena upon which the superiority of living things over one another depends. These are, properly speaking, laws of organic Nature.

First, we have the law of the increase of the mass of the organism, in virtue of which each living thing attains its full development only by passing through a series of phases characterized by an augmentation of its mass, and consequently by an augmentation of the quantity of force applicable for its physiological actions, as also by an augmentation of the quantity of functional products.

Then there is the law of the multiplication of parts in proportion as we ascend in the series of living things, this multiplication being determined by an increase of complexity in the organic machine, in virtue of the diversity both of the functions which make their appearance and of the organs which result from this diversity of functions.

Again, we have the law of coördination and subordination of functions and organs, in virtue of which, in proportion as complexity is introduced into the organism and as the functions and organs take on a more special character, certain functions and the organs performing them become dependent on other functions and other organs. Besides, a tie of solidarity is established between all the parts of the living body, so as to guide them toward a common end, the conservation of the individual, while at the same time all of the parts feel the reverberation of the actions to which each is subject.

Next comes the law of adaptation, in virtue of which an organism tends to be so modified as to seem to be specially created to suit the circumstances amid which it exists and the kind of life imposed upon it by them. This law is still, for many thinkers, the basis of ideas of final causes by means of which they strive to explain the structure of living things and the variations observed therein.

Finally, there is the law of heredity, in virtue of which organisms produce new organisms which repeat their type. Heredity is the law of fixity; it expresses the tendency to perpetuate a condition of things which is itself the result of past environments, and to set it up as a barrier against the influence of new environments.

Descending still deeper, scientific men have sought to explain the constitution of living things, their production, and the existence of the groups into which we find them divided. Hence three theories which have had different fortunes—the cellular theory, the doctrine of spontaneous generation, and transformism.

Schwann, applying to the animal organism Schleiden's discoveries in vegetal organisms, showed that the tissues are formed of primordial, i. e., irreducible, elements, called cells, though often these elements have no cavity and are simply rounded masses. The egg, which is the starting-point of all animal organisms, is at first merely a cell, and develops by producing within itself other cells, which are the primitive materials of the living being. All that the organism is comes ultimately from the cells, which are converted into living tissues. They adhere to one another end to end, and become flattened, or lengthened, or ramified; or they unite and form one common cavity, keeping their walls only at points where they are not in contact, thus forming tubes, or fibres, as, for example, in the histological elements of muscles and nerves.

Some authors have explained the production of cells on the hypothesis of a true spontaneous generation. According to them, cells are organized in a saline solution, the first step being the deposit of a nucleolus, around which there forms an envelope called the nucleus, and finally, at a greater distance, a second envelope, or cell-wall. But no actual experiment has ever been made on the production of cells in this way, and hitherto we have no knowledge of a cell being produced save from a cell. Of this famous theory so much yet remains, viz., that the cell, whatsoever its form and whatever modifications it may have received, is ever the basis of the vital phenomena.

"One only elementary form" (says Virchow) "runs through the whole organic world, remaining ever the same; in vain would we attempt to substitute any thing else for it; there is nothing that can take its place. We have come to regard even the highest formations, whether plant or animal, as being the sum of a larger or smaller number of like or unlike cells. The tree represents a mass put together according to a certain law; each of its parts, leaf or root, trunk or flower, contains cellular elements. The same is true of the animal world. *Each animal represents a sum of vital units*, every one of which has in itself the perfect characters of life. . . . The higher organism, the individual, is always the result of a sort of social organization, of the union of sundry elements combined; it is a mass of individual existences, dependent on each other, though their dependence is such that each element has its own proper activity; so that, whatever impulse or excitation other parts may give to the element, the resulting function nevertheless emanates from the element itself, and is its own."

The question as to how living bodies are produced gave rise, a few years ago, to discussions which have again brought to the surface a doctrine which was supposed to have been disproved two hundred years since, and which reappeared in the last century only to be assailed with Voltaire's sarcasms. I mean the theory of spontaneous generation, so called—a self-contradictory phrase, by which it was intended to assert that organisms are produced out-and-out without the aid of parents resembling them. While admitting that generation, sexual or asexual, is the mode of reproduction found among animals possessed of complex structure, the partisans of spontaneous generation held, on the strength of their experiments, that certain very low organisms might be developed spontaneously, without specific germs, in infusions of organic substances. But though in this dispute experiment has given no definitive verdict—nor, indeed, was such verdict to be expected—still, all the probabilities are on the side of those who assert the universality of generation by means of germs developed in the parents; and, in the absence of experimental demonstration, we are not without theoretic arguments against the spontaneous generation of the comparatively high organisms developed in infusions. If this doctrine is to be retained, it is not for the purpose of explaining the formation of organisms, a thing well enough explained without it, but in order to account for the production of really primitive living things—i. e., for the appearance of life in a fraction of organic substance, whether this is still possible in our day, or whether it was possible only at a time when, under conditions unknown to us, organic substance originated upon the earth. Thus stated, the question does not depend on experimentation; it becomes a mere exercise of the imagination, and the result is valueless.

Whatever is to be thought of the theory of the beginnings of life, one or more *first* living beings having appeared upon the earth, after the latter had become capable of supporting them, the question arises as to the transition from the primitive simplicity to the enormous degree of variety now existing. Here we have the problem of the origin of species, which is solved by the theory of descent, sometimes denominated transformism. The old conception of living Nature as an infinitely varied assemblage of organisms which faithfully copy certain types, all of whose parts are governed by the law of final causes, in our time gives way, not without a fierce struggle, before a new conception, which represents living Nature as an infinitely varied assemblage of organisms which are ever varying under the influence of external circumstances, while under the influence of heredity they tend to fix in a type the results of previous variations. At one time we have, as in breeding, artificial selection; at another time, as among people who have not yet discovered the laws of breeding, a selection that, though unsystematic, is none the less real; finally in Nature, without human intervention, a selection based simply on the conditions of existence. In natural selection, the action of which is by far the most general and powerful, the fixing of variations results from adaptation to the existing conditions. This adaptation finds expression in the *survival of the fittest* in the struggle for life; that is to say, those individuals continue to live and reproduce their kind whose structure enables them to undergo changed conditions without succumbing, while others, because they cannot adapt themselves, perish, leaving no posterity, no trace of their having ever existed, save, perhaps, in the geological strata of their epoch. The special advantage which has once insured the survival of an organism, while its congeners which possessed no such advantage perished, is fixed by heredity; it grows under the influence of that same law of survival which insures the upper-hand in the struggle for life to the organisms possessing the advantage in the highest degree; in virtue of the law of the coördination and subordination of parts and functions, it brings about in the whole organism very extensive modifications which insure its fixity; and the sum total of the new characters becomes sufficiently stable to convey to the mind which observes it the impression of the persistence of forms and the existence of types, whereas in fact there exist only changes amid which there remain, in virtue of the law of heredity, traits of resemblance to a common ancestor or stock.

Such are, in brief, the principal laws of biological phenomena, and the chief theories which have been devised for the purpose of assigning to them causes. When, in order to establish or to impugn laws and theories so far-reaching as these, we can have recourse to direct experiment and observation, the mind is satisfied and its certitude reposes on an immovable basis. But when a theory has to do with origins in the remote past, or even in the present, but inaccessible to experiment, our certitude rests on no solid foundation. In the absence of experiment, we have to be content with opinions formed according to the rules of induction and of analogy, and possessing more or less probability. Among views of this sort, those appear to have greatest weight which, in their contexture and in the method of their formation, are most in harmony with those beliefs of which we are most certain; which rest on the same general principles; which, so to speak, are incorporated with our beliefs, so that, were they to succumb to criticism, their fall would compromise the entire system. In other words, they must occupy their own place in a general philosophy, there appearing as so many links in a chain attached, on the one hand, to laws and theories which account for them, and, on the other, to laws and theories which without them cannot be explained.

Could we look for this result from the only general system of philosophy which has existed down to the present day? Having been written at a time when the science of life had for its generalizations only conclusions from Bichat's researches, the hypotheses of Gall, and the results of classification, that portion of the positive philosophy which treats of biology is too far behind the actual state of science to serve as its guide; yet, owing to the largeness of the views there expressed, Auguste Comte gave to this work a comprehensiveness which enabled it to take in some of the great biological systems elaborated in recent times, and one of his followers has recently declared that the success of these doctrines does not impair the unity of the positive philosophy. It can also be truly said that, if those doctrines were to succumb, the positive philosophy would suffer no loss; and this proves that they have no connection with this philosophy, and that they can receive no support from it. Still, in spite of this serious shortcoming of his philosophy, the services rendered by Auguste Comte are very great. He has given a better definition of life than the one then in vogue; he has perceived that life is a continuous chain of chemical facts, and to this doctrine he has given forcible expression; he has illustrated, by judicious contrast, the relations of the organism to the medium in which it lives; he has stated with great precision the problem of the science of life, which consists in expressing in the least number of laws of the utmost generality the harmony which unites the organism to its medium by vital acts; he has forcibly shown the close correlation which enables us to infer the function from the organ, and *vice versa;* not to speak of a multitude of useful and profound considerations upon the structure of living bodies, on comparative anatomy, and on the physiology of the functions of relation. But it was characteristic of Auguste Comte's philosophy to bind together the parts of its system only by a purely logical tie, and not at all by establishing relations between the phenomena, or by showing interdependency of laws. For him it was enough, in order to assure to biology its place between physico-chemistry and sociology, if on the one hand a knowledge of physical and chemical laws is necessary for the study of biological phenomena, and if the various classes of phenomena pertaining to these sciences really act a part in the production of vital phenomena; and if, on the other hand, a knowledge of the life of relation in its highest aspects, i. e., in the cerebral apparatus, and the elementary intellectual and passional faculties corresponding thereto, is an essential preliminary of the study of sociology. Hence, the biological work of Auguste Comte has not *per se* had any great influence on researches of this kind. The general current of his philosophy has exerted a good influence in so far as it has disinclined men toward theological and metaphysical explications. But we cannot admit that Comte has founded a philosophy of biology fitted to inspire or to guide research. Biological research is still what it was before the positive philosophy became popular; it is still restricted to special points; and, though its spirit is becoming more and more positive, the reason is because in such research the imagination is brought more and more under subjection to the laws of scientific investigation. But, meanwhile, we see no indications of philosophic purpose, no aiming to bring the results obtained under the dominion of a more comprehensive law.

It appears to us that, if a philosophy is to assume this *rôle* and to undertake the guidance of man's thought and action, it must bring forward general principles of such breadth that they will apply to all orders of phenomena, from the simplest to the most complex—a system of laws coördinated by deductive relations, and by its universality expressing all the phenomena of the universe. Whether these general principles are given *a priori*, as the intuitionists hold, or whether they are the abstract expression of an experience invariably and unconditionally repeated, at all events they must be such that from them all our scientific theories may be deduced; they must appear in all our researches as the criterion of the truth of the results, and they must underlie all our anticipations of truth as the guiding principles. Causes, that is to say, the sum of the antecedent phenomena, whose joint action is necessary for the production of the consequent phenomenon, or effect, may be as diverse as you please, nevertheless their relation to their effect will be expressed by the same general law.

A philosophy of biology must reduce under these principles of philosophy all the truths furnished by experience in the various branches of investigation pertaining to that science; must explain them by these principles; must present them to us as necessary, and the contrary results as illogical and unphilosophical, so as to produce a twofold effect, viz., the highest possible harmony in the system of our knowledges, and an ever-strengthening confirmation of the general principles which are their abstract expression. We must demand of it a verdict upon doctrines respecting the constitution of the living individual and its origin and the constitution of the species to which the individual belongs, which verdict shall oblige us to accept these doctrines as corollaries of the same general principles from which the accepted theories of the other abstract sciences are likewise deduced. Finally, we must derive from this philosophy of biology the assurance that the generalizations which it offers to us are grounds upon which we can stand securely in our deductions—of course within the province of biology—respecting man and the human species.

Mr. Herbert Spencer attempts something like this when he rests the laws of biology upon the theory of changes in the course of things, as set forth in his "First Principles." The "Principles of Biology" is the first application of his system of philosophy to a highly-complex order of phenomena.

It will be well to give a sketch of Mr. Spencer's whole system, so that we may better understand the meaning of the abstract terms he employs, and the relations between the general laws on which the system is based. We shall thus be in a position to appreciate the author's application of his system to the more restricted field of biology.

Underlying Spencer's system we find the principle of the persistence of force, "the sole truth which transcends experience," to which "an ultimate analysis brings us down," and on which "a rational synthesis must build up." From this first principle come as consequences two correlative principles, viz.: uniformity of law, which is simply the persistence of the relations between forces, manifested under identical forms and conditions; and the principle of the equivalence of forces, inductively established within the last twenty years. The researches which resulted in the establishment of this principle rest implicitly on the persistence of force, inasmuch as they measure all the precedent forces, which have disappeared, and all the consequent forces, which have been produced, by the aid of a unit supposed to be constant. If we add two other corollaries, the one relating to the direction of motion in the line of least resistance, the other to the form of motion, which is always rhythmic, we have, with the principles of the continuousness of motion and of the indestructibility of matter (these representing under two correlative forms the principle of the persistence of force), the sum total of the primary truths which serve as a basis for knowledge in general. But these principles, however general, are only analytical truths; though they are essential to a philosophy, they do not constitute a philosophy. They are the laws of the action of forces separately considered. The universal synthesis which is to constitute philosophy must express the total operation accomplished by the coöperation of these factors. The law which shall formulate this synthesis must be a law of the changes in forces under the two phases, matter and motion, by which they are manifested to us: it must be a principle of dynamics holding good both for the whole of the cosmos, and for its every detail. The changes of an object are all produced by new arrangements of the matter constituting it, and by a new distribution of the forces which belong to it. Their necessary direction is given in evolution in virtue of two principles, both of them corollaries of the primary principle of the persistence of force: the law of the instability of the homogeneous and the law of the multiplication of effects.

Every body tends to pass into a more heterogeneous state, because each of the units that constitute it is of necessity differently affected from the others by the combined action of the others upon it; because the resulting difference places each unit in different relations with the incident forces; finally, because these units, owing to their respective positions, cannot all receive the action of an external force in the same direction and with the same intensity. This law, which accounts for the commencement of the changes, accounts also for its continuance.

At the same time a uniform external force, acting on a body, is there dispersed; acting on unlike parts, it breaks up into forces differing in quality and intensity in proportion to the number and diversity of these parts. The same is to be said of each fraction of the force; the process of dispersion goes on increasing, and the result is expressed by the law of the multiplication of effects.

By another law, flowing from the same primary principle, the parts of a whole diverge from one another in proportion to their diversity, and group themselves together in proportion to their resemblances. Motions that are alike in direction or intensity, acting on these parts, drive them in the same direction, and with the same velocity, whence results an *integration* of these parts, while those driven by motions unlike in direction or intensity go in different directions with different velocities, separate from one another, are *disintegrated.* This is the law of segregation, the application of which brings into prominence the heterogeneous character of the products of change, by giving to their heterogeneity a clearer and more definite nature.

Finally, we note another consequence of the persistence of force. Every change in an aggregation of sensible parts is conditioned by opposing forces, the one representing action, the other reaction; the one the tendency to change, the other resistance; their antagonism can end only when equilibrium has been established, by the dissipation of the excess of the one force over the other. A body subject to any disturbance whatever, owing to a modification of its circumstances, tends toward equilibrium with its new circumstances; and, as the different forces acting on it have not the same intensity, those which are weaker soon find their equilibrium, while those which are stronger continue to give motion to the body, and then the latter presents the spectacle of an aggregate whose parts are in an invariable ratio to each other, while the total aggregate is ever changing its relations to external objects. This is *equilibrium mobile*, unstable equilibrium, and it serves as a transition to a more perfect equilibrium, or else to a renewal of the internal movements which have already found equilibrium.

The action of these laws of change of objects and their parts leads to two contrary results, according to the mode of distribution of the forces in action. We have evolution, i. e., change with integration of matter, dissipation of internal motion, increase of the number and diversity of the parts, whenever the external forces are not such as to break the bond which unites them; we have dissolution, continuous or discontinuous, i. e., a change with disaggregation of matter; absorption of motion (which, becoming internal, drives the constituent units with greater velocity) and diminution both of the numbers and of the diversity of the parts, whenever the external forces are sufficiently intense to destroy the cohesion of the aggregate and to restore to its parts their original independence.

The work of Mr. Spencer in his "Biology" consists in referring to these general laws the generalizations obtained in the various parts of the domain of biology, and in discerning those which possess the character of necessity. This course has the twofold advantage of giving to these generalizations greater authority, and of introducing into a coördinated system of philosophy the science whose generalized truths they are. The "Principles of Biology" is thus an attempt to explain the phenomena called vital, by general laws common to phenomena of every kind.

[*To be continued.*]

# LESSONS IN ELECTRICITY.[1]

## HOLIDAY LECTURES AT THE ROYAL INSTITUTION.

By Professor TYNDALL, F.R.S.

I.

SECTION 1. *Introduction.*—Many centuries before Christ, it had been observed that yellow amber (*elektron*) when rubbed possessed the power of attracting light bodies. Thales, the founder of the Ionic philosophy (B. C. 580), imagined the amber to be endowed with a kind of life.

This is the germ out of which has grown the science of *electricity*, which takes its name from the substance in which this power of attraction was first observed.

It will be my aim, during six hours of these Christmas holidays, to make you, to some extent, acquainted with the history, facts, and principles, of this science, and to teach you how to work at it.

The science has two great divisions; the one called "Frictional Electricity," the other "Voltaic Electricity." For the present, our studies will be confined to the first, or older portion of the science, which is called "Frictional Electricity," because in it the electrical power is obtained from the rubbing of bodies together.

SEC. 2. *Historic Notes.*—The attraction of light bodies by rubbed amber was the sum of the world's knowledge of electricity for more than 2,000 years. In 1600 Dr. Gilbert, physician to Queen Elizabeth, whose attention had been previously directed with great success to magnetism, vastly expanded the domain of electricity. He showed that not only amber, but various spars, gems, fossils, stones, glasses, and resins, exhibited when rubbed the same power as amber.

Robert Boyle (1675) proved that a suspended piece of rubbed amber, which attracted other bodies to itself, was in turn attracted by a body brought near it. He also observed the *light* of electricity, a diamond, with which he experimented, being found to emit light when rubbed in the dark.

Boyle imagined that the electrified body threw out an invisible, glutinous substance, which laid hold of light bodies, and, returning to the source from which it emanated, carried them along with it.

[1] A course of six lectures, with simple experiments in frictional electricity, before juvenile audiences during the Christmas holidays.

Otto von Guericke, Burgomaster of Magdeburg, contemporary of Boyle, and inventor of the air-pump, intensified the electric power previously obtained. He devised what may be called the first electrical machine, which was a ball of sulphur, about the size of a child's head. Turned by a handle and rubbed by the dry hand, the sulphur-sphere emitted light in the dark.

Von Guericke also noticed that a feather, having been first attracted toward his sulphur globe, was afterward repelled, and kept at a distance from it, until, having touched another body, it was again attracted. He also heard the hissing of the "electric fire," and observed that a body, when brought near his excited sphere, became electrical and capable of being attracted.

The members of the Academy del Cimento examined various substances electrically. They proved smoke to be attracted, but not flame, which, they found, deprived an electrified body of its power.

They also proved liquids to be sensible to the electric attraction, showing that when rubbed amber was held over the surface of a liquid, a little eminence was formed, from which the liquid was finally discharged against the amber.

Sir Isaac Newton, by rubbing a flat glass, caused light bodies to jump between it and a table. He also noticed the influence of the rubber in electric excitation. His gown, for example, was found to be much more effective than a napkin. Newton imagined that the excited body emitted an elastic fluid which penetrated glass.

Dr. Wall (1708) experimented with large, elongated pieces of amber. He found wool to be the best rubber of amber. "A prodigious number of little cracklings" was produced by the friction, every one of them being accompanied by a flash of light. "This light and crackling," says Dr. Wall, "seem in some degree to represent thunder and lightning."[1] This is the first published allusion to thunder and lightning in connection with electricity.

Stephen Gray (1729) also observed the electric brush, snappings, and sparks. He made the prophetic remark, that "though these effects are at present only minute, it is probable that in time there may be found out a way to collect a greater quantity of the electric fire, and, consequently, to increase the force of that power which by several of those experiments, if we are permitted to compare great things with small, seems to be of the same nature with that of thunder and lightning."[2]

Sec. 3. *The Art of Experiment.*—We have thus broken ground with a few historic notes, intended to show the gradual growth of electrical science. Our next step must be to get some knowledge of the facts referred to, and to learn how they may be produced and extended. The art of producing and extending such facts, and of inquiring into them by proper instruments, is the *art of experiment.*

[1] "Philosophical Transactions," 1708, p. 69.

[2] Ibid., vol. xxxix., p. 24.

It is an art of extreme importance, for by its means we can, as it were, converse with Nature, asking her questions and receiving from her replies.

It was the neglect of experiment, and of the reasoning based upon it, which kept the knowledge of the ancient world confined to the attraction of amber for more than 2,000 years.

Skill in the art of experimenting does not come of itself, it is only to be acquired by labor. When you first take a billiard-cue in your hand, your strokes are awkward and ill-directed. When you learn to dance, your first movements are neither graceful nor pleasant. By *practice* alone, you learn to dance and to play. This also is the only way of learning the art of experiment. You must not, therefore, be daunted by your clumsiness at first; you must overcome it, and acquire skill in the art *by repetition.*

By so doing you will come into direct contact with natural truth—you will think and reason not on what has been said to you in books, but on what has been said to you by Nature. Thought springing from this source has a vitality not derivable from mere book-knowledge.

Sec. 4. *Materials for Experiment.*—At this stage of our labors we are to provide ourselves with the following materials:

*a.* Some sticks of sealing-wax.

*b.* Two pieces of gutta-percha tubing, about eighteen inches long and three-quarters of an inch outside diameter.

*c.* Two or three glass tubes, about eighteen inches long and three-quarters of an inch wide, closed at one end, and not too thin, lest they should break in your hand and cut it.

*d.* Two or three pieces of clean flannel, capable of being folded into pads of two or three layers, about eight or ten inches square.

*e.* A couple of pads, composed of three or four layers of silk, about eight or ten inches square.

*f.* A board about eighteen inches square, and a piece of India-rubber.

*g.* Some very narrow silk ribbon, and a wire loop, like that shown in Fig. 1, in which sticks of sealing-wax, tubes of gutta-percha, rods of glass, or a walking-stick, may be suspended. I choose a narrow ribbon because it is convenient to have a suspending cord that will neither twist nor untwist of itself.

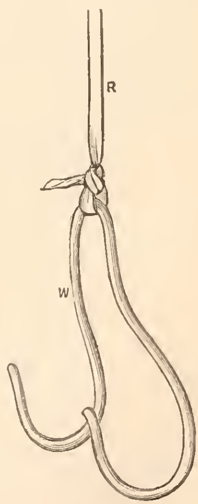

Fig. 1.

I usually employ a loop with the two ends, which are here shown free, soldered together. The loop would thus be unbroken. But you may not be skilled in the art of soldering, and I therefore choose the free loop, which is very easily constructed.

For the purpose of suspension an arrangement resembling a towel-horse, with a single horizontal rail, will be found convenient.

*h.* A straw, *I I′*, Fig. 2, delicately supported on the point of a sewing-needle *N*, inserted in a stick of sealing-wax *A*, attached below to a little circular plate of tin. In Fig. 3 the straw is shown on a

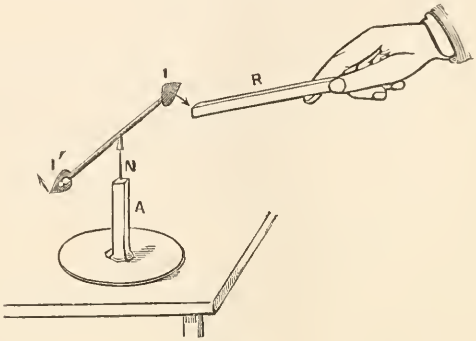


Fig. 2.

larger scale, and separate from its needle. The short bit of straw in the middle, which serves as a cap, is stuck on by sealing-wax.

*i.* The name of "amalgam" is given to a mixture of mercury with other metals. Experience has shown that the efficacy of a silk rubber is vastly increased when it is smeared over with an amalgam formed of one part by weight of tin, two of zinc, and six of mercury. A little lard is to be first smeared on the silk, and the amalgam is to be applied to the lard. The amalgam, if hard, must be pounded or bruised with a pestle or a hammer until it is soft. You can purchase sixpennyworth of it at a philosophical-instrument maker's. It is to be added to your materials.

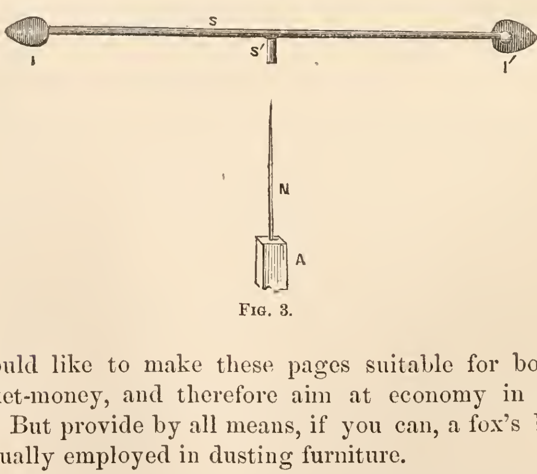


Fig. 3.

*k.* I should like to make these pages suitable for boys without much pocket-money, and therefore aim at economy in my list of materials. But provide by all means, if you can, a fox's brush, such as those usually employed in dusting furniture.

Sec. 5. *Electric Attractions.*—Place your sealing-wax, gutta-percha tubing, and flannel and silk rubbers before a fire, to insure their dryness. Be specially careful to make your glass tubes and silk rubbers not only warm, but hot. Pass the dried flannel briskly once or twice over a stick of sealing-wax or over a gutta-percha tube. A very small amount of friction will excite the power of attracting the suspended straw, as shown in Fig. 2. Repeat the experiment several times and cause the straw to follow the attracting body round and round. Do the same with a glass tube rubbed with silk.

I lay particular stress on the heating of the glass tube, because glass has the power, which it exercises, of condensing upon its surface, into a liquid film, the aqueous vapor of the surrounding air. This film must be removed.

I would also insist on practice, in order to render you expert. You will, therefore, attract bran, scraps of paper, gold-leaf, soap-bubbles, and other light bodies, by rubbed glass, sealing-wax, and gutta-percha. Faraday was fond of making empty egg-shells, hoops of paper, and other light objects, roll after his excited tubes.

It is only when the electric power is very weak that you require your delicately-suspended straw. With the sticks, tubes, and rubbers here mentioned, even heavy bodies, when properly suspended, may be attracted. Place, for instance, a common walking-stick in the wire loop attached to the narrow ribbon, Fig. 1, and let it swing horizontally. The glass, rubbed with its silk, or the sealing-wax, or gutta-percha, rubbed with its flannel, will pull the stick quite round.

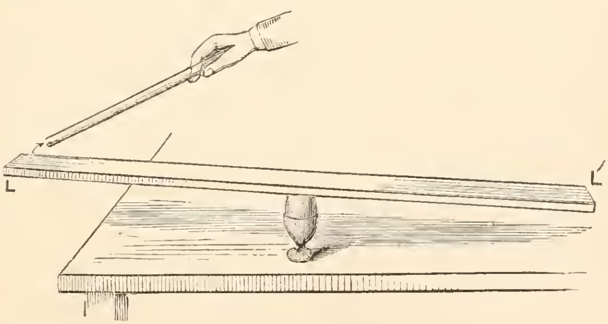


Fig. 4.

Abandon the wire loop; place an egg in an egg-cup, and balance a long lath upon the egg, as shown in Fig. 4. The lath, though it may be almost a plank, will obediently follow the rubbed glass, gutta-percha, or sealing-wax.

Nothing can be simpler than this lath and egg arrangement, and hardly any thing could be more impressive. The more you work with it, the better you will like it.

Pass an ebonite comb through the hair. In dry weather it produces a crackling noise; but its action upon the lath may be made plain in any weather. It is rendered electrical by friction against the hair, and with it you can pull the lath quite round.

If you moisten the hair with oil, the comb will still be excited and exert attraction; but, if you moisten it with water, the excitement ceases; a comb passed through wetted hair has no power over the lath.

After its passage through dry or oiled hair, balance the comb itself upon the egg; it is attracted by the lath. You thus prove the attraction to be *mutual:* the comb attracts the lath, and the lath attracts the comb. Suspend your rubbed glass, rubbed gutta-percha, and rubbed sealing-wax in your wire loop. They are all just as much attracted by the lath as the lath was attracted by them. This is an extension of Boyle's experiment with the suspended amber.

How it is that the unelectrified lath attracts, and is attracted by the excited glass, sealing-wax, and gutta-percha, we shall learn by-and-by.

A very striking illustration of electric attraction may be obtained with the board and India-rubber mentioned in our list of materials. Place the board before the fire and make it *hot;* heat also a sheet of foolscap paper and place it on the board. There is no attraction between them. Pass the India-rubber briskly over the paper. It now clings firmly to the board. Tear it away, and hold it at arm's length, for it will move to your body if it can. Bring it near a door or wall, it will cling tenaciously to either. The electrified paper also powerfully attracts the balanced lath from a great distance.

The friction of the hand, of a cambric handkerchief, or of wash-leather, fails to electrify the paper in any high degree. It requires friction by a special substance to make the excitement strong. This we learn by experience. It is also experience that has taught us that resinous bodies are best excited by flannel, and vitreous bodies by silk.

Take nothing for granted in this inquiry, and neglect no effort to render your knowledge complete and sure. Try various rubbers, and satisfy yourself that differences like that first observed by Newton exist between them.

Lay bare, also, the true influence of heat in our last experiment. Spread a cold sheet of foolscap on a cold board—on a table, for example. If the air be not very dry, rubbing, even with the India-rubber, will not make them cling together. But is it because they were *hot* that they attracted each other in the first instance? No, for you may heat your board by plunging it into boiling water, and your paper by holding it in a cloud of steam. Thus heated they cannot be made to cling together. The heat really acts by expelling the moisture. Cold weather, if it be only dry, is highly favorable to electric excitation. During the late frost the whisking of the hand over silk or flannel, or over a cat's back, would have rendered it electrical.

The experiment of the Florentine academicians, whereby they proved the electric attraction of a liquid, is pretty, and worthy of repetition. Fill a very small watch-glass with oil, until the liquid forms a round curved surface, rising a little over the rim of the glass. A strongly excited glass tube, held over the oil, raises not one eminence only, but several, each of which finally discharges a shower of drops against the attracting glass.

Cause the excited glass tube to pass close by your face, without touching it. You feel, like Hauksbee, as if a cobweb were drawn over the face. You also sometimes smell a peculiar odor, due to a substance developed by the electricity, and called ozone.

Long ere this, while rubbing your tubes, you will have heard the "hissing" and "crackling" so often referred to by the earlier electricians; and, if you have rubbed your glass tube briskly in the dark, you will have seen what they called the "electric fire." Using, instead of a tube, a tall glass jar, rendered hot, a good warm rubber, and vigorous friction, the streams of electric fire are very surprising in the dark.

Sec. 6. *Discovery of Conduction and Insulation.*—Here I must again refer to that most meritorious philosopher, Stephen Gray. In 1729, he experimented with a glass tube stopped by a cork. When the tube was rubbed, the cork attracted light bodies. Gray states that he was "much surprised" at this, and he "concluded that there was certainly an attractive virtue communicated to the cork." This was the starting-point of our knowledge of electric conduction.

A fir-stick four inches long, stuck into the cork, was also found by Gray to attract light bodies. He made his sticks longer, but still found a power of attraction at their ends. He then passed on to packthread and wire. Hanging a thread from the top window of a house, so that the lower end nearly touched the ground, and twisting the upper end of the thread round his glass tube, on briskly rubbing the tube, light bodies were attracted by the lower end of the thread.

But Gray's most remarkable experiment was this: He suspended a long hempen line horizontally by loops of packthread, but failed to transmit through it the electric power. He then suspended it by loops of silk and succeeded in sending the "attractive virtue" through 765 feet of thread. He at first thought the silk was effectual because it was thin; but, on replacing a broken loop by a still thinner wire, he obtained no action. Finally, he came to the conclusion that his loops were effectual, not because they were thin, but because they were *silk*. This was the starting-point of our knowledge of insulation.

It is interesting to notice the devotion of some men of science to their work. Dr. Wells finished his beautiful essay on "Dew" when he was on the brink of the grave. Stephen Gray was so near dying, when his last experiments were made, that he was unable to write out an account of them. On his death-bed, and indeed the very day before his death, his description of them was taken from his lips by Dr. Mortimer, secretary of the Royal Society.

One word of definition will be useful here. Some substances, as proved by Stephen Gray, possess in a very high degree the power of permitting electricity to pass through them; other substances stop the passage of the electricity. Bodies of the first class are called *conductors;* bodies of the second class are called *insulators.*

We cannot do better than repeat here the experiments of Gray. Push a cork into the open end of your glass tube; rub the tube, carrying the friction up to the end holding the cork. The cork will attract the balanced lath, shown in Fig. 4, with which you have already worked so much.

But the excited glass is here so near the end of the cork that you may not feel certain that the observed attraction is that of the cork. You can, however, prove that the cork attracts by its action upon light bodies which cling to it. Stick a pen-holder into the cork, and rub the glass tube as before. The free end of the holder will attract the lath. Stick a deal rod three or four feet long into the cork, even its free end will attract the lath when the glass tube is excited. In this way, you prove to demonstration that the electric power is conveyed along the rod.

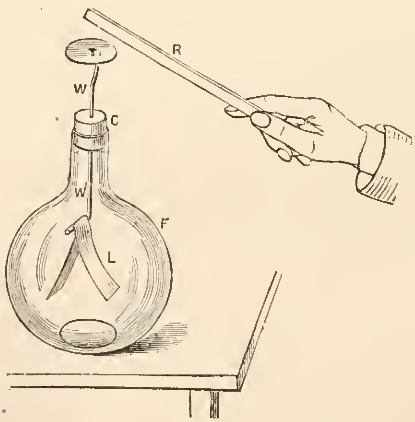


Fig. 5.

Sec. 7. *Further Inquiries on Conduction and Insulation.*—A little addition to our apparatus will now be desirable. You can buy a book of "Dutch metal" for fourpence, and a globular flask like that shown in Fig. 5 for sixpence, or at the most a shilling. Find a cork, *C*, which fits the flask; pass a wire, *W*, through the cork, and bend it near one end at a right angle. Stick by sealing-wax upon the other end of the wire a little plate of tin or sheet-zinc, *T*, about two inches in diameter. Attach, also, by means of wax to the bent arm, which ought to be about three-quarters of an inch long, two strips, *I*, of the Dutch metal about three inches long and from half an inch to three-quarters of an inch wide. The strips will hang down face to face, in contact with each other. In all cases you must be careful so to use your wax as not to interrupt the metallic connection of the various parts of your apparatus, which we will name an *electroscope.* Gold-leaf, instead of Dutch metal, is usually employed for electroscopes. I recommend the "metal" because it is less frail, and will stand rougher usage.

See that your globular flask is dry and free from dust. Bring your rubbed sealing-wax, *R*, or your rubbed glass, *near* the little plate of tin, the leaves of Dutch metal open out; withdraw the excited body, the leaves fall together. We shall inquire into the cause of this action immediately. Practise the approach and withdrawal for a little time. Now draw your rubbed sealing-wax or glass along the edge of the tin plate, *T.* The leaves diverge, and after the sealing-wax or glass is withdrawn they remain divergent. In the first experiment you communicated no electricity to the electroscope; in the second experiment you did. At present I will only ask you to take the opening out of the leaves as a proof that electricity has been communicated to them.

And now we are ready for Gray's experiments in a form different from his. Connect the end of a long wire with the tin plate of the electroscope; coil the other end round your glass tube. Rub the tube briskly, carrying the friction close to the coiled wire. A single stroke of your rubber, if skillfully given, will cause the leaves to diverge. The electricity has obviously passed through the wire to the electroscope.

Substitute for the wire a string of common twine, rub briskly, and you will cause the leaves to diverge; but there is a notable difference as regards the promptness of the divergence. You soon satisfy yourself that the electricity passes with greater facility through the wire than through the string. Substitute for the twine a string of silk. No matter how vigorously you rub you can now produce no divergence. The electricity cannot get through the silk at all.[1]

Mr. Cottrell, who has been recently working very hard for you and me, has devised an electroscope which we shall frequently employ in our lessons. *M*, Fig. 6, is a little plate of metal, or of wood covered with tin-foil, supported on a rod of glass or of sealing-wax. *N* is another plate of Dutch metal paper, separated about an inch from *M*. *N I* is a long straw (broken off in the figure), and *A A′* is

[1] It is hardly necessary to point out the meaning of Gray's experiment where he found that, with loops of wire or of packthread, he could not send the electricity from end to end of his suspended string. Obviously the electricity escaped in each of these cases through the conducting support to the earth.

a pivot formed by a sewing-needle, and supported on a bent strip of metal, as shown in the figure. By weighting the straw with a little wire near *N*, you so balance it that the plate *N* shall be just lifted away from *M*. The wire *w*, which may be 100 feet long, proceeds from *M* to your glass tube, round which it is coiled. A single vigorous stroke of the tube by the rubber sends electricity along *w* to *M*;

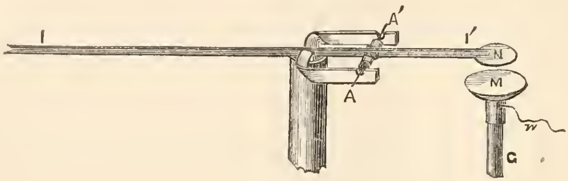


Fig. 6.

*N* is attracted downward, the other end of the long straw being lifted through a considerable distance. In subsequent figures you will see the complete straw-index, and its modes of application.

A few experiments with either of these instruments will enable you to classify bodies as conductors, semi-conductors, and insulators. Here is a list of a few of each, which, however, differ much among themselves:

*Conductors.*

The common metals. Solutions of salts.
Well-burned charcoal. Rain-water.
Concentrated acids. Linen.
Living vegetables and animals.

*Semi-conductors.*

Alcohol and ether. Marble.
Dry wood. Paper.
Straw.

*Insulators.*

Fatty oils. Silk.
Chalk. Glass.
India-rubber. Wax.
Dry paper. Sulphur.
Hair. Shellac.

This is the place to demonstrate, in a manner never to be forgotten, the influence of moisture. Assure yourself that your dry silk string insulates. Wet it throughout, and squeeze it a little, so that the water from it may not trickle over your glass tube. Coil it round the tube as before, and excite the tube. The leaves of the electroscope immediately diverge. The *water* is here the conductor. The influence of moisture was first demonstrated by Du Fay (1733 to

1737), who succeeded in sending electricity through 1,256 feet of moist packthread.

A little reflection will enable you to vary these experiments indefinitely. Rub your excited sealing-wax or glass against the tin plate of your electroscope, and cause the leaves to diverge. Touch the plate with any one of the conductors mentioned in the list; the electroscope is immediately discharged. Touch it with a semi-conductor; the leaves fall as before, but less promptly. Touch the plate finally with an insulator; the electricity cannot pass, and the leaves remain unchanged.

# NATURAL EUTHANASIA.[1]

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

By the strict law of Nature a man should die as unconscious of his death as of his birth.

Subjected at birth to what would be, in the after-conscious state, an ordeal to which the most cruel of deaths were not possibly more severe, he sleeps through the process, and only upon the subsequent awakening feels the impressions, painful or pleasant, of the world into which he is delivered. In this instance the perfect law is fulfilled, because the carrying of it out is retained by Nature herself: human free-will and the caprice that springs from it have no influence.

By the hand of Nature death were equally a painless portion. The cycle of life completed, the living being sleeps into death when Nature has her way.

This purely painless process, this descent by oblivious trance into oblivion, this natural physical death, is the true enthanasia; and it is the duty of those we call physicians to secure for man such good health as shall bear him in activity and happiness onward in his course to this goal. For euthanasia, though it be open to every one born of every race, is not to be had by any save through obedience to those laws which it is the mission of the physician to learn, to teach, and to enforce. Euthanasia is the sequel of health, the happy death engrafted on the perfect life.

When the physician has taught the world how this benign process of Nature may be secured, and the world has accepted the lesson, death itself will be practically banished; it will be divested equally of fear, of sorrow, of suffering. It will come as a sleep.

If you ask what proof there is of the possibility of such a consummation, I point to our knowledge of the natural phenomena of one

[1] From "Diseases of Modern Life," by Dr. B. W. Richardson, now in press of D. Appleton & Co.

form of dissolution revealed to us even now in perfect, though exceptional, illustration. We have all seen Nature, in rare instances, vindicating herself despite the social opposition to her, and showing how tenderly, how soothingly, how like a mother with her foot on the cradle, she would, if she were permitted, rock us all gently out of the world; how, if the free-will with which she has armed us were brought into accord with her designs, she would give us the riches, the beauties, the wonders of the universe for our portion so long as we could receive and enjoy them; and at last would gently withdraw us from them, sense by sense, with such imperception that the pain of the withdrawal would be unfelt and indeed unknown.

Ten times in my own observation I remember witnessing, with attentive mind, these phenomena of natural euthanasia. Without pain, anger, or sorrow, the intellectual faculties of the fated man lose their brightness. Ambition ceases or sinks into desire for repose. Ideas of time, of space, of duty, lingeringly pass away. To sleep and not to dream is the pressing, and, step by step, still pressing need; until at length it whiles away nearly all the hours. The awakenings are short and shorter; painless, careless, happy awakenings to the hum of a busy world, to the merry sounds of children at play, to the sounds of voices offering aid; to the effort of talking on simple topics and recalling events that have dwelt longest on the memory; and then again the overpowering sleep. Thus on and on, until, at length, the intellectual nature is lost, the instinctive and merely animal functions, now no longer required to sustain the higher faculties, in their turn succumb and fall into the inertia.

This is death by Nature, and when mankind has learned the truth, when the time shall come—as come it will—that "there shall be no more an infant of days, nor an old man who hath not filled his days," this act of death, now, as a rule, so dreaded because so premature, shall, arriving only at its appointed hour, suggest no terror, inflict no agony.

The sharpness of death removed from those who die, the poignancy of grief would be almost equally removed from those who survive, were natural euthanasia the prevailing fact. Our sensibilities are governed by the observance of natural law and the breach of it. It is only when Nature is vehemently interrupted that we either wonder or weep. Thus the old Greeks, fathers of true mirth, who looked on prolonged grief as an offense, and attached the word madness to melancholy, even they were so far imbued with sorrow when the child or youth died, that they bore the lifeless body to the pyre in the break of the morning, lest the sun should behold so sad a sight as the young dead; while we, who court rather than seek to dismiss melancholy, who find poetry and piety in melancholic reverie, and who indulge too often in what, after a time, becomes the luxury of woe, experience a gradation of suffering as we witness the work of death. For the loss of the child and the youth we mourn in the perfect purity of sorrow; for the loss of the man in his activity, we feel grief mingled with selfish regret that so much that was useful has ceased to be. In the loss of the aged, in their days of second childishness and mere oblivion, we sympathize for something that has passed away, and for a moment recall events saddening to the memory; but how soon this consoling thought succeeds and conquers—that the race of the life that has gone was run, and that for its own sake the dispensation of its removal was most merciful and most wise!

To the rule of natural death there are a few exceptions. Unswerving in her great purposes for the universal good, Nature has imposed on the world of life her storms, earthquakes, lightnings, and all those sublime manifestations of her supreme power which, in the infant days of the universe, cowed the boldest and implanted in the human heart fears and superstitions which in hereditary progression have passed down even to the present generations. Thus she has exposed us all to accidents of premature death, but, with infinite wisdom, and as if to tell us that her design is to provide for these inevitable calamities, she has given a preponderance of number at birth to those of her children who by reason of masculine strength and courage shall have most frequently to face her elements of destruction. Further, she has provided that death by her, by accidental collision with herself, shall, from its very velocity, be freed of pain. For pain is a product of time. To experience pain the impression producing it must be transmitted from the injured part of the living body to the conscious centre, must be received at the conscious centre, and must be recognized by the mind as a reception; the last act being in truth the conscious act. In the great majority of deaths from natural accidents there is not sufficient time for the accomplishment of these progressive steps by which the consciousness is reached. The unconsciousness of existence is the first and last fact inflicted upon the stricken organism: the destruction is so mighty that the sense of it is not revealed.

The duration of time intended by Nature to extend between the birth of the individual and his natural euthanasia is undetermined, except in an approximative degree. From the first, the steady, stealthy attraction of the earth is ever telling upon the living body. Some force liberated from the body during life enables it, by self-controlled resistance, to overcome its own weight. For a given part of its cycle the force produced is so efficient that the body grows as well as moves by its agency against weight; but this special stage is limited to an extreme, say of thirty years. There is, then, another period, limited probably also to thirty years, during which the living structure in its full development maintains its resistance to its weight. Finally, there comes a time when this resistance begins to fail, so that the earth, which never for a moment loses her grasp, commences and continues to prevail, and after a struggle, extended from twenty to thirty years, conquers, bringing the exhausted organism, which has daily approached nearer and nearer to her dead self, into her dead bosom.

Why the excess of power developed during growth or ascent of life should be limited as to time; why the power that maintains the developed body on the level plain should be limited as to time; why the power should decline so that the earth should be allowed to prevail and bring descent of life, are problems as yet unsolved. We call the force that resists the earth vital. We say it resists death, we speak of it as stronger in the young than in the old; but we know nothing more of it really, from a physical point of view, than that while it exists it opposes terrestrial weight sufficiently to enable the body to move with freedom on the surface of the earth.

These facts we accept as ultimate facts. To say that the animal is at birth endowed with some reserved force, something over and above what it obtains from food and air, would seem a reasonable conclusion; but we have no proofs that it is true, save that the young resist better than the old. We must, therefore, rest content with our knowledge in its simple form, gathering from it the lesson that death, a part of the scheme of life, is ordained upon a natural term of life, is beneficently planned, "is rounded with a sleep."

## SKETCH OF HERBERT SPENCER.

HERBERT SPENCER was born in Derby, April 27, 1820. He comes of a race of pedagogues—his father, grandfather, and uncles, having followed the profession of teaching. He has written a book upon education, which some people think "theoretical;" but it was a product of experience, for he was himself subjected to much the same method as that he lays down in his work.

The father of Mr. Spencer was a gentleman of fine culture, of engaging manners, and enlightened views which he carried into practice as a teacher. He was strongly disinclined to the prevailing method of imparting knowledge and loading the memory with book acquisitions. He believed that true mental development can only come through self-instruction, and he constantly encouraged his pupils to find things out for themselves. He held it to be of great importance to foster independence and originality of thought. He hence aimed to arouse feelings of interest, curiosity, and love of inquiry in the minds of the young, and then leave them to solve their own problems. One of the objects he constantly sought to attain was to quicken and give scope to the constructive and inventive faculties. He was an excellent mathematician, but in dealing with this subject he sought to secure objects not usually recognized in the method of this study. He prepared for the use of beginners a little manual entitled "Inventional Geometry,"[1] consisting of questions and problems designed to familiarize the pupil with geometrical conceptions, and to exercise his inventive capacity in actual and accurate constructions with the use of simple instruments.

It was in this discreet way, never crowding or cramming, but kindling his interest and leaving him much to himself, that Mr. Spencer conducted the education of his son.

When Herbert was three years of age, his father's health having broken down, he was compelled to give up his school, and removed to Nottingham. He here entered into the manufacture of lace by machinery, which was just then the rage.

Herbert was the only surviving child, and his health was so delicate that his parents had little hope of raising him. As a lad his health was not strong, although he was not ill; his constitution being well balanced but not hardy. His father, fearing that he would give way under strain, did not press him to study. Three years were spent at Nottingham, in which the boy attended, for a short time, a common day-school kept by a mistress.

When Herbert was between six and seven the family returned to Derby, but Mr. Spencer did not resume his school; he took to private teaching. The lad did not read until he was seven. The first book to which he was attracted was "Sanford and Merton." When, afterward, he went to school, he was very inattentive and idle, having a repugnance to lesson-learning, and never reciting a lesson correctly that was learned by rote. He was, however, leniently dealt with, his father probably directing that he should not be urged. During boyhood he was greatly given to playing games, fishing, birds-nesting, country rambles, gathering wild fruits and mushrooms—all Saturday afternoons being turned to such purposes. Apart from school-studies, his father early led him into drawing, especially from objects. During this same period he encouraged him to keep insects through their transformations, and for years the finding and rearing of caterpillars, the catching and preserving of winged insects were constant and enjoyed occupations. He was also incited to make drawings of these insects. He rarely made friends of bigger boys, being intolerant of any thing like bullying. But his father mentions the fact in one of his letters that the younger boys were very fond of him; implying, perhaps, that while he would not be imposed upon by his elders, he did not bully his juniors. The latter part of his school-days at Derby was passed at a school set up by an uncle who, also having rational ideas of teaching, carried out his father's views. Among some dozen or so of boys he was characterized as backward in things requiring memory and recitation, but as in advance of the rest in in-

[1] Now in the press of D. Appleton & Co.

telligence. Drawing from objects was here continued. They had some experimental lessons in mechanics, and Herbert took to reading a good deal; Rollin's "Ancient History" and many miscellaneous books being gone through. He found a very varied literature in his father's house. Mr. Spencer, Sr., was Secretary of the Derby Philosophical Society, and also member of a Methodist book-committee. Besides many works of different kinds, there came various periodicals and magazines—the *Lancet*, the medical quarterlies, *Athenæum*, *Chambers's Journal*, volumes of travel, and occasionally graver works. All these he habitually looked into as a boy, picking up medical, mechanical, and various information. Mr. Spencer and his brothers, when they were together, habitually discussed all kinds of questions, political, ethical, religious, and scientific. All were liberal and independent thinkers—radicals when radicalism was unpopular. Both Mr. and Mrs. Spencer were brought up Methodists, but, during his boyhood, the father acquired so strong a repugnance toward the priestliness of the Methodist organization, that he early ceased to attend their services, and went to Quaker meeting—never adopting their peculiarities, but approving their unsacerdotal system. As his mother continued a Methodist, it resulted that on Sunday he went with his father in the morning, and with his mother in the evening. The enforced learning of hymns, and reading of chapters, at this time, produced a lasting repugnance to Scriptural language.

Mr. Spencer encouraged his son in all kinds of little constructive operations, as carpentering, the making of his own fishing-tackle, etc. Readiness in manipulation was thus cultivated. During this period, Mr. Spencer from time to time had at the house assemblies of his private pupils to witness electrical, mechanical, and air-pump experiments. In these Herbert always assisted, becoming thus familiar with the facts, explanations, and practical manipulations. At the same time he made chemical experiments. He is reported as being much in disgrace as a disobedient boy, always more or less in hot water, which led to desponding anticipations of his future.

At thirteen (1833) he was sent to his uncle, a clergyman, with whom he remained three years. This uncle, the Rev. Thomas Spencer, Rector of Hinton, was a cultivated scholar, who graduated with honors at Cambridge. He was a man of great liberality, advanced in his political views, broad in his theology, and the first clergyman of the Established Church to take a public and prominent part in the movement for the repeal of the corn-laws; having written and published extensively upon the subject. He will be remembered by some as having made a tour through this country some twenty-five years ago, delivering occasional lectures. His uncle was anxious that Herbert should prepare for the university, but he was disinclined to this, and the question was a matter of controversy between them. His uncle, however, lived to acknowledge that Herbert probably took the right view of the matter. Yet his prescribed studies were those which constitute the usual preparation for a university course. Latin and Greek, which had been taken up at Derby, though but to little purpose, were resumed at Hinton, but they were pursued without interest, and no satisfactory progress was made in them. But in mathematics the pupil made rapid advancement, being the equal or superior of fellow-students several years his seniors, who were studying with him. Geometry, trigonometry, algebra, mechanics, and the beginning of Newton's "Principia," were gone through. Though his memory was never a good one for details, yet it is noted that principles were habitually so seized as to remain. The tendency to independent exploration was shown in the spontaneous making of problems, and finding out new demonstrations. The discipline to which Herbert was subjected was here more decided than it had been at home. Yet during his stay at Hinton there were various accusations of disobedience which led to temporary disgrace.

At sixteen (1836) Herbert returned home, and one year was passed in miscellaneous but not very persistent study. He went through perspective with his father, on the principle of independent discovery; the successive problems being put in such order that he was enabled to find out the solutions himself. There was evidently a natural readiness here, as during this year he hit upon a curious theorem in descriptive geometry, which was afterward published with the demonstration in the *Civil Engineer's and Architect's Journal.*

At midsummer, 1837, after being a year at home, he had three months' experience in teaching, taking the place of assistant in the school to which he had first gone as a boy. His father had always been anxious that he should follow the profession of teacher, the dignity of which he estimated highly. This wish was strengthened by the success which he had in this trial, as he evinced a strong natural faculty for exposition, and the capacity of leading pupils to feel an interest in their lessons by the use of copious and correct illustrations.

In the autumn of that year, young Spencer was offered an engagement under Mr. Charles Fox (afterward Sir Charles Fox), a civil-engineer who had been a pupil of his father, and who subsequently became widely known as the builder of the Great Exhibition building of 1850. He was at that time resident engineer on the London & Birmingham Railway, then in process of construction. Here, partly in making surveys and drawings, he passed nearly a year, still carrying on his mathematical studies, and showing in his letters that inventions and improvements were much in his thoughts. In the autumn of 1838 he was recommended to Captain Moorsum, engineer of the Birmingham & Gloucester Railway. He took this place, and some eighteen months were passed in making engineers' drawings, and other railway works, with some contributions to the *Civil Engineer's Journal*, describing improved methods and constructions. Toward the end of this period he became for a time Captain Moorsum's engineering secretary, and during this time he devised the little instrument which he called the velocimeter, and described in the *Civil Engineer's Journal.* It was for the purpose of calculating, by mechanical means, the speeds of locomotive engines from given fractional distances and times, which otherwise required much trouble in estimating the velocity. Then followed a period of some six months occupied in out-door works, partly in superintending the completion of constructions, and partly in testing the performances of engines.

During this period he was led, by collecting fossils, into the study of geology, and read Sir Charles Lyell's "Principles," then recently published. The noteworthy fact respecting this is, that in it the doctrine of Lamarck respecting the development of species is there set forth, combated and rejected. Mr. Spencer cannot say whether he was before familiar with this doctrine, but he remembers that Lyell's arguments failed to disprove it to him, and he became, thereafter, a firm believer in the general idea that all organized beings had arisen by development (1839). He had so profound a belief in natural causation, in general so strong a tendency to see a unity of processes in things, that an hypothesis of this kind, which suggested that the genesis of organisms had arisen from physical actions, was one that he was prepared to accept as congruous with the system of things known by experience. Such a notion as that of miracle, utterly inharmonious with the ideas of cause and law and order which had become ingrained in him, was inadmissible, and hence the only alternative view presented itself to his mind as obviously necessary. Nothing ever afterward shook this belief. There naturally went along with this a gradual dropping of the current theology, although Mr. Spencer cannot say when it began or when it ended. The conception of the natural genesis of things gradually replaced the conception of the supernatural genesis, and belief in the prevailing creed gradually faded away.

In April, 1841, having declined the offer of an engineering appointment, Mr. Spencer returned home, intending to carry further his mathematical studies. Very little came of this intention, however, and some two years were spent at home in a miscellaneous and seemingly futile manner. Botany occupied his attention for some months. He made a botanical press and an herbarium. He practised drawing to some extent, and made pencil-portraits of various friends. Phrenology, of which he did not at that time see the fallacies, occupied some attention. All the time, however, he had in progress one or other scheme of invention. Improvements in watch-making, machines for making type by compression of the metal instead of casting, a printing-press of a new form, the application of the electrotype for engraving, afterward known as the glyptograph, occupied his attention. The great flood in Derby, in 1842, caused by the sudden overflow of a tributary of the Derwent, having occurred, Mr. Spencer wrote a detailed report upon it with proposals for remedy to the town council, which was printed by that body. The summer of that year was spent in a visit at Hinton, and while there he modeled a bust of his uncle, having during the previous year given some attention to that art. He also there commenced contributing to the *Nonconformist* a series of letters on the proper sphere of government. These were completed in the autumn. Shortly after there was commenced in England a movement called the complete-suffrage agitation, which arose out of a pamphlet published by the editor of the *Nonconformist*, Mr. Miall. In this agitation Mr. Spencer took an active part, becoming the local secretary for Derby, and he was afterward delegate to a conference at Birmingham, where a futile attempt was made to coöperate with the Chartists. In the spring of 1843 he went to London, with the vague idea of getting some literary occupation, and while there he made an engineering engagement, which lasted a few months till the work was complete. Returning then to Derby, he was again occupied chiefly with inventions. The railway mania, which was rising in 1844, drew him again to engineering, and he was for some months in charge of a London office, where he had at one time about sixty men under him. That winter and the subsequent spring were spent before parliamentary committees. But the lines in which he was interested failed to be chartered, and he then had much experience in legal proceedings, helping the engineer to recover his charges.

During 1846 and the beginning of 1847 he was occupied with inventions, and took out a patent for a sawing and planing machine, but, the friend who joined him in it going to India, the business dropped through. During these years he contributed papers to the *Philosophical Magazine* and to the *Zoöist*, in one of which he propounded a view respecting the nature of sympathy, which he afterward found that Adam Smith had previously proposed. In 1848 he commenced writing "Social Statics." In the autumn of that year he was engaged as the sub-editor of the *Economist*, and during 1849 and 1850 while occupying that post he completed the volume, his first considerable work, "Social Statics."

It is unnecessary to sketch here the intellectual labors of Mr. Spencer, as that has been already done with some degree of fullness in our pages.[1]

Much solicitude regarding the disturbed health of Mr. Spencer has been expressed by many who are interested in the progress of his work, and exaggerated rumors have been circulated respecting it. As we have said, his constitution was never robust, but it was sound in the earlier portions of his life. His health gave way when thirty-five years old, from intense application in writing "The Principles of Psychology," published in 1855. Since that time he has been incapable of steady mental application, and has been compelled frequently

[1] *See* Popular Science Monthly for November, 1874.

to suspend labor entirely for varying intervals to recover his working condition. When he entered upon his philosophical undertaking in 1860—laying out twenty years of original work—his health was so insecure that many thought the project foolhardy, and that it would prove fatal to him. But, forced by painful experience to economize his energies, he has become an adept in the art of taking care of himself; so that, instead of breaking down, his condition has perhaps improved with the progress of his work. He would probably never have been able to *write* the volumes of his philosophy, but in 1859 he adopted the expedient of dictation to an amanuensis, and attributes his power of going on to the immense economy and advantages of this practice. He has latterly not been so well as usual, for, though turning off a large amount of work on "The Principles of Sociology," and also carrying along the "Descriptive Sociology," both of which works are well advanced, he has yet been interrupted by more prolonged intervals of inability to labor. He has, besides, had to spend a great deal of his force in attention to business, which is not a very exhilarating occupation, as he has now sunk nearly $20,000 in the preparation and publication of his "Descriptive Sociology." He has, besides, had to maintain a burdensome correspondence, which growing at last intolerable, he has lately sought relief by lithographing the following form of a letter, which will explain itself:

"Mr. Herbert Spencer regrets that he must take measures for diminishing the amount of his correspondence.

"Being prevented by his state of health from writing more than a short time daily, he makes but slow progress with the work he has undertaken, and this slow progress is made slower by the absorption of his time in answering those who write to him. Letters inviting him to join committees, to attend meetings, or otherwise to further some public object; letters requesting interviews and autographs; letters asking opinions and explanations—these, together with presentation copies of books that have to be acknowledged, entail hindrances which, small as they may be individually, are collectively very serious—very serious, at least, to one whose hours of work are so narrowly limited.

"As these hindrances increase, Mr. Spencer finds himself compelled to do something to prevent them. After long hesitation, he has reluctantly decided to confine himself absolutely to the task which he is endeavoring to accomplish—to cut himself off from all engagements that are likely to occupy any attention, however slight, and to decline all correspondence not involved by his immediate work.

"To explain the absence of a special reply to each communication, he has adopted the expedient of lithographing this general reply; and he hopes that the reason given will sufficiently excuse him for not answering, in a more direct way, the letter of Mr. ——.

"37 QUEEN'S GARDENS, BAYSWATER, W."

# CORRESPONDENCE.

"THE CONFLICT OF THE AGES."

*To the Editor of the Popular Science Monthly.*

DEAR SIR: I have read this morning, with great pleasure, the article by President White, in the February number of your magazine; and am free to express gratification at seeing the extracts from my Vanderbilt University Address placed in such "goodlie companie."

But you must permit me to express my surprise at the tone and some of the statements which you make with regard to the two articles, and to the important subject which they discuss. You say that you print my argument because it is "on the other side of the question," and you would "not be accused of partiality or injustice to opposite views." This is utterly unaccountable to me. President White and myself are in perfect accord in our articles so far as "the conflict" is concerned, so much so that, if we had had a conference previous to the preparation of our two addresses, we could scarcely have selected modes of treatment different from those we adopted. We should possibly have changed the order of the printing, and let his follow mine. Mine is a statement of doctrine, and his the proof. He has written almost nothing in his article which I might not have written if I had had his ability. He brings a masterly analysis and great wealth of learning to prove what I have asserted, and nothing in his article seems to stand against any thing in mine. We hold the same thesis, and sometimes express our ideas *ipsissimis verbis*. We both agree, if I have not utterly misapprehended President White, that religious men make mistakes, and scientific men make mistakes, but there is no conflict between *true* religion and *true* science, the warfare of science being with something other than religion. The first words of mine which you quote are these: "The *recent* cry of the 'Conflict of Religion and Science' is *fallacious*, and *mischievous* to the interests of both science and religion" (p. 434). President White, in the first sentence of his thesis says, "In all *modern* history, interference with science in the *supposed interest* of religion . . . has resulted in the *direst evils both to religion and to science*, and invariably" (p. 385). There we agree, and each undertakes to show the same thing in his own way. President White, in the second sentence of his thesis, says, "All untrammeled scientific investigation, no matter how dangerous to religion *some* of its stages may have *seemed*, *for the time*, to be, has invariably resulted in the highest good of religion and of science." In divers places in my article the same is set forth and maintained. On page 444 I say, "If, for instance, a conflict should come between geology and theology, and geology should be beaten, it will be *so much the better for religion*; and, if geology should beat theology, *still so much the better for religion*," etc. In the next sentence, "geologists, psychologists, and, theologists, *must all* ULTIMATELY promote the cause of religion, because they *must* confirm one another's truths and explode one another's errors," etc. And, next sentence, "He (the religious man) knows and feels that it would be as irreligious in him to reject any truth found in Nature as it would be for another to reject any truth found in the Bible."

Now, on this showing, my dear sir, I think that in a review of the two articles you should be ready to admit that Dr. White and I are *not* on "opposite" sides. We are advocates for the same client, speaking from different briefs but promoting the same cause.

But I am sorry to find that, while I thoroughly agree with Dr. White, *you* do not. You consider the conflict to be "natural," "inevitable," "wholesome." Dr. White teaches that "the idea that there is a necessary antagonism between science and religion" is "*the most unfortunate of all ideas*" (p. 403). You oppose Dr. White more than you do me, for my moderate statement is, that it is "fallacious" and "mischievous."

I would fain "labor" with you, as some of our religious brethren say. It grieves me that you hold that an antagonism between *loving obedience to God*—Religion, and *intelligent study of God's works*—Science, is "natural," "inevitable," "wholesome." If that be true it would seem to follow that the more religious a man is the less scientific he can be, or, what is worse, that the more scientific a man the less religious can he be! Really you cannot mean what your statements logically convey. You cannot mean to teach that, the more wicked a man is, the better he is prepared for scientific investigation. But do not your words mean that?

To prove that there is a necessary conflict you call attention to "the attitude of mind of the great mass of devout and sincerely religious people toward the more advanced conclusions and scientific men of the present day." Who can tell what attitude that is? Each man knows his circle of acquaintances; and here is my testimony: All "the devout and sincerely religious people" with whom I am acquainted accept *all* the "conclusions" of science so far as they know them. Some of them go further, and accept even the hypotheses and guesses of the most poetic and superstitious of "the scientific men of the day." The body of devout religious people, however, it is fair to add, do not accept all the guesses. All that can be reasonably asked of the religious people is that they shall accept as *scientific* "*conclusions*" only those teachings of science in regard to which there is no controversy *among scientific men*. A case cannot be called "concluded" while the argument is going on in court. The rotundity of the earth, the heliocentric theory, Kepler's three laws, are "concluded." No scientific man of repute expresses the slightest doubt of those, and the attitude of religious people toward them is one of thorough acceptance and genuine faith. There are some religious people who are evolutionists. Some are not. But the scientific men, "*as such*," are just as much divided, so that that question cannot be called concluded.

As to the attitude of religious people toward advanced scientific men, it would be difficult to determine, because it would be difficult to determine who are the "advanced" scientific men. Whenever they settle that among themselves, your question will really have great importance; but, if a clique should cry up one man as a burning and shining light in science, while the French Academy should be reported to have rejected him when nominated for membership, on the ground that *he is not scientific*, need religious people have any attitude toward him at all?

But that there is no hostile attitude toward scientific men is shown by the fact that *any* scientific lecturer of ability may come from Europe to America, and the devout and religious people of the country will go in throngs to hear him, and pay liberally for the privilege.

You close your article by expressing the opinion that a "desirable consummation" to "reach" would be "the entire indifference of religious people, *as such*, to the results of scientific inquiry." This is amazing. How can they be? Religious people who are not scientific know very well, having had their attention freshly called thereto by Dr. White, the great benefits conferred on religion by the progress of science, which, as he admirably says, has "given to religion great new foundations, great new ennobling conceptions, a great new revelation of the might of God." Religious people owe too much to science, while science owes almost every thing to religious people, to allow them to become entirely indifferent, and give up science wholly to irreligious men.

One thing let us agree on before we part. Nothing is advanced and no one is profited if religious men write and speak as though no man could be scientific and at the same time religious; nor is any thing profited if men professing to be scientific talk of religious people patronizingly, as if they were simpletons. Can you not say "Amen" to that, and shake hands with

Very respectfully and truly yours,

CHARLES F. DEEMS.

CHURCH OF THE STRANGERS,
NEW YORK, *January* 27, 1876.

# EDITOR'S TABLE.

## *HISTORY AND THE CENTENNIAL.*

THERE are symptoms of a revival of the study of history, or of a new impulse to it, as a consequence of the fact that the life of the nation has reached a round hundred years. Histories of the United States are in special order, and histories of the world for common schools are copiously forthcoming. The importance of history is, of course, a foregone conclusion; and the triple importance of the history of one's own country goes for self-evident. This is the wrong year to disturb political superstitions, and we are not going to question the great necessity of reading more about the doings of politicians for the last hundred years than past facilities have made practicable. But we may suggest that it is not an unsuitable time to widen and liberalize somewhat our notions of what history properly is, or should be. That it has hitherto dealt mainly with the superficies of human affairs, with conspicuous surface effects, and with the sayings and doings of men who have been skillful in the art of keeping themselves in the focus of public observation, has come to be a truism. And, when a history of the United States is announced, it is well enough understood that we are to have a new shaking-up of the old materials, with new pictures, but with the usual account of Indians, constitution-making, political administrations, and the wars in which the country has been engaged.

But is not our impending Centennial celebration in Philadelphia calculated to impress upon us the historic interest of quite a different class of things? No doubt there will be collected and placed on show numerous relics and curiosities of purely national import; but these will not constitute the staple attractions of the exhibition. Its supreme interest will consist in the array of products which will be there gathered of the art, science, invention, and skill, of the world. It is these that have been appealed to, to signalize and make memorable the hundredth year of our separate national life. This is the realization of an idea which could hardly have entered into the dreams of the men who figured as "founders of the republic." Their notion of "celebrating" our "Independence" for all time, consisted in making a prodigious noise, by ringing bells, and exploding gunpowder. But now we celebrate this event on a grand scale, by invoking the coöperation of the civilized world in the competitive display of industrial resources, constructions, fabrics, and works of use and beauty, distributed through a hundred departments of classified variety. And, of these multitudinous results of man's inventive and constructive faculty, the great mass will be the products of the past century's experience and progress, of which hardly the germs existed when we set up in politics for ourselves. And they will not be the results of administrative policy or forms of government. In a large sense they will not belong to any nation, but to civilization and humanity. They will be, to no small degree, the achievements of enterprise which politicians of all countries have done their best to hinder and defeat. It is the triumph of our time, that the forces that have brought such vast and benign consequences have overcome all resistance. They represent the growth and power of the pacific and constructive agencies of modern society—the headway that has been made against the political barbarisms of the past. The chief display at the Centennial will symbolize the silent revolutions of ideas—triumphs achieved by individuals through heroic self-sacrifice, and unwearying labor, in the seclusion of the laboratory, the study, and the workshop. And, as regards popular history, it is now pertinent to ask if it might not be wisely extended over this field of human exploit. The records of inventive, scientific, and social progress might lack something of the tragic excitement that belongs to the chronicles of battles and campaigns, and might be read with less avidity than accounts of cabinet intrigues, partisan strife, and gossiping sketches of men who have got themselves voted into the category of the great; but, for the serious purposes of education, would not histories of the former type be better suited for the wants of an enterprising, practical, self-governing people, than those which are now pressed upon our schools? We need popular histories of the arts and sciences, of inventions and discoveries, of industries and commerce, the development of ideas, the order of social changes, and the working of those deeper forces in human affairs which history has hitherto overlooked, and of which, indeed, mankind has only become fully conscious in recent years. We need them, but the need is probably no measure of the demand for them. If they were written, the chances for their "adoption" would, perhaps, not be very encouraging. But we may indulge the hope that the influence of the Centennial Exhibition will, at any rate, be favorable to the growth of this branch of literature.

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### *RETROSPECTS OF OUR PAST HUNDRED YEARS.*

The reviews that have been published of what has been done in this country in the great departments of thought, during the past century, are not without promise that the mind of the time is moving in the direction desiderated in the preceding article. The *North American Review*, for example, has published a centennial number, devoted entirely to the course of American thought in religion, politics, abstract science, economic science, law, and education, from 1776 to 1876. The papers are able, calm, and philosophic, without a glimpse of the "spread eagle" or trace of the "stump," and their general tone, in fact, is by no means that of jubilation.

Mr. J. L. Diman begins by giving an instructive account of religion in America, and pointing out the leading changes that have taken place, most important of which is the complete separation which has been effected between church and state. He shows how deep was the conviction in our early history that laws for "maintaining public worship, and decently supporting the teachers of religion," are "absolutely necessary for the well-being of society." This view was not the result of ecclesiastical prejudice, but was most strongly advocated by laymen. Chief-Justice Parsons, not a member of a church, in entering upon his official career, expressed his most solemn conviction "of the necessity of a public support of religious institutions;" and, still later, Judge Story maintained the same view. This ground, now generally abandoned by American Protestants, is that still held by the Catholic Church, and gives rise to one of the gravest difficulties of public policy, that in relation to religion and state education.

As regards the growth of sects, it is stated that "a century ago the more important religious bodies (tested by the number of churches) were ranked in the following order: Congregational, Baptist, Church of England, Presbyterian, Lutheran, German Reformed, Dutch Reformed, Roman Catholic. By the census of 1870 they stood: Methodist, Baptist, Presbyterian, Roman Catholic, Christian, Lutheran, Congregational, Protestant Episcopal." The growth of religious organizations has outstripped the growth of population. At the beginning of the Revolution there were less than 1,950 with a population of 3,500,000, showing a church for every 1,700 souls. There are now more than 72,000, which, with a population of 38,000,000, would show a church for every 529. "In other words, while the population has multiplied elevenfold, the churches have multiplied nearly thirty-seven-fold." The most signal religious fact which the past century presents is stated to be the growth of Methodism. When their first conference met at Baltimore they collected but sixty preachers, and it was reckoned that in the whole country they could muster but twenty more. "By the census of 1870 they were credited with more than 25,000 parish organizations, and a church property of $70,000,000." Notice is taken of the tendency to appreciate a more educated clergy, and of a growing ambition in the matter of church architecture. The general movement, it is said, has led not so much toward the multiplication of sects as toward the formation of compact and powerful religious organizations. But there has been little reciprocal influence among ecclesiastical bodies, and no tendency to theological unity. The general conclusion of the writer is that "a review of our past history should incline us to place a modest estimate on our success;" and "at the close of a century we seem to have made no advance whatever in harmonizing the relations of religious sects among themselves, or in defining their common relation to the civil power. . . . The function of American Christianity has been discharged in a moral and practical, rather than in a scientific and theological development."

Prof. Sumner's sketch of American politics for a hundred years is highly instructive and readable, but on the whole any thing but flattering to the national vanity. The "Ring" and the "Boss" seem to be its latest outcome, and of the latter character it is said, "he is the last and perfect flower of the long development at which hundreds of skillful and crafty men have labored, and into which the American people have put by far the greatest part of their political energy." Whether in politics the course of the nation has been on the whole upward or downward, the writer considers an open question, but comforts us with his individual opinion that we are not degenerating.

Prof. Newcomb, in reviewing the abstract science of the century, discusses with much ability the conditions on which the cultivation of pure science depends, and finds that they are greatly wanting in this country. There is a lack of intimate intercourse among scientific men; of government appreciation of the aid they require in devoting themselves to original research. There is, besides, a kind of national one-sidedness—not merely an absorption in material interests—a kind of faith in practical sagacity and the sufficiency of plain common-sense for all emergencies, which excludes the need of more exact methods of thought, and is inappreciative of the value of refined and remote inquiries that yield no palpable or directly useful results. It is therefore natural "that the development of the higher branches of science in our country should be marked by the same backwardness which characterizes the higher forms of thought in other directions." Prof. Newcomb brings out, in an admirable passage, the complete antagonism between the ideas "which animate the so-called 'practical man' of our country and those which animate the investigator in any field which deserves the name of science or philosophy;" from which it appears that the most potent hindrance to science with us is that adverse state of the general mind which prevents our people from taking interest in it, and of encouraging those who devote themselves to it. He says: "It is strikingly illustrative of the absence of every thing like an effective national pride in science that two generations should have passed without America having produced any thing to continue the philosophical researches of Franklin. . . . Until Henry commenced his experiments there was not an electrical investigation published in the country, which the present time has any object in remembering."

"We have described and illustrated the generally low state of American science during the first forty years of the present century—a state which may be described as one of general lethargy broken now and then by the activity of some first-class man, which, however, commonly ceased to be directed into purely scientific channels. Since 1840 there has been a great and general increase of activity in some directions, which, from some points of view, would seem to have inaugurated an entirely new state of things, and to promise well for the future. But there are also many features of the case which strongly suggest the backward state of things from which the present condition sprung."

After reviewing a large mass of facts, Prof. Newcomb says: "We must not conclude, from all this, that no interest in science is taken by the American people, but only that that interest does not manifest itself in such a way as to promote scientific research." And his general conclusion is that, "on the whole, we have not been able to present the first century in roseate colors; and, while we can well contemplate the future with hope, we cannot do so with entire confidence."

Prof. Dunbar's delineation of a century of economic science is clear and cogent, but no more flattering than that of his predecessor. He gives an interesting account of the various writings that have been contributed by prominent men to this question, and, although it would at first seem that the practical genius of our people would here find its legitimate field, and that what they loved dearest and thought of most—money, currency, property, trade—they would be the ones to explore to the utmost depths; yet such is far from having been the case. The tracing out of unknown laws and the original discovery of principles are the same in all spheres of phenomena. Prof. Dunbar concludes: "The general result, then, to which, as we believe, a sober examination of the case must lead any candid inquirer, is that the United States have thus far done nothing toward developing the theory of political economy, notwithstanding their vast and immediate interest in its practical applications." He shows how it is that our politicians are interested in bemuddling economical questions, and spreading the notion that nothing is here settled, because the interests are to be manipulated for selfish ends. "In the case of the currency question, then, it appears that the subject, from the first, came before our public men in a form which seemed to make its political bearings too important to be subordinated to any scientific treatment. The same might be said of the tariff discussion, which, apart from its inevitable complication with individual interests, has never failed also to present itself in such sectional or party relations as to make its settlement turn largely upon far other considerations than those of general principles." It is further shown how the great prosperity of the country has blinded men to the injurious influence of economic blunders. "The idea that the management of our resources is of little account so long as we find ourselves sweeping along with the current of growth has for years been the habitual consolation of our public men, if not an article of their faith. That it easily leads to indifference, as to the monitions of economic law, is sufficiently obvious."

Mr. G. T. Bispham treats of the progress of American jurisprudence during the past century. He first considers those deviations from English law which originated in the contrast of physical features between this country and England. That country is a compact, densely-populated island, with small rivers, forests that are the objects of jealous care, with cheap labor, and high-priced land; contrasting strongly with the extent of this country—its enormous streams, sparse population, cheap lands, imperfect roads, and timber so abundant that it was an impediment to improvement. These differences necessitated marked modifications in American law to adapt it to the physical and geographical peculiarities of the country. Many changes of jurisprudence, of course, grew out of the adoption of a new form of government embodied in a new constitution, which gave a distinctive character, in many features, to the system of American law. It is maintained, also, that general intellectual influences have wrought an advance in American jurisprudence, which is seen in the amelioration of criminal legislation, and in legislation establishing public or state education. It is, moreover, contended that the adoption of written constitutions is an important step of progress which the world owes to the United States; another American step being the codification and simplification of municipal law. The writer finally concludes that "the law in this country has, in the progress of its hundred years of life, become (1) more simple, (2) more humane, and (3) more adaptive;" and he thinks that "the pathway it has pursued is one upon which we can turn our eyes with feelings of no little pride."

Prof. D. C. Gilman sketches the history of American education, regarding it "in the three stages which are commonly known as 'primary,' 'secondary,' and 'superior' instruction." A large amount of historical information is digested, relating to the rise and progress of the primary-school system, the course of legislation upon the subject, the controversies it has involved, and the difficulties that have arisen by the extension of it to the freedmen of the South. The weakest portion of the American system is stated to be that of "secondary" instruction, which is intermediate between the elementary and collegiate schools. The maxim that "our public schools must be cheap enough for the poorest; good enough for the best," indicates an obstacle that has long stood in the way of the organization of higher schools; but within the last twenty years, especially within the cities and large towns, many of these have arisen, and in the West have become the favorite means of securing higher instruction. As regards the "superior" education, it is stated that, at the commencement of the Revolution, there were nine colleges in eight of the thirteen colonies. These establishments have multiplied, until "in 1875 the Commissioner of Education reported the names of 374 institutions, mostly called universities and colleges, which are legally entitled to confer academic degrees, besides independent schools of law, medicine, and theology, of which there are 106, and colleges for women, of which there are 65; so that there are known and recorded 545 degree-giving institutions within the United States.

The general scope of our "superior" education is thus indicated:

> "The typical American college has been a place where a prescribed course of study, largely devoted to Greek, Latin, and mathematics, with a brief introduction to historical, political, and ethical sciences, has continued during four years and led to a bachelor's degree."

Various questions regarding our collegiate system are ably discussed by Prof. Gilman, but he hardly touches the important topic of scientific education. Perhaps this was from lack of space, but, as he is engaged in the organization of a university to be devoted to the higher studies, this subject must have engaged his very serious consideration, and we hope he will favor the public with his views upon it at some suitable time.

## LITERARY NOTICES.

The Emotions and the Will. By Alexander Bain, LL. D., Professor of Logic in the University of Aberdeen. Pp. 604. Price, $5. New York: D. Appleton & Co.

The author of this work stands among the very foremost in the school of modern scientific psychology, which has its chief development in Great Britain. His two principal works, "The Senses and Intellect" and "The Emotions and the Will," are widely known as giving the only complete and systematic account of mental phenomena from a modern point of view. As we know nothing of mind, except as an organic manifestation—as physically embodied and working its effects through a complex and wonderful vital machinery—no exposition of it can be regarded as scientific or complete that leaves the material side of the phenomena out of account. We have often insisted upon this, and must continue to do so; for the importance of the truth is only equaled by the inveteracy with which the futile and exhausted metaphysical method is still clung to in the general study of mind. There is hardly a chapter of either of Dr. Bain's books that is not a virtual demonstration of the necessity of including the physical accompaniments of mind in any treatment of it that claims to be scientific in method, and valuable in application. The general adoption of these works as college and high-school text-books would give a new and valuable element to our higher culture. Mental philosophy would then become what it ought to be, a study of human character, and such an analysis and understanding of the constitution of man as would give us a better interpretation than hitherto of his relations to surrounding Nature.

The third edition of "The Emotions and the Will" has been thoroughly revised at every point. Although it may seem a hopeless task to introduce quantitative inquiries involving much precision into psychology, yet, as Dr. Bain remarks, it is essential to the scientific handling of the subject, and he has accordingly given much attention to the problem of degrees of intensity and force in regard to the feelings, and to the extension and improvement of the means adopted in this branch of psychical investigation.

But perhaps the most significant feature of the new edition of this work is its reconstruction with reference to the doctrine of evolution. As the eminent comparative anatomist of Germany, Gegenbauer, reorganized his great biological work so as to bring it into harmony with evolutionary views, and as Sir Charles Lyell recast his "Principles of Geology" so as to base it upon the doctrine of development and descent, Dr. Bain has now done the same thing with his elaborate treatise upon the mind. Herbert Spencer had indeed grounded psychology upon evolution in a remarkable work published twenty years ago; but it was far in advance of the thought of the time, and even progressive psychologists have but slowly come up to his position. Prof. Bain fully recognizes the eminence and authority of Mr. Spencer in this field of psychological investigation.

The Teacher's Handbook for the Institute and the Class-Room. By William F. Phelps, M. A., Principal of the State Normal School, Winona, Minnesota. Pp. 335. Price, $1.50. New York: A. S. Barnes & Co.

This little work by an experienced educator, who is also an enthusiast in his profession, may be regarded as the outcome of the most advanced and perfected methods of instruction in the American school system. It is a text-book for teachers in acquiring the art of their vocation, and aims to familiarize them both with the theoretical principles and the practical processes by which general education should be conducted in schools, under the control of the state. Prof. Phelps is an ardent advocate of state education, and urges it on the usual ground of political necessity in a popular government. And whatever question there may be as to the right or wrong, or the good and bad of this policy, we have entered upon it, and are committed to it, and nothing remains but to meet the responsibilities and discharge the duties that grow out of it. Such a system inevitably results in comprehensive organization. With system in study there comes gradation in schools, and with improvement in methods and results there comes a demand for the special cultivation of teachers, by means of institutes and normal schools.

This complex machinery of education must be thoroughly understood by every efficient teacher in its principles and practical working, and Prof. Phelps's book has been prepared to facilitate this special professional culture. It is written with the warmth of a man who is in earnest, and with the clearness of one who understands his subject. Unsettled questions and difficulties in education are recognized, with judicious suggestions, as in the following passage:

"The question as to what shall be taught in our common schools is yet to receive a definite solution. Next in importance to right methods of teaching ranks the subject-matter of teaching. 'What knowledge is of most worth? What branches are the most useful, first for discipline, and second for use or particular application?' Upon this subject we have no settled policy. As a consequence, many things inferior usurp the place of those of superior worth. The dry details of so-called geography, the abstract definitions, rules, and formulas of grammar, the comparatively valueless signs and symbols of algebraic notation, consume a vast amount of the time that should be devoted to the study of the earth, its climate and productions in their relations to man, and the course of human history; of the English language, as a means of communication, and of the living sciences which lie at the basis of all the arts and industries of life. But it is futile to attempt a revolution in subject-matters while teachers, their attainments, and methods of work, are so inadequate to the public needs. It is idle to talk of the necessity of the elements of physics and chemistry, botany and physiology, natural history and agriculture, so long as we have neither the knowledge nor the skill requisite to their proper treatment. Of what value would these sciences be to the people when mechanically memorized from the printed page, as are most of the subjects now in our common-school curriculum? To be of use, either for discipline or application, they must be properly taught by observation, experiment, and demonstration. In short, their objects must be seen, handled, analyzed, compared, and classified. These practical sciences must be investigated by methods and processes analogous to those by which they have been themselves developed, and thus far perfected. Can our children be expected to grope their way to these natural processes in spite of their teachers? or, must the latter first be made capable of leading the way, inspiring the young by the fullness of their learning, and the skill of their methods? Until our children and youth learn the right use of their own powers, it is in vain to expect that they can master the powers of Nature, or accomplish any other important result."

The Uranian and Neptunian Systems, investigated with the 26-inch Equatorial of the United States Naval Observatory. By Simon Newcomb, LL. D., Professor United States Navy. Washington Observations for 1873. Appendix I. Government Printing-Office, 1875, pp. 72, 4to.

This pamphlet, separately printed, contains the first published discussion of work done by the 26-inch Clark refractor of the Naval Observatory. What this work was, and how great necessity existed for its prosecution, may be gathered from the first two paragraphs of the memoir:

"The remoteness of the two outer planets of our system renders the accurate investigation of their satellites a task of great difficulty. This is strongly evinced by the great discordances between the conclusions respecting the masses of those planets which have been reached by various observers. Thus, in the case of Uranus, Von Asten, the latest investigator, cites a number of determinations of the mass from recent observations, which range between $\frac{1}{19371}$ and $\frac{1}{27818}$ [of the sun's mass], so that the largest result is nearly half as large again as the smallest. Even different results, obtained by the same observer under slightly different circumstances, were surprisingly discordant. The best determination was that of Struve; but even here there was a difference of four per cent. between the results from the two [brighter] satellites. In the case of Neptune, discordances of the same kind showed themselves; Struve's mass being greater than that of Bond by one-third.

"For these and other reasons, when the 26-inch equatorial, with an object-glass nearly perfect in figure, was mounted at the Naval Observatory, the observation of the satellites of the outer planets, with a view of determining not only the elements of their orbits, but more especially the masses of the planets, was made the first great work of the instrument. Entertaining the opinion that, in the present state of astronomy, it was better to do one thing well than many things indifferently, the minor arrangements of the instrument were all made subservient to the end in view, and no other serious work of a dissimilar character was attempted during the continuance of the observations."

It is well known that the two brighter satellites of Uranus, viz., *Oberon* and *Titania*, are quite faint objects even in the large 15-inch telescopes of Harvard College and of Pulkova, but the two interior satellites, *Ariel* and *Umbriel*, are incomparably the faintest and most difficult objects to observe in the solar system. Indeed, it is not wholly certain that they have ever been seen save in the telescopes of Mr. Lassell (their discoverer), Lord Rosse, and by the Washington refractor, although there are several telescopes now mounted both in Europe and in America which are adequate for their observation.

The satellite of Neptune, too, is a very difficult object, and hence it is extremely gratifying to find so many measures of these satellites as Prof. Newcomb has obtained. The telescope was mounted in November, 1873. From that time to April, 1875, there were made:

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| 31 | observations of | | *Oberon.* |
| 34 | " | " | *Titania.* |
| 10 | " | " | *Umbriel.* |
| 8 | " | " | *Ariel.* |
| 54 | " | " | *Neptune's satellite.* |

It must be remembered that *Neptune* was only observed from July to February, and *Uranus* from January to May.

From a consideration of all the measures of *Uranus's* satellites, the author assigns as the mass of that planet $\frac{1}{22600}$ of the mass of the sun, and he estimates the probable error of the denominator of this fraction at 100, so that we may say that this mass is not *less* than $\frac{1}{22700}$, and not *more* than $\frac{1}{22500}$; that is, the mass is determined within less than $\frac{1}{200}$ part of its value. To understand the nicety of such measurements as have been made, it must be remembered that any error in the measures of the *distance* of the satellite from the planet is shown in the resulting mass of the planet in an amount not proportional to this error directly, but to the *third power* of the error.

The times of revolution of the satellites have been determined with high accuracy by a comparison of Newcomb's observations with those of the elder Herschel—the uncertainty in the period of *Titania* = $8^{\text{days}}.705897$, being not more than one second of time, or $\frac{1}{1000000}$ of the whole amount.

From the relative brightness of the satellites of Uranus, Prof. Newcomb concludes that they have masses not more than $\frac{1}{80000}$ of that of Uranus itself, i. e., vastly less than the mass of our own moon.

It is an interesting fact too that the author suspects that the nearest of the satellites of Uranus (*Ariel*) "belongs to that class of satellites of which the brilliancy is variable, and depends on its position in the orbit." With regard to the interesting question as to the number of satellites of Uranus, Prof. Newcomb's testimony is as follows:

"No systematic search for new satellites of this planet was entered upon, partly because the season in which Uranus is in opposition is now an unfavorable one for prosecuting such a search, and partly because the attempt would have absorbed so much of the observer's time and energies as to detract from the excellence of the micrometer-observations. When faint objects, which might have been new satellites, were seen around the planet, their positions relative to the latter were noted; but in no instance was any such object found to accompany the planet. I think I may say, with considerable certainty, that there is no satellite within 2′ of the planet, and outside of Oberon, having one-third the brilliancy of the latter, and therefore that none of Sir William Herschel's supposed outer satellites can have any real existence. The distances of the four known satellites increase in so regular a way that it can hardly be supposed that any others exist between them. Of what may be inside of Ariel, it is impossible to speak with certainty, since, in the state of atmosphere which prevails during our winter, all the satellites would disappear at 10″ distance from the planet.'

The second section of the memoir deals with the Neptunian system. Three principal determinations of the mass of Neptune have been made:

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| Bond's, | which | gives the | mass | $\frac{1}{19400}$. |
| Struve's, | " | " | " | $\frac{1}{14446}$. |
| Lassell's, | " | " | " | $\frac{1}{17135}$. |

From the work of the Washington telescope the mass results $\frac{1}{19380}$, which agrees most remarkably with Bond's previous determination.

No evidence for an elliptic form to the orbits of any of these satellites has been made out: "We are thus led to the remarkable conclusion that the orbits of all the satellites of the two outer planets are less eccentric than those of the planets of our system, and that, so far as observations have yet shown, they may be perfect circles. No trace of a second satellite of Neptune has ever been seen, though several times carefully looked for, under the finest atmospheric conditions, during July, 1874."

We have thus far spoken mainly of the

most interesting results reached in Prof. Newcomb's memoir. It contains besides these a very complete development of the analytical methods required for the discussion of observations of this class, and practical hints as to the manner of making and treating such observations, which are of great importance. It is a gratifying thing to be able so soon to announce important results attained by means of the new telescope at Washington, and to see that so great a scientific trust as this has been administered by competent and faithful hands.

The Scientific Monthly. Pp. 55. Toledo, O.: E. H. Fitch, Editor and Proprietor.

The second number of this magazine has a diversified table of contents. The first article (illustrated) is on "The Swallow-tailed Kite." There are two articles by Prof. Charles Whittlesey; the one on "Rock Inscriptions" in Lorain Co., Ohio, and the other a comparison of the Indian and the Mound-Builder. The titles of the other leading articles are: "Climate and Disease," "The Brain," "The Archippus Butterfly," and "Some Atmospheric Phenomena." Price, $3.00 per year.

The Journal of Mental and Nervous Disease. Chicago: 57 Washington Street. Pp. 175. Subscription, $5 per annum.

This quarterly commences with the January number a new series. Its editors are J. S. Jewell, M. D., and H. M. Bannister, M. D., with Drs. W. A. Hammond, S. Weir Mitchell, and E. H. Clarke, as associate editors. This first number of the new series contains Dr. Hammond's address on "The Brain not the Sole Organ of the Mind;" a paper by Dr. R. W. Taylor on "Syphilis of the Nervous System;" "Pathology of Tetanus," by Dr. Bannister; "Pathology of the Sympathetic Nervous System," by Dr. Clark; "Treatment of Inebriates," by Dr. N. S. Davis; and "Cerebral Anæmia," by Dr. T. L. Teed.

Science Byways. By Richard A. Proctor. Pp. 438. Philadelphia: Lippincott. Price, $4.00.

Under this title Mr. Proctor brings together sixteen essays, originally published in various magazines, on a wide range of topics. Two of these essays have appeared in the Monthly, namely, "Finding the Way at Sea," and "Money for Science." The latter subject the author purposes to discuss at greater length in a pamphlet soon to be published. As a popular expositor of science Mr. Proctor stands high, and this volume will be heartily welcomed by the important public to whom the author addresses himself. Among the other subjects treated in the present volume, we may name the following: "Life in Other Worlds," "Comets," "The Sun a Bubble," "The Weather and the Sun," "Rain," "Have we Two Brains?" "Automatic Chess and Card Playing."

The *American Naturalist* begins the year 1876 with improved form and increased volume; each number now contains 64 pages. The magazine will be less technical than heretofore, and will have some additional departments, devoted to geography and travel, proceedings of scientific societies, etc. The first number issued since the "new departure" opens with a paper by Prof. A. Gray, entitled "Burs in the Borage Family." There is also a paper by Rev. Samuel Lockwood, in his usual lively style, on *Anolis principalis*, the American analogue of the chameleon of the Old World. There are five other leading articles in this first number. The *Naturalist* is now published by Hurd & Houghton, Boston. Subscription price, $4 per annum.

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PUBLICATIONS RECEIVED.

Native Races of the Pacific States. By H. H. Bancroft. Vol. V. New York: D. Appleton & Co. Price, $5.50. Pp. 796.

Angola and the River Congo. By J. J. Monteiro. Pp. 366. New York: Macmillan. Price, $2.50.

The Christ of Paul. By George Reber. Pp. 397. New York: Somerby. Price, $2.00.

Magnetism and Electricity. By F. Guthrie. Pp. 364. New York: Putnams. Price, $1.50.

Public Instruction in Minnesota. Pp. 235. St. Paul: *Pioneer Press* print.

The American State. By W. G. Dix. Pp. 187. Boston: Estes & Lauriat. Price, $1.50.

Life Histories of Animals. By A. S. Packard, Jr. Pp. 243. New York: H. Holt & Co. Price, $2.50.

How to build Ships. By a Seaman. Pp. 62. New York: Van Nostrand. Price, 75 cents.

Hayden's Geological Survey of the Territories. Vol. II. Pp. 304, with numerous Plates. Washington: Government Printing-Office.

Water and Water-Supply. By W. H. Corfield. Pp. 145. New York: Van Nostrand. Price, 50 cents.

Principles of Coal-Mining. By J. H. Collins. Pp. 150. New York: Putnams. Price, 75 cents.

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## MISCELLANY.

**Exhibition of Scientific Apparatus.**—There will be opened next April, at the South Kensington Crystal Palace, London, a universal exposition of scientific instruments. This exposition will continue for six months. Its object is to bring together as large a number as possible of scientific instruments possessing an historic interest, for instance, Tycho Brahe's astrolabes, Galileo's telescopes, Lavoisier's balances, Franklin's lightning-rods, the remnants of Charles's balloons, Giffard's injector, Leon Foucault's pendulum and gyroscope, etc. All the cost of transportation will be borne by the Department of Arts and Sciences. The home committee consists of one hundred scientific men, with the lord-chancellor. It is stated in the *Moniteur Industriel Belge* that an invitation has been sent to every civilized nation to take a part in the exhibition.

**Fossil Coniferæ.**—Prof. J. W. Dawson, in the *American Journal of Science* for October, invites correspondence from geologists who have examined the remains of coniferous trees in the carboniferous rocks of the United States. Hitherto, he says, little attention seems to have been given in this country to these remains of ancient vegetation. In Nova Scotia, several species are known, and are to some extent characteristic of definite horizons. In the carboniferous sandstones of the United States such remains seem to be frequent, but Dr. Dawson has seen no detailed account of them. The subject, he adds, is deserving of the attention of microscopists in the coal districts, as there can be little doubt that several interesting species remain to be discovered; for instance, the curious *dictyoxylon* of Williamson, found also in Nova Scotia, would probably reward patient slicing of trunks showing structure. The Devonian has treasures of the same kind. In the United States it has already afforded *Dadoxylon Halli* from New York, and *D. Newberryi* from Ohio, besides the curious *Ormoxylon Erianum*. No doubt other species remain to be discovered, especially in the Upper and Middle Devonian.

**Habits of Hermit-Crabs.**—In the *American Journal of Science* for October, Mr. A. Agassiz records some observations on the hermit-crab. He raised a number of these animals from a very early stage in their life till they reached the condition in which they require the protection of a shell. A number of shells, some empty, others occupied by living mollusks, were now placed in the glass dish with the young crabs. The empty shells were at once taken possession of. The crabs which were not so fortunate as to obtain untenanted shells remained riding about upon the mouth of their future dwelling, and on the death of the tenant, which generally occurred soon after in captivity, commenced at once to tear out the animal, and, having eaten him, proceeded to take his place within the shell. The question arises, How did the crab acquire the faculty of performing this act? Not by imitation, in this instance at least. Possibly by inheritance; Mr. Agassiz, however, is inclined to regard the act as purely mechanical—rendered necessary by the conditions of the young hermit-crab. "When the moult has taken place, which brings them to the stage at which they need a shell, we find important changes in the two hind-pairs of feet, now changed to shorter feet capable of propelling the crab in and out of the shell; we find, also, that all the abdominal appendages except those of the last joint are lost, but the great distinction between this stage and the one preceding it is the curling of the abdomen; its rings are now quite indistinct, and the test covering it is reduced to a mere film, so that the whole abdomen becomes of course very sensitive. It is, therefore, natural that the young crab should seek some shelter for this exposed portion of his body, and, from what I have observed, any cavity will answer the purpose; one of the young crabs having established himself most comfortably in the anterior part of the cast skin of a small isopod, which seemed to satisfy him as well as a shell, there being several empty shells at his disposal."

**Position of Science in English Schools.**—In their sixth report the British Commission on Scientific Instruction relate their observations on the state of science-teaching in public and endowed schools. The present state of scientific instruction in the upper schools is declared to be extremely unsatisfactory. The returns furnished by the public schools show that, even where science is taught, from one to two hours' work per week may be regarded, with very few exceptions, as the usual time allotted to it in such classes as receive scientific instruction at all. Moreover, the instruction in science is generally confined to certain classes in the school. Of the 128 minor endowed schools from which returns were received, only 18 devote as much as four hours per week to the teaching of science, and only 13 have a laboratory of any kind. The commissioners hold that science is a complementary and not an exceptional part of education; that it should not be regarded merely as a by-work, whether to satisfy the natural curiosity of most, or to develop the peculiar tastes of a few; and that, if need be, Greek should yield place to it in the universal curriculum.

**Liebig's Influence on German Science.**—Dr. Thudichum recently delivered a lecture before the London Society of Arts, on "Liebig's Discoveries, and their Influence on the Advancement of Arts, Manufactures, and Commerce." Toward the end of the lecture he indicates, as follows, one of the indirect effects of Liebig's researches: "The Prussian and other German universities now teach students of science and agriculture in great numbers, where thirty years ago law and theology filled the auditories. In that time the number of students of Protestant theology has decreased in Prussia from upward of 2,000 to less than 800, and in Hesse-Darmstadt from 50 to 13. One-sixth of all parsonages are without incumbents, because there is no one to receive the appointments. Such is the beginning of the great reformation which is now being wrought in human affairs by science."

## NOTES.

The Smithsonian Institution is making a collection to illustrate, at the Centennial Exhibition, the resources of the United States as derived from the animal kingdom. This collection will embrace specimens of the animals of the United States which are hunted or collected for economical purposes; the products derived from the various species; also the apparatus or devices employed by hunters, trappers, sportsmen, and others.

The artesian well at the Collier White-Lead Works, St. Louis, Missouri, has attained a depth of over 700 feet, nearly all of which depth has been through limestone. The drift is but slightly above the encrinitic limestone, and has passed through but little of either sandstone or chert. The boring commenced in the lower Archimedean limestone.—*Scientific American.*

A profitable industry in the vicinity of Cape May, New Jersey, is the mining of ancient cedar-logs in the mire of the swamps. In these swamps, says the Monmouth *Democrat*, are buried enormous trees at a depth of from three to ten feet. The logs lie one across another, and there is abundant evidence that they are the growth of successive forests. The mode of searching for the logs is as follows: An iron rod is thrust into the soft mud, over which, often, the water lies. After several soundings the workman is able to tell how the tree lies, which is its root-end, and how thick it is. He then contrives to get a chip from the tree, and so determines at once whether it is worth the labor of mining. A pit is now dug, into which the water soon flows, filling it up. The tree is then cut across with a saw at regular intervals, each section floating to the surface. A layer of such trees is found covered by another layer and these again by another, and even a third, while living trees may still be growing over all.

A marble scroll has been set up in Westminster Abbey, bearing an inscription in honor of Jeremiah Horrocks. Among the labors of his short life the inscription signalizes the following: Discovery of the long inequality in the mean motion of Jupiter and Saturn; demonstration of the elliptical form of the moon's orbit; determination of the motion of the lunar apse; prediction, from his own observations, of the transit of Venus in 1639.

Fifty years ago the great auk was found in large numbers on the Funk Islands, off the coast of Newfoundland, but soon after became extinct. The story of its extermination is briefly told as follows in the *American Naturalist:* The birds were hunted for their feathers by the Newfoundland fishermen, who would row round them in small boats and drive them ashore (the auks being unable to fly) into pounds. The birds were immersed in scalding water to remove the feathers, and their bodies were used as fuel for boiling the water. It is doubtful if the species *Alca impennis* now exists anywhere about the islands of Newfoundland or Labrador.

In the year ending November 30, 1875, the Royal Society of London lost 29 Fellows by death. Of these, fourteen were between 70 and 80 years of age, six between 80 and 90, and three between 90 and 95. Of all the Fellows now living, Sir Edward Sabine has been for the longest time a member of the Society; he was elected in 1818.

In a paper by John Willis Clarke, published in the *Contemporary Review*, it is stated that the Confederate cruisers Alabama and Shenandoah, by interfering with the American seal-fishery, preserved the breed of the fur-seal in the Southern Ocean from complete extinction.

At a recent meeting of the Buffalo Society of Natural Science, Profs. Grote and Pitt announced the discovery of a marine fucoid in the water-line group. The specimen is one of the best preserved of the kind yet discovered. It shows no close affinity to any known fucoidal remains.

Lieutenant Cameron reached Loanda in November, having made the journey from Zanzibar, including a two months' survey of Lake Tanganyika, in two years and eight months.

The California Academy of Sciences is now absolute owner of the property given to it by Mr. Lick. Its present income, in the shape of rents, is about $4,000, and this sum is destined to increase rapidly. Its members number five hundred, including seventy-five life members. The donations to the museum during the year 1875 were numerous and valuable. At the last annual meeting the vice-president, Mr. Edwards, suggested the adoption of some plan of distributing the members in sections of Geology, Botany, Entomology, etc., each section to assemble weekly and pass upon papers which, if approved, would be presented at the fortnightly meetings of the Academy.

The remains of a mastodon have been discovered at Lisle, Broome County, New York. The portions so far found are a piece of tusk 7 feet 3 inches long, and another piece 2 feet long; a humerus 38 inches long; one rib 49 inches long, and 21 shorter ribs; the atlas, 10 by 17 inches, and several of the caudal vertebræ.

*Caroline Herschel.*

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# ON THE BORDER TERRITORY BETWEEN THE ANIMAL AND THE VEGETABLE KINGDOMS.

By T. H. HUXLEY, LL. D., F. R. S.

IN the whole history of science there is nothing more remarkable than the rapidity of the growth of biological knowledge within the last half century, and the extent of the modification which has thereby been effected in some of the fundamental conceptions of the naturalist.

In the second edition of the "Règne Animal," published in 1828, Cuvier devotes a special section to the "Division of Organized Beings into Animals and Vegetables," in which the question is treated with that comprehensiveness of knowledge and clear critical judgment which characterize his writings, and justify us in regarding them as representative expressions of the most extensive, if not the profoundest, knowledge of his time. He tells us that living beings have been subdivided from the earliest time into *animated beings*, which possess sense and motion, and *inanimated beings*, which are devoid of these functions, and simply vegetate.

Although the roots of plants direct themselves toward moisture, and their leaves toward air and light; although the parts of some plants exhibit oscillating movements without any perceptible cause, and the leaves of others retract when touched, yet none of these movements justify the ascription to plants of perception or of will.

From the mobility of animals, Cuvier, with his characteristic partiality for teleological reasoning, deduces the necessity of the existence in them of an alimentary cavity or reservoir of food, whence their nutrition may be drawn by the vessels, which are a sort of internal roots; and in the presence of this alimentary cavity he naturally sees the primary and the most important distinction between animals and plants.

Following out his teleological argument, Cuvier remarks that the organization of this cavity and its appurtenances must needs vary according to the nature of the aliment, and the operations which it has to undergo, before it can be converted into substances fitted for absorption; while the atmosphere and the earth supply plants with juices ready prepared, and which can be absorbed immediately.

As the animal body required to be independent of heat and of the atmosphere, there were no means by which the motion of its fluids could be produced by internal causes. Hence arose the second great distinctive character of animals, or the circulatory system, which is less important than the digestive, since it was unnecessary, and therefore is absent, in the more simple animals.

Animals further needed muscles for locomotion and nerves for sensibility. Hence, says Cuvier, it was necessary that the chemical composition of the animal body should be more complicated than that of the plant; and it is so, inasmuch as an additional substance, nitrogen, enters into it as an essential element, while in plants nitrogen is only accidentally joined with the three other fundamental constituents of organic beings—carbon, hydrogen, and oxygen. Indeed, he afterward affirms that nitrogen is peculiar to animals; and herein he places the third distinction between the animal and the plant.

The soil and the atmosphere supply plants with water, composed of hydrogen and oxygen; air, consisting of nitrogen and oxygen; and carbonic acid, containing carbon and oxygen. They retain the hydrogen and the carbon, exhale the superfluous oxygen, and absorb little or no nitrogen. The essential character of vegetable life is the exhalation of oxygen, which is effected through the agency of light.

Animals, on the contrary, derive their nourishment either directly or indirectly from plants. They get rid of the superfluous hydrogen and carbon, and accumulate nitrogen.

The relations of plants and animals to the atmosphere are therefore inverse. The plant withdraws water and carbonic acid from the atmosphere, the animal contributes both to it. Respiration—that is, the absorption of oxygen, and the exhalation of carbonic acid—is the specially animal function of animals, and constitutes their fourth distinctive character.

Thus wrote Cuvier in 1828. But, in the fourth and fifth decades of this century, the greatest and most rapid revolution which biological science has ever undergone was effected by the application of the modern microscope to the investigation of organic structure; by the introduction of exact and easily manageable methods of conducting the chemical analysis of organic compounds; and, finally, by the employment of instruments of precision for the measurement of the physical forces which are at work in the living economy.

That the semi-fluid contents (which we now term protoplasm) of the cells of certain plants, such as the *Charæ*, are in constant and regular motion, was made out by Bonaventura Corti a century ago; but the fact, important as it was, fell into oblivion, and had to be rediscovered by Treviranus in 1807. Robert Brown noted the most complex motions of the protoplasm in the cells of *Tradescantia* in 1831; and now such movements of the living substance of plants are well known to be some of the most widely-prevalent phenomena of vegetable life.

Agardh, and other of the botanists of Cuvier's generation, who occupied themselves with the lower plants, had observed that, under particular circumstances, the contents of the cells of certain water-weeds were set free and moved about with considerable velocity, and with all the appearances of spontaneity, as locomotive bodies, which, from their similarity to animals of simple organization, were called "zoöspores."

Even as late at 1845, however, a botanist of Schleiden's eminence deals very skeptically with these statements; and his skepticism was the more justified since Ehrenberg, in his elaborate and comprehensive work on the *Infusoria*, had declared the greater number of what are now recognized as locomotive plants to be animals.

At the present day, innumerable plants and free plant-cells are known to pass the whole or part of their lives in an actively locomotive condition, in no wise distinguishable from that of one of the simpler animals; and, while in this condition, their movements are, to all appearance, as spontaneous—as much the product of volition—as those of such animals.

Hence the teleological argument for Cuvier's first diagnostic character—the presence in animals of an alimentary cavity, or internal pocket, in which they can carry about their nutriment, has broken down—so far, at least, as his mode of stating it goes. And, with the advance of microscopic anatomy, the universality of the fact itself among animals has ceased to be predicable. Many animals of even complex structure, which live parasitically within others, are wholly devoid of an alimentary cavity. Their food is provided for them, not only ready cooked, but ready digested, and the alimentary canal, become superfluous, has disappeared. Again, the males of most rotifers have no digestive apparatus; as a German naturalist has remarked, they devote themselves entirely to the "Minnedienst," and are to be reckoned among the few realizations of the Byronic ideal of a lover. Finally, amid the lowest forms of animal life, the speck of gelatinous protoplasm, which constitutes the whole body, has no permanent digestive cavity or mouth, but takes in its food anywhere; and digests, so to speak, all over its body.

But, although Cuvier's leading diagnosis of the animal from the plant will not stand a strict test, it remains one of the most constant of the distinctive characters of animals. And, if we substitute for the possession of an alimentary cavity the power of taking solid nutriment into the body and there digesting it, the definition so changed will cover all animals, except certain parasites, and the few and exceptional cases of non-parasitic animals which do not feed at all. On the other hand, the definition thus amended will exclude all ordinary vegetable organisms.

Cuvier himself practically gives up his second distinctive mark when he admits that it is wanting in the simpler animals.

The third distinction is based on a completely erroneous conception of the chemical differences and resemblances between the constituents of animal and vegetable organisms, for which Cuvier is not responsible, as it was current among contemporary chemists.

It is now established that nitrogen is as essential a constituent of vegetable as of animal living matter; and that the latter is, chemically speaking, just as complicated as the former. Starchy substances, cellulose and sugar, once supposed to be exclusively confined to plants, are now known to be regular and normal products of animals. Amylaceous and saccharine substances are largely manufactured, even by the highest animals; cellulose is widespread as a constituent of the skeletons of the lower animals; and it is probable that amyloid substances are universally present in the animal organism, though not in the precise form of starch.

Moreover, although it remains true that there is an inverse relation between the green plant in sunshine and the animal, in so far as, under these circumstances, the green plant decomposes carbonic acid, and exhales oxygen, while the animal absorbs oxygen and exhales carbonic acid; yet the exact investigations of the modern chemical investigator of the physiological processes of plants have clearly demonstrated the fallacy of attempting to draw any general distinction between animal and vegetable on this ground. In fact, the difference vanishes with the sunshine, even in the case of the green plant; which, in the dark, absorbs oxygen and gives out carbonic acid like any animal. While those plants, such as the fungi, which contain no chlorophyl and are not green, are always, so far as respiration is concerned, in the exact position of animals. They absorb oxygen and give out carbonic acid.

Thus, by the progress of knowledge, Cuvier's fourth distinction between the animal and the plant has been as completely invalidated as the third and second; and even the first can be retained only in a modified form and subject to exceptions.

But has the advance of biology simply tended to break down old distinctions, without establishing new ones?

With a qualification, to be considered presently, the answer to this question is undoubtedly in the affirmative. The famous researches of Schwann and Schleiden, in 1837 and the following years, founded the modern science of histology, or that branch of anatomy which deals with the ultimate visible structure of organisms, as revealed by the microscope; and, from that day to this, the rapid improvement of methods of investigation and the energy of a host of accurate observers have given greater and greater breadth and firmness to Schwann's great generalization, that a fundamental unity of structure obtains in animals and plants; and that, however diverse may be the fabrics, or *tissues*, of which their bodies are composed, all these varied structures result from the metamorphoses of morphological units (termed *cells*, in a more general sense than, that in which the word "cells" was at first employed), which are not only similar in animals and in plants respectively, but present a close fundamental resemblance when those of animals and those of plants are compared together.

The contractility which is the fundamental condition of locomotion has not only been discovered to exist far more widely among plants than was formerly imagined, but, in plants, the act of contraction has been found to be accompanied, as Dr. Burdon Sanderson's interesting investigations have shown, by a disturbance of the electrical state of the contractile substance comparable to that which was found by Du Bois-Reymond to be a concomitant of the activity of ordinary muscle in animals.

Again, I know of no tests by which the reaction of the leaves of the sundew and of other plants to stimuli, so fully and carefully studied by Mr. Darwin, can be distinguished from those acts of contraction following upon stimuli, which are called "reflex" in animals.

On each lobe of the bilobed leaf of Venus's fly-trap (*Dionœa muscipula*) are three delicate filaments which stand out at right angles from the surface of the leaf. Touch one of them with the end of a fine human hair, and the lobes of the leaf instantly close together[1] in virtue of an act of contraction of part of their substance, just as the body of a snail contracts into its shell when one of its "horns" is irritated.

The reflex action of the snail is the result of the presence of a nervous system in that animal. A molecular change takes place in the nerve of the tentacle, is propagated to the muscles by which the body is retracted, and, causing them to contract, the act of retraction is brought about. Of course the similarity of the acts does not necessarily involve the conclusion that the mechanism by which they are effected is the same; but it suggests a suspicion of their identity which needs careful testing.

The results of recent inquiries into the structure of the nervous system of animals converge toward the conclusion that the nerve-fibres, which we have hitherto regarded as ultimate elements of nervous tissue, are not such, but are simply the visible aggregations of vastly more attenuated filaments, the diameter of which dwindles down to the limits of our present microscopic vision, greatly as these have been extended by modern improvements of the microscope; and

[1] Darwin, "Insectivorous Plants," p. 289.

that a nerve is, in its essence, nothing but a linear tract of specially modified protoplasm between two points of an organism—one of which is able to affect the other by means of the communication so established. Hence it is conceivable that even the simplest living being may possess a nervous system. And the question whether plants are provided with a nervous system or not thus acquires a new aspect, and presents the histologist and physiologist with a problem of extreme difficulty, which must be attacked from a new point of view and by the aid of methods which have yet to be invented.

Thus it must be admitted that plants may be contractile and locomotive; that, while locomotive, their movements may have as much appearance of spontaneity as those of the lowest animals; and that many exhibit actions comparable to those which are brought about by the agency of a nervous system in animals. And it must be allowed to be possible that further research may reveal the existence of something comparable to a nervous system in plants. So that I know not where we can hope to find any absolute distinction between animals and plants, unless we return to their mode of nutrition, and inquire whether certain differences of a more occult character than those imagined to exist by Cuvier, and which certainly hold good for the vast majority of animals and plants, are of universal application.

A bean may be supplied with water in which salts of ammonia and certain other mineral salts are dissolved in due proportion; with atmospheric air containing its ordinary minute dose of carbonic acid; and with nothing else but sunlight and heat. Under these circumstances, unnatural as they are, with proper management, the bean will thrust forth its radicle and its plumule; the former will grow down into roots, the latter grow up into the stem and leaves of a vigorous bean-plant; and this plant will, in due time, flower and produce its crops of beans, just as if it were grown in the garden or in the field.

The weight of the nitrogenous proteine compounds of the oily, starchy, saccharine, and woody substances contained in the full-grown plant and its seeds will be vastly greater than the weight of the same substances contained in the bean from which it sprang. But nothing has been supplied to the bean save water, carbonic acid, ammonia, potash, lime, iron, and the like, in combination with phosphoric, sulphuric, and other acids. Neither proteine, nor fat, nor starch, nor sugar, nor any substance in the slightest degree resembling them, has formed part of the food of the bean. But the weights of the carbon, hydrogen, oxygen, nitrogen, phosphorus, sulphur, and other elementary bodies contained in the bean-plant, and in the seeds which it produces, are exactly equivalent to the weights of the same elements which have disappeared from the materials supplied to the bean during its growth. Whence it follows that the bean has taken in only the raw materials of its fabric and has manufactured them into bean-stuffs.

The bean has been able to perform this great chemical feat by the help of its green coloring matter, or chlorophyl, which, under the influence of sunlight, has the marvelous power of decomposing carbonic acid, setting free the oxygen, and laying hold of the carbon which it contains. In fact, the bean obtains two of the absolutely indispensable elements of its substance from two distinct sources; the watery solution, in which its roots are plunged, contains nitrogen but no carbon; the air, to which the leaves are exposed, contains carbon, but its nitrogen is in the state of a free gas, in which condition the bean can make no use of it;[1] and the chlorophyl is the apparatus by which the carbon is extracted from the atmospheric carbonic acid—the leaves being the chief laboratories in which this operation is effected.

The great majority of conspicuous plants are, as everybody knows, green; and this arises from the abundance of their chlorophyl. The few which contain no chlorophyl and are colorless are unable to extract the carbon which they require from atmospheric carbonic acid, and lead a parasitic existence upon other plants; but it by no means follows, often as the statement has been repeated, that the manufacturing power of plants depends on their chlorophyl and its interaction with the rays of the sun. On the contrary, it is easily demonstrated, as Pasteur first proved, that the lowest fungi, devoid of chlorophyl, or of any substitute for it, as they are, nevertheless possess the characteristic manufacturing powers of plants in a very high degree. Only it is necessary that they should be supplied with a different kind of raw material; as they cannot extract carbon from carbonic acid, they must be furnished with something else that contains carbon. Tartaric acid is such a substance; and if a single spore of the commonest and most troublesome of moulds—*Penicillium*—be sown in a saucer full of water, in which tartrate of ammonia, with a small percentage of phosphates and sulphates is contained, and kept warm, whether in the dark or exposed to light, it will in a short time give rise to a thick crust of mould, which contains many million times the weight of the original spore in proteine compounds and cellulose. Thus we have a very wide basis of fact for the generalization that plants are essentially characterized by their manufacturing capacity, by their power of working up mere mineral matters into complex organic compounds.

Contrariwise, there is no less wide foundation for the generalization that animals, as Cuvier puts it, depend directly or indirectly upon plants for the materials of their bodies; that is, either they are herbivorous, or they eat other animals which are herbivorous.

But for what constituents of their bodies are animals thus dependent upon plants? Certainly not for their horny matter; nor for

[1] I purposely assume that the air with which the bean is supplied in the case stated contains no ammoniacal salts.

chondrine, the proximate chemical element of cartilage; nor for gelatine, nor for syntonine, the constituent of muscle; nor for their nervous or biliary substances; nor for their amyloid matters, nor, necessarily, for their fats.

It can be experimentally demonstrated that animals can make these for themselves. But that which they cannot make, but must in all known cases obtain directly or indirectly from plants, is the peculiar nitrogenous matter proteine. Thus the plant is the ideal *prolétaire* of the living world, the worker who produces; the animal, the ideal aristocrat, who mostly occupies himself in consuming, after the manner of that noble representative of the line of Zähdarm, whose epitaph is written in "Sartor Resartus."

Here is our last hope of finding a sharp line of demarkation between plants and animals; for, as I have already hinted, there is a border-territory between the two kingdoms, a sort of no-man's land, the inhabitants of which certainly cannot be discriminated and brought to their proper allegiance in any other way.

Some months ago, Prof. Tyndall asked me to examine a drop of infusion of hay, placed under an excellent and powerful microscope, and to tell him what I thought some organisms visible in it were. I looked and observed, in the first place, multitudes of *Bacteria* moving about with their ordinary intermittent spasmodic wriggles. As to the vegetable nature of these there is now no doubt. Not only does the close resemblance of the *Bacteria* to unquestionable plants, such as the *Oscillatoriæ*, and lower forms of *Fungi*, justify this conclusion, but the manufacturing test settles the question at once. It is only needful to add a minute drop of fluid containing *Bacteria*, to water in which tartrate, phosphate, and sulphate of ammonia are dissolved, and, in a very short space of time, the clear fluid becomes milky by reason of their prodigious multiplication, which, of course, implies the manufacture of living Bacterium-stuff out of these merely saline matters.

But other active organisms, very much larger than the *Bacteria*, attaining in fact the comparatively gigantic dimensions of $\frac{1}{3000}$ of an inch or more, incessantly crossed the field of view. Each of these had a body shaped like a pear, the small end being slightly incurved and produced into a long curved filament, or *cilium*, of extreme tenuity. Behind this, from the concave side of the incurvation, proceeded another long cilium, so delicate as to be discernible only by the use of the highest powers and careful management of the light. In the centre of the pear-shaped body a clear round space could occasionally be discerned, but not always; and careful watching showed that this clear vacuity appeared gradually, and then shut up and disappeared suddenly, at regular intervals. Such a structure is of common occurrence among the lowest plants and animals, and is known as a *contractile vacuole*.

The little creature thus described sometimes propelled itself with great activity, with a curious rolling motion, by the lashing of the front cilium, while the second cilium trailed behind; sometimes it anchored itself by the hinder cilium and was spun round by the working of the other, its motions resembling those of an anchor-buoy in a heavy sea. Sometimes, when two were in full career toward one another, each would appear dexterously to get out of the other's way; sometimes a crowd would assemble and jostle one another, with as much semblance of individual effort as a spectator on the Grands Mulets might observe with a telescope among the specks representing men in the valley of Chamounix.

The spectacle, though always surprising, was not new to me. So my reply to the question put to me was, that these organisms were what biologists call *Monads*, and though they might be animals, it was also possible that they might, like the *Bacteria*, be plants. My friend received my verdict with an expression which showed a sad want of respect for authority. He would as soon believe that a sheep was a plant. Naturally piqued by this want of faith, I have thought a good deal over the matter; and as I still rest in the lame conclusion I originally expressed, and must even now confess that I cannot certainly say whether this creature is an animal or a plant, I think it may be well to state the grounds of my hesitation at length. But, in the first place, in order that I may conveniently distinguish this "monad" from the multitude of other things which go by the same designation, I must give it a name of its own. I think (though, for reasons which need not be stated at present, I am not quite sure) that it is identical with the species *Monas lens*, as defined by the eminent French microscopist Dujardin, though his magnifying power was probably insufficient to enable him to see that it is curiously like a much larger form of monad which he has named *Heteromita*. I shall, therefore, call it not *Monas*, but *Heteromita lens*.

I have been unable to devote to my *Heteromita* the prolonged study needful to work out its whole history, which would involve weeks, or it may be months, of unremitting attention. But I the less regret this circumstance, as some remarkable observations, recently published by Messrs. Dallinger and Drysdale,[1] on certain monads, relate, in part, to a form so similar to my *Heteromita lens*, that the history of the one may be used to illustrate that of the other. These most patient and painstaking observers, who employed the highest attainable powers of the microscope and, relieving one another, kept watch day and night over the same individual monads, have been enabled to trace out the whole history of their *Heteromita;* which they found in infusions of the heads of fishes of the cod tribe.

Of the four monads described and figured by these investigators,

[1] "Researches in the Life-history of a Cercomonad: a Lesson in Biogenesis," and "Further Researches in the Life-history of the Monads," *Monthly Microscopical Journal*, 1873.

one, as I have said, very closely resembles *Heteromita lens* in every particular, except that it has a separately distinguishable central particle or "nucleus," which is not certainly to be made out in *Heteromita lens;* and that nothing is said by Messrs. Dallinger and Drysdale of the existence of a contractile vacuole in this monad, though they describe it in another.

Their *Heteromita*, however, multiplied rapidly by fission. Sometimes a transverse constriction appeared; the hinder half developed a new cilium, and the hinder cilium gradually split from its base to its free end, until it was divided into two; a process which, considering the fact that this fine filament cannot be much more than $\frac{1}{100000}$ of an inch in diameter, is wonderful enough. The constriction of the body extended inward until the two portions were united by a narrow isthmus; finally they separated, and each swam away by itself, a complete *Heteromita*, provided with its two cilia. Sometimes the constriction took a longitudinal direction, with the same ultimate result. In each case the process occupied not more than six or seven minutes. At this rate, a single *Heteromita* would give rise to a thousand like itself in the course of an hour, to about a million in two hours, and to a number greater than the generally-assumed number of human beings now living in the world in three hours; or, if we give each *Heteromita* an hour's enjoyment of individual existence, the same result will be obtained in about a day. The apparent suddenness of the appearance of multitudes of such organisms as these, in any nutritive fluid to which one obtains access, is thus easily explained.

During these processes of multiplication by fission, the *Heteromita* remains active; but sometimes another mode of fission occurs. The body becomes rounded and quiescent, or nearly so, and, while in this resting state, divides into two portions, each of which is rapidly converted into an active *Heteromita*.

A still more remarkable phenomenon is that kind of multiplication which is preceded by the union of two monads, by a process which is termed *conjugation*. Two active *Heteromitæ* become applied to one another, and then slowly and gradually coalesce into one body. The two nuclei run into one; and the mass resulting from the conjugation of the two *Heteromitæ*, thus fused together, has a triangular form. The two pairs of cilia are to be seen, for some time, at two of the angles, which answer to the small ends of the conjoined monads; but they ultimately vanish, and the twin organism, in which all visible traces of organization have disappeared, falls into a state of rest. Sudden wave-like movements of its substance next occur; and, in a short time, the apices of the triangular mass burst, and give exit to a dense yellowish, glairy fluid filled with minute granules. This process, which, it will be observed, involves the actual confluence and mixture of the substance of two distinct organisms, is effected in the space of about two hours.

The authors whom I quote say that they "cannot express" the excessive minuteness of the granules in question, and they estimate their diameter at less than $\frac{1}{200000}$ of an inch. Under the highest powers of the microscope at present applicable, such specks are hardly discernible. Nevertheless, particles of this size are massive when compared to physical molecules; whence there is no reason to doubt that each, small as it is, may have a molecular structure sufficiently complex to give rise to the phenomena of life. And, as a matter of fact, by patient watching of the place at which these infinitesimal living particles were discharged, our observers assured themselves of their growth and development into new monads. These, in about four hours from their being set free, had attained a sixth of the length of the parent, with the characteristic cilia, though at first they were quite motionless; and in four hours more they had attained the dimensions and exhibited all the activity of the adult. These inconceivably minute particles are therefore the germs of the *Heteromita*; and from the dimensions of these germs it is easily shown that the body formed by conjugation may, at a low estimate, have given exit to 30,000 of them; a result of a matrimonial process whereby the contracting parties, without a metaphor, "become one flesh," enough to make a Malthusian despair of the future of the universe.

I am not aware that the investigators from whom I have borrowed this history have endeavored to ascertain whether their monads take solid nutriment or not; so that, though they help us very much to fill up the blanks in the history of my *Heteromita*, their observations throw no light on the problem we are trying to solve—Is it an animal or is it a plant?

Undoubtedly it is possible to bring forward very strong arguments in favor of regarding *Heteromita* as a plant.

For example, there is a fungus, an obscure and almost microscopic mould, termed *Peronospora infestans.* Like many other fungi, the *Peronosporæ* are parasitic upon other plants; and this particular *Peronospora* happens to have attained much notoriety and political importance, in a way not without a parallel in the career of notorious politicians, namely, by reason of the frightful mischief it has done to mankind. For it is this *Fungus* which is the cause of the potato-disease; and, therefore, *Peronospora infestans* (doubtless of exclusively Saxon origin, though not accurately known to be so) brought about the Irish famine. The plants afflicted with the malady are found to be infested by a mould, consisting of fine tubular filaments, termed *hyphæ*, which burrow through the substance of the potato-plant, and appropriate to themselves the substance of their host; while, at the same time, directly or indirectly, they set up chemical changes by which even its woody framework becomes blackened, sodden, and withered.

In structure, however, the *Peronospora* is as much a mould as the common *Penicillium;* and just as the *Penicillium* multiplies by the breaking up of its hyphæ into separate rounded bodies, the spores, so, in the *Peronospora*, certain of the hyphæ grow out into the air through the interstices of the superficial cells of the potato-plant, and develop spores. Each of these hyphæ usually gives off several branches. The ends of the branches dilate and become closed sacs, which eventually drop off as spores. The spores falling on some part of the same potato-plant, or carried by the wind to another, may at once germinate, throwing out tubular prolongations which become hyphæ, and burrow into the substance of the plant attacked. But, more commonly, the contents of the spore divide into six or eight separate portions. The coat of the spore gives way, and each portion then emerges as an independent organism, which has the shape of a bean, rather narrower at one end than the other, convex on one side, and depressed or concave on the opposite. From the depression, two long and delicate cilia proceed, one shorter than the other, and directed forward. Close to the origin of these cilia, in the substance of the body, is a regularly-pulsating contractile vacuole. The shorter cilium vibrates actively, and effects the locomotion of the organism, while the other trails behind, the whole body rolling on its axis with its pointed end forward.

The eminent botanist, De Bary, who was not thinking of our problem, tells us, in describing the movements of these "zoöspores," that, as they swim about, "foreign bodies are carefully avoided, and the whole movement has a deceptive likeness to the voluntary changes of place which are observed in microscopic animals."

After swarming about in this way in the moisture on the surface of a leaf or stem (which, film though it may be, is an ocean to such a fish) for half an hour, more or less, the movement of the zoöspore becomes slower, and is limited to a slow turning upon its axis, without change of place. It then becomes quite quiet, the cilia disappear, it assumes a spherical form, and surrounds itself with a distinct though delicate membranous coat. A protuberance then grows out from one side of the sphere, and, rapidly increasing in length, assumes the character of a hypha. The latter penetrates into the substance of the potato-plant, either by entering a stomate or by boring through the wall of an epidermic cell, and ramifies, as a mycelium, in the substance of the plant, destroying the tissues with which it comes in contact. As these processes of multiplication take place very rapidly, millions of spores are soon set free from a single infested plant; and from their minuteness they are readily transported by the gentlest breeze. Since, again, the zoöspores set free from each spore, in virtue of their powers of locomotion, swiftly disperse themselves over the surface, it is no wonder that the infection, once started, soon spreads from field to field, and extends its ravages over a whole country.

However, it does not enter into my present plan to treat of the potato-disease, instructively as its history bears upon that of other epidemics; and I have selected the case of the *Peronospora* simply because it affords an example of an organism, which, in one stage of its existence, is truly a "monad," indistinguishable by any important character from our *Heteromita*, and extraordinarily like it in some respects. And yet this "monad" can be traced, step by step, through the series of metamorphoses which I have described, until it assumes the features of an organism, which is as much a plant as an oak or an elm is.

Moreover, it would be possible to pursue the analogy further. Under certain circumstances, a process of conjugation takes place in the *Peronospora*. Two separate portions of its protoplasm become fused together, surround themselves with a thick coat, and give rise to a sort of vegetable egg called an *oöspore*. After a period of rest, the contents of the oöspore break up into a number of zoöspores like those already described, each of which, after a period of activity, germinates in the ordinary way. This process obviously corresponds with the conjugation and subsequent setting free of germs in the *Heteromita*.

But it may be said that the *Peronospora* is, after all, a questionable sort of plant; that it seems to be wanting in the manufacturing power, selected as the main distinctive character of vegetable life; or, at any rate, that there is no proof that it does not get its proteine matter ready made from the potato-plant.

Let us, therefore, take a case which is not open to these objections.

There are some small plants known to botanists as members of the genus *Coleochæte*, which, without being truly parasitic, grow upon certain water-weeds, as lichens grow upon trees. The little plant has the form of an elegant green star, the branching arms of which are divided into cells. Its greenness is due to its chlorophyl, and it undoubtedly has the manufacturing power in full degree, decomposing carbonic acid and setting free oxygen under the influence of sunlight.

But the protoplasmic contents of some of the cells of which the plant is made up occasionally divide, by a method similar to that which effects the division of the contents of the *Peronospora*-spore; and the severed portions are then set free as active monad-like zoöspores. Each is oval and is provided at one extremity with two long active cilia. Propelled by these, it swims about for a longer or shorter time, but at length comes to a state of rest, and gradually grows into a *Coleochæte*.

Moreover, as in the *Peronospora*, conjugation may take place and result in an oöspore; the contents of which divide and are set free as monadiform germs.

If the whole history of the zoöspores of *Peronospora* and *Coleo-*

*chæte* were unknown, they would undoubtedly be classed among "monads" with the same right as *Heteromita;* why, then, may not *Heteromita* be a plant, even though the cycle of forms through which it passes shows no terms quite so complex as those which occur in *Peronospora* and *Coleochæte?* And, in fact, there are some green organisms, in every respect characteristically plants, such as *Chlamydomonas*, and the common *Volvox*, or so-called "Globe animalcule," which run through a cycle of forms of just the same simple character as those of *Heteromita.*

The name of *Chlamydomonas* is applied to certain microscopic green bodies, each of which consists of a protoplasmic central substance invested by a structureless sac. The latter contains cellulose, as in ordinary plants; and the chlorophyl which gives the green color enables the *Chlamydomonas* to decompose carbonic acid and fix carbon, as they do. Two long cilia protrude through the cell-wall, and effect the rapid locomotion of this "monad," which, in all respects except its mobility, is characteristically a plant.

Under ordinary circumstances the *Chlamydomonas* multiplies by simple fission, each splitting into two or into four parts, which separate and become independent organisms. Sometimes, however, the *Chlamydomonas* divides into eight parts, each of which is provided with four instead of two cilia. These "zoöspores" conjugate in pairs, and give rise to quiescent bodies, which multiply by division, and eventually pass into the active state.

Thus, so far as outward form and the general character of the cycle of modifications through which the organism passes in the course of its life are concerned, the resemblance between *Chlamydomonas* and *Heteromita* is of the closest description. And on the face of the matter there is no ground for refusing to admit that *Heteromita* may be related to *Chlamydomonas*, as the colorless fungus is to the green alga. *Volvox* may be compared to a hollow sphere, the wall of which is made up of coherent Chlamydomonads; and which progresses with a rotating motion effected by the paddling of the multitudinous pairs of cilia which project from its surface. Each *Volvox*-monad has a contractile vacuole like that of *Heteromita lens;* and, moreover, possesses a red pigment-spot like the simplest form of eye known among animals.

The methods of fissive multiplication and of conjugation observed in the monads of this locomotive globe are essentially similar to those observed in *Chlamydomonas;* and, though a hard battle has been fought over it, *Volvox* is now finally surrendered to the botanists.

Thus there is really no reason why *Heteromita* may not be a plant; and this conclusion would be very satisfactory, if it were not equally easy to show that there is really no reason why it should not be an animal.

For there are numerous organisms presenting the closest resemblance to *Heteromita*, and, like it, grouped under the general name of "Monads," which, nevertheless, can be observed to take in solid nutriment, and which therefore have a virtual, if not an actual, mouth and digestive cavity, and thus come under Cuvier's definition of an animal. Numerous forms of such animals have been described by Ehrenberg, Dujardin, H. James Clark, and other writers on the *Infusoria.*

Indeed, in another infusion of hay in which my *Heteromita lens* occurred, there were innumerable infusorial animalcules belonging to the well-known species *Colpoda cucullus.*[1]

Full-sized specimens of this animalcule attain a length of between $\frac{1}{300}$ or $\frac{1}{400}$ of an inch, so that it may have ten times the length and a thousand times the mass of a *Heteromita.* In shape it is not altogether unlike *Heteromita.* The small end, however, is not produced into one long cilium, but the general surface of the body is covered with small, actively-vibrating ciliary organs, which are only longest at the small end. At the point which answers to that from which the two cilia arise in *Heteromita*, there is a conical depression, the mouth; and in young specimens a tapering filament, which reminds one of the posterior cilium of *Heteromita*, projects from this region.

The body consists of a soft granular protoplasmic substance, the middle of which is occupied by a large oval mass called the "nucleus;" while at its hinder end is a "contractile vacuole," conspicuous by its regular rhythmic appearances and disappearances. Obviously, although the *Colpoda* is not a monad, it differs from one only in subordinate details. Moreover, under certain conditions, it becomes quiescent, incloses itself in a delicate case or *cyst*, and then divides into two, four, or more portions, which are eventually set free and swim about as active *Colpodæ.*

But this creature is an unmistakable animal, and full-sized *Colpodæ* may be fed as easily as one feeds chickens. It is only needful to diffuse very finely-ground carmine through the water in which they live, and, in a very short time, the bodies of the *Colpodæ* are stuffed with the deeply-colored granules of the pigment.

And if this were not sufficient evidence of the animality of *Colpoda*, there comes the fact that it is even more similar to another well-known animalcule, *Paramœcium*, than it is to a monad. But *Paramœcium* is so huge a creature compared with those hitherto discussed—it reaches $\frac{1}{120}$ of an inch or more in length—that there is no difficulty in making out its organization in detail; and in proving that it is not only an animal, but that it is an animal which possesses a somewhat complicated organization. For example, the surface-layer of its body is different in structure from the deeper parts. There are two contractile vacuoles, from each of which radiates a system of vessel-like canals; and not only is there a conical depression continu-

[1] Excellently described by Stein, almost all of whose statements I have verified.

ous with a tube, which serve as mouth and gullet, but the food ingested takes a definite course and refuse is rejected from a definite region. Nothing is easier than to feed these animals and to watch the particles of indigo or carmine accumulate at the lower end of the gullet. From this they gradually project, surrounded by a ball of water, which at length passes with a jerk, oddly simulating a gulp, into the pulpy central substance of the body, there to circulate up one side and down the other, until its contents are digested and assimilated. Nevertheless, this complex animal multiplies by division, as the monad does, and, like the monad, undergoes conjugation. It stands in the same relation to *Heteromita* on the animal side, as *Coleochæte* does on the plant side. Start from either, and such an insensible series of gradations leads to the monad that it is impossible to say at any stage of the progress, Here the line between the animal and the plant must be drawn.

There is reason to think that certain organisms which pass through a monad stage of existence, such as the *Myxomycetes*, are, at one time of their lives, dependent upon external sources for their proteine-matter, or are animals, and at another period manufacture it, or are plants. And, seeing that the whole progress of modern investigation is in favor of the doctrine of continuity, it is a fair and probable speculation—though only a speculation—that, as there are some plants which can manufacture proteine out of such apparently intractable mineral matters as carbonic acid, water, nitrate of ammonia, and metallic salts, while others need to be supplied with their carbon and nitrogen in the somewhat less raw form of tartrate of ammonia and allied compounds, so there may be yet others, as is possibly the case with the true parasitic plants, which can only manage to put together materials still better prepared—still more nearly approximated to proteine—until we arrive at such organisms as the *Psorospermiæ* and the *Panhistophyton*, which are as much animal as vegetable in structure, but are animal in their dependence on other organisms for their food.

The singular circumstance observed by Meyer, that the *Torula* of yeast, though an indubitable plant, still flourishes most vigorously when supplied with the complex nitrogenous substance, pepsin; the probability that the *Peronospora* is nourished directly by the protoplasm of the potato-plant; and the wonderful facts which have recently been brought to light respecting insectivorous plants, all favor this view; and tend to the conclusion that the difference between animal and plant is one of degree rather than of kind; and that the problem, whether, in a given case, an organism is an animal or a plant, may be essentially insoluble.—*Macmillan's Magazine.*

# AN INTERESTING BIRD.

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KERGUELEN Island is in latitude 48°–49° south; longitude 70° east from Greenwich. That is to say, it is in the South Indian Ocean, about half-way between the Cape of Good Hope and Australia, but well to the southward of both. It is rather an archipelago than an island, innumerable small peaks being grouped around and in the estuaries of a central mass of volcanic rock, about ninety miles long by fifty wide, and shaped somewhat like a spider, of which its numerous long promontories and peninsulas represent the legs. Be-

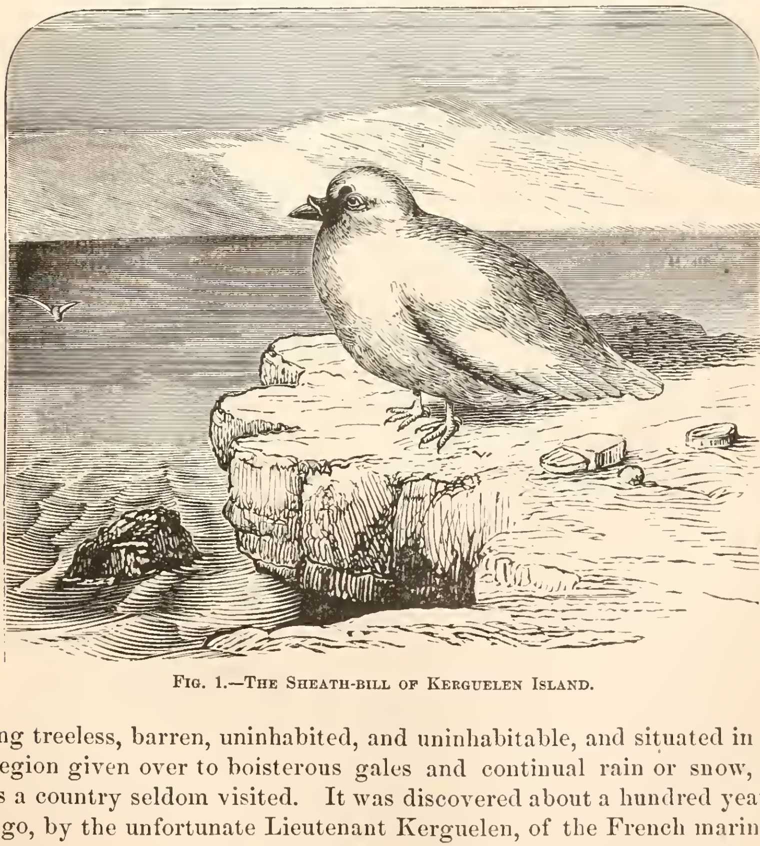


FIG. 1.—THE SHEATH-BILL OF KERGUELEN ISLAND.

ing treeless, barren, uninhabited, and uninhabitable, and situated in a region given over to boisterous gales and continual rain or snow, it is a country seldom visited. It was discovered about a hundred years ago, by the unfortunate Lieutenant Kerguelen, of the French marine, and about two years afterward found again by Captain Cook, who gave it the name of Desolation Island. During May, June, and July, 1840, Sir James Clark Ross remained there with the Erebus and Terror; and it is to this visit, and to the fact that Dr. Joseph D. Hooker was botanist to the expedition, that we owe our present full knowledge of the botany of the island. Had it not been long noted as a favorite breeding-place for the sea-elephant, and hence resorted to by scalers and whalers, it is doubtful whether any human being, other than the intrepid explorers already alluded to, would have cared to visit so desolate and forbidding a spot, until it came to be fixed upon as a locality whence the transit of Venus could advantageously be observed.

Lying, as this island does, upon the very skirts of the world, far removed from any large body of land, and so placed as to be very unlikely to receive additions to its flora and fauna by the agency of either winds or currents, it was to be expected that its natural history would present very many peculiarities, both of form and of adaptation. Its flora, accordingly, and invertebrate animal life include an unusually large number of genera and species peculiar to the island and its near neighbors; a fact which, considered in connection with its geological characters, has led some scientific men[1] to regard it as one of the few remaining peaks of a great Antarctic Continent, probably (judging from its botanical relations) once continuous with that of South America.

Even among birds there are at least two species not found elsewhere, one of which, the *Chionis minor* of Hartlaub, or White Paddy, sheath-bill, and "sore-eyed pigeon" of sealers and whalers, I propose to give a short account of.

It was first seen by the transit-of-Venus parties and ship's company of the Swatara on the 11th of September, 1874, as that vessel was steaming up Royal Sound toward the spot selected as the observing station of the Kerguelen part of the expedition. It was a very pretty white bird, of about the size and much the appearance of a large pigeon, which came flying over from the shore, and alighted on the keel of a boat that had been secured bottom-up at the stern-davits. It walked up and down the keel of the boat, turning its head from side to side, and examining with great curiosity the crowd of interested spectators gathered on the poop, but showing not the slightest fear. After a few minutes it flew back again, with a note, while flying, not unlike the "chat-chat" of the common blackbird. That afternoon several were caught without difficulty; some were knocked down with stones, and some were actually taken, unhurt, by hand, being approached very gradually, and fed with crumbs until they came within reach.

The nearer examination thus afforded gave us a plump bird, much like a pigeon in size and shape, of pure white, very soft and downy plumage, and with bright black eyes, surrounded by a quite distinct,

[1] *See* "Flora Antarctica," by Dr. J. D. Hooker (London, Reeve Brothers, 1847), vol ii., pp. 210–220, *inter alia*.

pale-pink eyelid (whence the name "sore-eyed pigeon"). The bill was black, conical, and very strong; the nostrils oval, placed at about the centre of the bill, and directed fore-and-aft. Covering just half of the nostril on each side was the curved anterior edge of a saddle-shaped horny sheath (Fig. 2), also black, and bestriding the posterior half of the bill. The pommel of the saddle was canted upward, so as to clear the bill by about three-tenths of an inch; its cantle was lost in the short feathers covering the forehead, and the flaps continued downward on each side, becoming soldered to the upper mandible

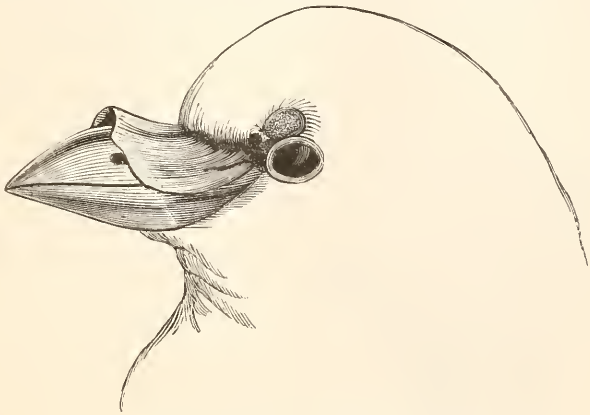


Fig. 2.—Head of Chionis Minor.

near its base. On each side they sent up a black fleshy process (caruncle), deeply pitted with holes, which lay in contact with the upper eyelid. And, a fact not before observed, on clipping away the forehead-feathers, this black fleshy mass was found to extend entirely across the forehead, like the upper part of a black-silk domino, the little feathers which hide it during life passing through the holes with which it was everywhere pitted (Fig. 3). The legs were stout, pale flesh-colored, and scaly, with large, pavement-like knobs, but not what ornithologists call "scutellated," excepting over the upper surfaces of the toes. There were four toes, the first or hinder one being of good size for a hind-toe, and elevated above the rest, arising a little to the inner side of the leg. The claws were large, blunt, and black, and on the wrist-joint of each wing was a small black knob, like a spur (flesh-colored in females and young birds), which was afterward found to be supported by a distinct bony process, or exostosis, from the bone of the wing. The tail was very slightly rounded, and composed of twelve feathers—the wing-primaries were ten, and the first three of equal length.

It may be as well to mention here that this species was erected by Dr. Hartlaub in 1841, when he wrote to the *Revue Zoölogique*[1]

[1] *Revue Zoölogique*, 1841, p. 5.

that he had found in the museum at Leyden a new species of chionis, "patrie inconnue." He called it *Chionis minor*, and distinguished it from Forster's *Chionis alba*, described in 1788, as being of smaller size, having a *black* bill and sheath, and a fleshy process of the same color over the eye. He also noted the color of the thickened eyelid and of the legs, and gave measurements of the principal dimensions. In 1842 [1] appeared in the same journal a drawing of the head of the Leyden specimen, also from Dr. Hartlaub.

In 1849 it was figured by G. R. Gray,[2] being classed by him with the *Gallinæ* or fowl order, and associated with two other curious ant-

FIG. 3.—BILL OF CHIONIS, WITH FRONTAL FEATHERS CUT AWAY, TO SHOW THE CARUNCLE.

arctic genera, called *Thinocorus* and *Attagis*. It would seem probable that Gray's drawing was made from the Leyden specimen also, since I have been able to find a record of only three other individuals (besides the eleven specimens brought to the National Museum by myself), all of which were sent to the Zoölogical Society. These were: a living specimen sent from Cape Town by Mr. Layard, of which the skin was exhibited to the society by Mr. Sclater, November 28, 1867;[3] and two skins received October 26, 1868,[4] also from Mr. Layard. All three of these specimens came originally from the Crozet Islands, which lie about six hundred miles to the west of Kerguelen, and present substantially the same natural history characteristics.

[1] *Revue Zoölogique*, 1842, pl. 2, Fig. 2.

[2] "Genera of Birds," 1849, p. 522.

[3] "Proceedings of Zoölogical Society," 1867.

[4] Ibid., 1868.

An egg was received by the Zoölogical Society[1] in January, 1871, and described by Mr. Alfred Newton as the first of either species of the genus ever known, overlooking Mr. Layard's description of the egg of *C. minor* published in 1867.[2] Schlegel gives a figure and some description,[3] which I suppose, from the date, to refer also to the Leyden specimen, but have not yet been able to get access to the article.

If there ever were any other specimens, I have not been able to find the record of their receipt; and, whether there be or not, it is very evident that the birds are but little known to science, since the history of the species can be summed up in so few lines.

During a four months' residence on Kerguelen Island I had ample opportunity for observing the habits of the few living things which inhabited it, and none were more interesting in their ways than the chionis. Two or three lived near our huts, frequenting the rocks along the shore between tides. They were particularly plentiful upon a bold promontory called Malloy's Point, where many cormorants nested; and at another place, some two miles away, where the *débris* broken off from lofty, precipitous cliffs had made a sort of "lean-to" of irregular fragments of rocks. Here, likewise, was a nesting-place for cormorants, and also a great rookery of the curious "rock-hoppers," or crested penguins. These two birds were the chosen companions of the chionis, which lived with them on terms of perfect friendship and close association. One day (October 15th), seeing a large number of white specks on the farther side of Malloy's Point, I began to approach them very cautiously, so as to watch their movements at closer quarters. Caution proved, however, to be quite thrown away in that instance, since so great was the curiosity of the birds that they would scarcely get out of my way. When I finally sat down upon a rock and kept perfectly still for a few moments, they crowded around me like a mob of street-boys around an organ-grinder. Others flew up from more distant rocks, apparently called by the short, rattling croaks of those already near, and some came almost within reach of my arm. All seemed perfectly fearless and trustful, and very unlike in this respect to any other birds that I had ever seen. They ran with great swiftness over the rocks, stopping now and then to peck at a common green sea-weed (*ulva*), upon which they seemed to feed, shaking the water from it by a rapid, flirting motion of the bill. In running over the rocks they rather avoided the little pools of water left by the tide, seeming to dislike wetting their feet.

After sufficient time spent in observation, I changed the cartridges in my gun for others loaded with small shot, and moved off, so as to get far enough away to shoot two or three without tearing the skins; not without a good deal of compunction at destroying their friendly

[1] "Proceedings of Zoölogical Society," 1871, p. 57. [2] Ibid., 1867, p. 458.

[3] Handl. Dierk., pl. 5—De Dierk., Fig., p. 232.

illusions. The interest of all was at once renewed; some started to follow me, making little swift runs and stopping short to look. Even after one had been shot they seemed rather startled than frightened by the noise of the gun. A few flew off for a short distance, but most remained, looking from me to the dead bird with great surprise, so that I was enabled to secure four specimens without moving from where I stood.

On subsequent occasions several specimens were captured alive, by hand, all that was necessary being to remain perfectly still, and feed them with bread-crumbs until they ventured within reach. When brought home, and let loose within-doors, they still showed no fear, running about the room actively, eating freely what was given them, and, oddly enough, fighting fiercely among themselves (a habit which I never observed an instance of when they were in the open air), but never using their wing-spurs as weapons. We put several of them into an extemporized coop, where they fought and pecked at the woodwork all night, chirping the while so like chickens that I once got up, thinking that some of our fowls had been fastened into the house. When shut up in this way they bore the confinement very illy, beating themselves constantly against the bars of the cage, and pecking fiercely at the woodwork. They would often stay around the house for several days, however, when let loose, running with our chickens and feeding with them like tame pigeons. One, whose wing had been clipped, remained for a week or more, but finally wandered off and was killed by the great southern skua which fills the place of a hawk in those regions.

Cuvier,[1] on the authority of Vieillot, attributes to the larger species a propensity for carrion, and a power of erecting the horny sheath, neither of which characters was to be found in those which we observed. The Australian species (identical with *Chionis alba* of Forster[2]) was named *C. necrophaga* by Vieillot on this account, but our chionis was one of the very few birds never found feeding on carrion. It was quite omnivorous in its diet, taking with equal readiness bread, vegetables, and fresh meat. The sheath was found to be firmly soldered to the base of the upper mandible, and therefore could not possibly be erectile.

About the middle of December (midsummer in the antarctic region) the sheath-bills began to break up into pairs, and to show signs of breeding. I never was so fortunate as to find a completed nest, although I often observed the pairs frequenting the crevices of fallen rocks, as if preparing to build. By the sealers, of whom several visited the island during our stay, I was informed that they build in the localities that I had attributed to them, constructing a nest of grass-stems, and laying three party-colored eggs; moreover, that they are exceedingly dexterous in misleading the egg-hunter as to the

[1] "Animal Kingdom," London, 1849, p. 250. [2] *Vide* "Genera of Birds," Gray, *loc. cit.*

locality of their nests. The Rev. Mr. Eaton, naturalist to the English party, kindly gave me an egg which he had found on the day of our breaking up camp, January 10th, it being one of a nest of three, and evidently very fresh. It is a large egg, rather less than a hen's, pointed like a Guinea-fowl's, and marked by streaks and blotches of different shades of brown, which are said to vary much in hue in different specimens.

The sheath-bill is not only "an interesting bird" to know, on account of its trustful and familiar habits, but has been something of a puzzle to ornithologists from the time of its first description, by Forster, in 1788.[1] Up to 1841 his species, *C. alba* (*necrophaga*, Vieillot) was the only one known, and has been quite variously classified. By G. R. Gray it was placed as a member of the fifth family (*Chionididæ*) of the order *Gallinæ*, a place retained for it in the British Museum Catalogue. Bonaparte associated it with gulls and petrels, as a member of his tribe *Longipennes*, order *Gaviæ;* and De Blainville,[2] after a careful anatomical examination, decided that its nearest affinities were with the *Oyster-catchers* (*Hæmatopus*). This last decision has been accepted as final by ornithologists in general. Mr. W. K. Parker[3] thus refers to another relationship: "There are certain curious, thoroughly *marine* plovers (chionis), in which the sheathing of the upper jaw is very perfect; they thus retain a struthious character, but have it in an exaggerated condition." Were this a proper place for the discussion of osteological details, it would be easy to point out other characteristics that might show a very plausible affinity of chionis to the *ostrich!*

Not to go deeply into the troubled and doubtful sea of the various grounds of classification of birds, it will perhaps not be out of place to mention some of the principal groups of characteristics upon which we rely to determine the place in Nature of any particular bird. First, there are the external parts: bill, eyes, plumage, feet, legs, etc., relied upon almost entirely by the older writers, and likely to hold their own, because of their convenience, for a long time yet. Then there is the digestive system, indicating also some of the affinities based upon *habit.* Third, and doubtless most to be relied upon, the structure of the skeleton, particularly of the skull (Huxley) and sternum, and the variations in muscular form and attachment. Last, but by no means, in my opinion, least, the habits and behavior of the bird during life.

Considered as to externals only, we find *Chionis minor* with the general form of a pigeon, the beak of a crow, surmounted by a sheath declared to be a characteristic of the ostrich family, with stout, knobby, short legs and feet, four-toed like a fowl's, but bare for a little way

[1] "Enchiridion Hist. Nat. Ins.," p. 37.

[2] "Sur la place que doit occuper dans le système ornithologique le genre *Chionis*, ou Bec-en-fourreau," De Blainville, Ann. Sc. Nat., 1836, vi., p. 93.

[3] "Osteology of Gallinaceous Birds," "Transactions of Zoölogical Society," p. 206.

above the heel like a wading-bird. The "contour feathers" have a large downy "after-shaft," a characteristic of gallinaceous birds, and there is a thick, wattle-like caruncle on the forehead, a common feature of the swan family.

The intestinal canal presents first a large *crop*, a rather long *proventriculus* or true stomach, well furnished with tubular follicles, a decidedly muscular gizzard or grinding-stomach, and two long appendages, the cæca, all features which are characteristic of gallinaceous birds. On the other hand we find the gastric follicles large and tubular, more like those of the swan than of any other that I know of, and quite unlike the lobulated follicles of the *Gallinæ*. The tendinous parts of the gizzard, moreover, are at the *sides*, instead of before and behind as is the (almost ?) universal rule.

It would probably be neither interesting nor profitable to recapitulate here the various resemblances to and differences from other families, presented by the bony framework of the chionis. The features of the skull are pretty evenly balanced between those characteristic of the plovers and of the gulls, with a slight sprinkling of the ostrich. The breastbone, a part to which great importance is attached by ornithologists in the determination of affinities, is decidedly like that of the gull family, between which and the plovers, considering only the skeleton, the genus must probably be placed, as De Blainville has already decided. That is to say, on summing up the various osteological peculiarities which mark the skeleton of this very composite bird, the greatest number is found to lie on the gull side.

Considered with regard to habits, however, the confusion grows worse again. It looks and flies like a pigeon, croaks like a crow, "chats" like a blackbird, or (in confinement) chirps like a fowl. It lives, to be sure, upon the seacoast, and feeds largely upon small marine animals and seaweed ; but it dislikes wading, becomes perfectly helpless when accidentally in the water, and has no idea of swimming. Its diet is as various as that of fowls, and like them it swallows numbers of pebbles to aid digestion. Its natural tendencies seem to be toward domestication, or at least companionship with man. Like the plants of Kerguelen, it finds its nearest relatives in Patagonia, although Africa is so much less distant. How shall we explain all these incongruities ? Perhaps it represents an older, more synthetic form, from which *Gallinæ*, *Waders*, and *Gulls*, are descended, preserving its own identity by its isolated habitat. Perhaps, as the ostrich represents an ancestral type, its apparent struthious characters may indicate real relationship after all, handed down from that distant time when all birds were more nearly allied than now. Since there certainly once was a time when Kerguelen Island, perhaps then part of a continent, was habitable, when the tree trunks that are now lying buried in its northern hills were upright and flourishing forests, perhaps the men of those days had also a bird tamed, like the domestic fowl ; and perhaps the chionis is descended therefrom, and its liking for man is an inherited tendency.

Mr. Darwin exactly expressed the present attitude of this bird to science, as long ago as the voyage of the Beagle. He found a bird in Patagonia (*Thinochorus rumicivorus*) which "nearly equally partakes of the characters, different as they are, of the quail and snipe," and in this connection proceeds to remark: "A bird of another closely-allied genus, *Chionis alba*, is an inhabitant of the antarctic regions; it feeds on seaweed and shells on the tidal rocks. . . . This small family of birds is one of those which from its varied relations to other families, although at present offering only difficulties to the systematic naturalist, ultimately may assist in revealing the grand scheme, common to the present and past ages, on which organized beings have been created."

## THE PROPOSED INLAND SEA IN ALGERIA.

By JOHN D. CHAMPLIN, Jr.

AMONG the most revolutionary of the geographical schemes of the day are the projects of flooding portions of the African Sahara, and thus restoring to the sea what was once an integral part of it. In the Pliocene period, according to Sir Charles Lyell, the great desert was under water between latitudes 20° and 30° N., so that the southeastern part of the Mediterranean communicated with that portion of the Atlantic now bounded by the west coast of Africa. This is indicated not only by the presence of marine shells and other remains throughout the Sahara, but also by the radical difference between the fauna and flora north and south of it. What was formerly separated by a barrier of water is now separated by a barrier of sand.

There are two principal depressions in the Sahara, the basin called El-Juf, in the Sahel, north of the Middle Niger, which covers an area of about 126,000 square miles, and that of the *shotts* in the Algerian Sahara.

Mr. Donald Mackenzie, a British engineer, who has investigated the former depression, affirms that a long valley extends from its northwest corner to the Atlantic coast opposite the Canary Islands. It is only necessary, he argues, to cut through the accumulated sands at its mouth, which is laid down on the maps as the river Belta, to let in the waters and flood the entire basin. This scheme, advocated by Mr. J. A. Skertchly, General Sir Arthur Cotton, and others, will probably result in a thorough exploration of that part of the Sahara and its alleged outlet. The other project is in a more advanced state.

The depression of the *shotts* lies at the foot of the Aures Mountains, spurs of the main chain of the Atlas, partly in the province of Constantine in Algeria, and partly in Tunis. Its western extremity is in latitude 34° 30′ N., longitude 5° 65′ E., and it extends thence eastward two hundred and thirty-five miles to within about thirteen miles of the foot of the Gulf of Cabes, or Gabes, in the Mediterranean, anciently the Lesser Syrtis, from which it is now separated by an isthmus of sand. The breadth of the depression is about thirty-seven miles. Within these limits lie several connected lake-beds, called by the Arabs *shotts* or *sebkas*, *shott* signifying properly the bottom of a lake left dry by evaporation, and *sebka* a saline marsh. The largest of these are Shotts Melrir, or Melgig, whose eastern extremity is called Es-Selam, El-Rharsa, or Gharsa, and El-Jerid, or Fejej. About one-half is in French territory, the Tunisian boundary line cutting the western bank of Shott El-Rharsa.

This great depression is supposed to mark the site of the lake of Triton, or Tritonis, mentioned by Herodotus, Scylax, Pomponius Mela, Ptolemy, and other ancient writers, and around which were localized the Greek divinities Poseidon and Athena, and the Argonautic myth. Into it was driven the good ship Argo, when blown from her course around the Malean promontory by an adverse wind. Jason, lost among the shallows, propitiated the local divinity, Triton, son of Poseidon, by presenting him with the brazen tripod, whereupon the god, filled with prophetic heat, foretold that a hundred Grecian cities would spring up around Tritonis whenever a descendant of the Argo's crew should seize and bear away the precious gift. Through the foresight of the subtle Libyans, who hid the tripod, the prophesy was unfulfilled, but many noble cities were afterward built north and east of Tritonis, and along the coast of Syrtis Minor. Indeed, so numerous were they, and so flourishing as trade-centres, that the country was named Emporia. All the ancient writers agree in praising it for its wonderful riches and fertility. Says Scylax: "This region, which is occupied by Libyans, is most magnificent and fertile; it abounds in fine cattle, and its inhabitants are most beautiful and wealthy." It was within the dominion of Carthage, and here were the storehouses and granaries from which Rome's great rival supplied her troops.

But now all is changed. The drying up of the ancient sea has deprived the land of its moisture, and the once fertile plain between the mountains and the north bank of the *shotts* is, with the exception of a few oases, a sterile waste. Nothing remains to tell of former greatness but ruins, which are said to be scattered over the country far up into the mountains.

Herodotus, the most ancient writer by whom Tritonis is mentioned, says that it was fed by the great river Triton; but modern research has failed to identify it, there being now but a few rivulets which enter it from the mountains on the north, or lose themselves in the desert. If there ever was a great river flowing into it, its bed has been obliterated by the shifting sands.

At a later date Tritonis appears as three connected lakes, called, respectively, Libyca, Pallas, and Tritonis, which some recognize in the Shotts Melrir, El-Rharsa, and El-Jerid. It is probable that the mouth became gradually blocked up with sand, and the lake, no longer receiving sufficient water from the Mediterranean to supply the waste from evaporation, separated into several smaller seas, which, by continued desiccation, became transformed at last into their present condition. When this took place can only be conjectured, but it was probably in the early centuries of the Christian era. The Arabs preserve the tradition that Shott Es-Selam was a lake at the time of the Mussulman conquest. They also aver that the lake bed has not been covered with water during the past hundred years.

Although it has long been known that this desert basin was lower than the Mediterranean, nothing was positively settled in regard to it until 1873, when Captain Roudaire, a staff officer of the French army in Algeria, ascertained the altitude of Biskra, and by a series of levelings from that point proved that the western extremity of Shott Melrir was twenty-seven metres, or nearly eighty-nine feet, below the level of the sea. The publication of his investigations and an exhaustive discussion of the probabilities of success in reopening the ancient lake, in the *Revue des Deux Mondes* (May, 1874), aroused interest in the project in hope not only of reclaiming the country, but also of opening a commercial avenue to Southern Algeria. The French have long sought to deflect the caravan trade of Middle Africa, which is now mostly monopolized by Morocco and Tripoli, to Algiers, but in vain, the increase in prices to be obtained in Algiers not being sufficient to compensate for the increase in distance. But with an inland sea the circumstances would be changed. The country around it would resume its ancient character of a littoral province, and the caravan routes of the Sahara would converge toward a port established on its southern border, whence the gold dust, ivory, gums, and ostrich feathers of Soodan would be shipped directly to Europe to the detriment of the Mohammedan markets. Tougourt, too, the French military post in southern Algeria, now distant nearly two hundred and fifty miles from the port where its provisions are landed, would then be only about forty miles from the sea.

Captain Roudaire discusses also the probable climatic changes which would ensue from reopening the Bay of Triton. He argues that the northwest winds, which prevail in summer, would be less violent than now, and the southwest winds, which blow during the remainder of the season, would be charged with vapor and cause a greater fall of rain in Algeria, Sicily, and South Italy, without materially modifying the climate. This increased rainfall would restore the land to its ancient fertility, and the region of the *shotts* would again become the home of a thriving population and the granary of North Africa.

To flood the *shotts* would require only the piercing of the isthmus between El-Jerid and the Gulf of Cabes. This is about thirteen miles wide; but Captain Roudaire thinks that the curve of altitude would reach zero at about eleven miles from the Mediterranean, which would materially reduce the amount of excavation. As the evaporation would be much greater than in the Mediterranean, a large and constant flow of water from the latter would be necessary to keep it at its proper level. This would require a canal at least one hundred yards wide, which could be constructed, it is calculated, at a cost of twenty million francs. To this amount would have to be added a sufficient sum to compensate for the destruction of property in the Tunisian part of the depression, which would ensue from its submersion. Besides the towns of Nefta and Tozer, there are many douars, or villages, in the oases, surrounded by cultivated lands and date plantations. These are generally in the lowest part of the depression, for there only can potable water be found, the higher land being without springs.

The superior council of Algeria, comprehending the immense advantages which would accrue to the colony from the consummation of this scheme, voted in 1873 a sum sufficient to continue the survey, and a well-appointed expedition, under command of Captain Roudaire, made a thorough examination of the bed of the Algerian portion of the *shotts* in the following year. The French Geographical Society, taking a national as well as a scientific interest in the question, also contributed money in furtherance of the object, and deputed M. Duverrier, one of its members, to accompany the party. The expedition entered the depression on the northwest side of Shott Melrir. The soil there is sand and marl, charged with salt. The many streams which traverse the country have, with a few exceptions, no running water, excepting in winter and spring, the season of rains and of the melting of snow in the mountains. These rivers usually divide, before reaching the *shotts*, into several branches, which again subdivide and form innumerable ramifications. Where these begin to disappear, the soil, which is charged with salt and almost bare, swells and cracks, and the water sinks, when the crust reforms. Farther east are naked plains of marl, level and smooth, and covered with a white incrustation which produces frequent mirages. On the extreme west the river beds enter Shott Melrir with separating. On the south side are sand hills and moving sands.

All the *shotts* are alike in general features. All have flat bottoms with an inclination too slight to be perceptible to the eye, and all form basins which receive water-courses. The soil of all contains a great quantity of salt, which whitens their bed in dry places. But each has its peculiarities. The west end of Melrir has a bottom of sandy earth, strewed along the borders with small round and polished quartz pebbles. Near the banks is a meagre salsuginous vegetation. In the interior its bed is clay, filled with crevices, but moist; farther on the crevices close and the saturated marl and clay form quagmires in which horse and rider might be swallowed up.

The eastern end of Shott Melrir, which is called Shott Es-Selam, presents other general characteristics. Near the banks the bed is sandy, but toward the middle it forms a hard crust of salt and sand. Elsewhere the soil is a hard surface of clay, which shines in the sun. Mirage is very frequent in this *shott.*

Between the Shotts Es-Selam and El-Rharsa the expedition first began to encounter obstacles which may seriously interfere with the projected inland sea. In the intervening country are numerous smaller *shotts*, of which that called Mouia-el-Tadjer is the largest. This shott has a long extension stretching southward, called El-Hadjila, connected with which on the east is Shott Mouia-el-Tofla. Measurements in the highest part of the bed of the latter showed it to be more than eleven feet above the level of the sea. A low ridge separates it from Shott El-Asloudg, the western border of which is only between six and seven feet below the sea, and the eastern about twelve feet. Between this and Shott Bou Dhouil, which is little more than eight feet above the sea, is an extended ridge of sand. Bou Dhouil is but a short distance from the Tunisian frontier and the great Shott El-Rharsa. At this point the expedition ceased its labors and returned to Biskra, convinced that a secondary canal connecting El-Rharsa and Melrir, or some of the *shotts* belonging to its system, would be necessary before the proposed inland sea could be extended far enough west to benefit Algeria. This would entail a considerable additional expense, but whether large enough to seriously affect the realization of the scheme cannot be known until the publication of the official reports.

This expedition made no investigation of the Tunisian portion of the depression, being evidently under the impression that no insurmountable obstacle existed in that part. Whether this belief was founded on the accounts of the ancient geographers or on an actual knowledge of the country is not apparent, but it is said that levels were taken from Shott El-Jerid to the Mediterranean several years ago by Captain Pricot de Sainte Marie, of the staff of the French army in Algeria. His report, which is deposited in the archives of the Ministry of War in Paris, must have been favorable, else the survey of the Algerian *shotts* would scarcely have been undertaken.

It is reported, however, on the contrary, that a survey was made of the same isthmus in 1874 by M. Fuchs, a French geologist employed by the government of Tunis to investigate the mineral resources of the country, who discovered that physical obstacles exist of a nature to render a canal impossible; that a range of sandstone hills lies between El-Jerid and the sea, and that the bed of El-Jerid itself is considerably above the sea. If this be true, not only is the proposed inland sea an impossibility, but we must also relegate to the domain of fable the accounts of the great lake of Tritonis, or assign it to another locality.

## ANIMAL PARASITES AND MESSMATES.

THE fight for a foothold in the animal world brings the combatants into many strange relations, few of which are more curious and interesting than those existing between the creatures popularly known as parasites and the animals which furnish them support. In these relations all grades of pauperism and criminality are represented. There is the miserable wretch that lives entirely at the expense of others, finding it easier to die than to help himself; the poor weakling, willing enough to do what he can, but sure to starve to death if left wholly unassisted; the petty thief that sneaks into his neighbor's premises and steals a portion of his store; and the audacious robber that boldly appropriates another's substance, and not unfrequently adds murder to his list of crimes. In his entertaining and instructive work on "Animal Parasites and Messmates,"[1] from which this article and its illustrations are mainly taken, Van Beneden makes these different degrees of dependence the basis of a rough but convenient classification, by which he separates, what have hitherto been known as parasites, into three groups, named respectively *messmates*, *mutualists*, and *parasites*.

The messmate is one that takes his place at his neighbor's table to partake with him of the product of the day's toil. He does not live directly at the expense of his host, but, abiding with him, obtains thereby better opportunities for securing a supply of food. This mode of getting a living is very common, and a curious thing about it is that animals comparatively high in the scale of organization do not scruple to quarter themselves upon others of much inferior grade. The fish known to naturalists as fireasfer lives in this relation. He takes up his lodgings in the digestive tube of a holothurian, and, regardless of the rules of hospitality, appropriates a portion of all the food that enters. He thus manages to get himself served by another better provided than he is with the means of fishing. Dr. Greef found at Madeira a holothurian over a foot long, in which one of these fishes was enjoying a peaceful and vigorous existence. Other fishes besides the fireasfer have been found in similar quarters; indeed, the situation appears a very favorable one for this mode of life, since not only fishes but crustaceans here take up their abode, sometimes in considerable numbers. Prof. Semper has seen holothuriæ in the Philip-

[1] No. XIX. "International Scientific Series," New York, D. Appleton & Co., 1876.

pine Islands which bore considerable resemblance in this respect to a hotel with its *table-d'hôte.*

A somewhat more excusable piece of pauperism is found in the case of an eel, which ensconces itself in the branchial sac of that curious fish known as the angler, or fishing-frog (Fig. 1), where he afterward plays the part of a messmate. Although the eels generally

FIG. 1.—THE ANGLER-FISH.

get their living easily, the angler possesses fishing-implements which are wanting in them, and, when immersed in the ooze, it carries on a fishery sufficiently abundant for both. This relationship was first observed by Risso in the Mediterranean; the same fish in more northern seas has since been found to harbor, in like manner, an amphipod crustacean.

Another remarkable example of this kind of association among fish was made known by Reinhardt, of Copenhagen. A siluroid fish occurring in Brazil, and possessed of numerous barbules that make it successful as a fisherman, lodges in the cavity of its mouth some very small fishes, that for a long time were supposed to be young siluroids; it was believed that the mother brought her progeny to maturity in the mouth, as marsupials do in the abdominal pouch, or as some other fishes do. But this is a mistake. The supposed young are perfectly developed adult fish, that, instead of living by their own labor, prefer to install themselves in the mouth of a neighbor, and take tithes of the morsels which he swallows.

The little crab that makes its abode within the shell of the edible oyster (Fig. 2) is a true messmate, and the oyster is but one of many bivalve mollusks that give shelter and partial support to these diminutive crustaceans. These crabs, called by naturalists *Pinnotheres*, though in one sense dependents, are at the same time of great service to the animals within whose shells they receive protection. Van Beneden says of them: "The pinnothere is a brigand who causes himself to be followed by the cavern which he inhabits, and which opens only at a well-known watchword. The association redounds to

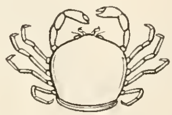


Fig. 2.—Oyster Crab.[1]

the advantage of both; the remains of food which the pinnothere abandons are seized upon by the mollusk. It is the rich man who installs himself in the dwelling of the poor, and enables him to participate in all the advantages of his position. The pinnotheres are, in our opinion, true messmates. They take their food in the same waters as their fellow-lodgers, and the crumbs of the rapacious crabs are doubtless not lost in the mouth of the peaceful mussel. . . . Little as they are, these crabs are well furnished with tackle and advantageously placed to carry on their fishery in every season; concealed in the bottom of their living dwelling-place, they choose admirably the moment to rush out to the attack, and always fall on their enemy unawares. Some pinnotheres live in all seas, and inhabit a great number of bivalve mollusks."

In the examples thus far cited, and in many more that have been observed, the dependent forms are free to depart whenever they choose, and are therefore called *free messmates*. Though for a time giving up their liberty, they sooner or later resume it, in possession of all their organs for fishing and locomotion, and in all respects fitted to live an independent life. There are others, however, that enter into the same sort of association, and make the relation a permanent one: these are known as *fixed messmates*. They are free in their youth, but, as maturity approaches, and the cares of a family are thought of, a host is selected in which they establish themselves, and, throwing aside their fishing and locomotive apparatus, they renounce the world, and even part with the most precious organs of animal life, not excepting those of the senses.

[1] From Morse's "First Book of Zoölogy."

The most interesting fixed messmates are those cirripeds or barnacles which, under the names of *Coronula* and *Tubicinella* (Figs. 3 and 4), cover the skins of whales. They are, like all the rest, free while young, but later they take shelter on the back or on the head of one of these huge cetaceans, and, having once chosen their abode, are afterward permanent tenants. Each whale lodges a particular species, and

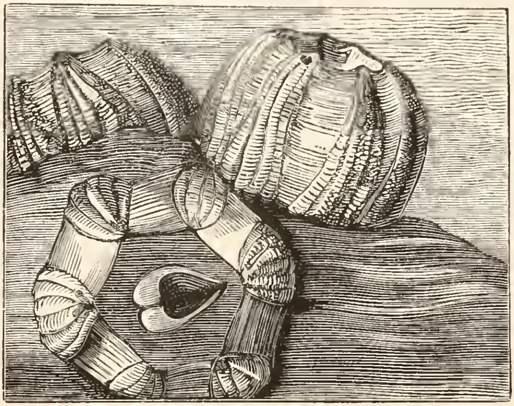


FIG. 3.—CORONET BARNACLE (*Coronula diadema*).

the manatee, marine turtles, and various sea-snakes, have also their different sorts. Others establish themselves on their own immediate relations and on other crustaceans. A pretty genus found near Cape Verd, living on the carapace of a large lobster, spreads itself over the

FIG. 4.—BURROWING BARNACLE (*Tubicinella trachealis*).

centre of the lobster's back, and looks not unlike a bouquet of flowers. Fig. 5 shows a fixed messmate attached to a sertularian.

Mutualists, as the name suggests, are animals which live on each other; and, though usually confounded with messmates and parasites, they differ from both in making some sort of return for benefits obtained. Many insects shelter themselves in the fur of the mammalia or in the down of birds, and remove from the hair or the feathers the pellicle and epidermal *débris* which encumber them. At the same time they minister to the outward appearance of their host, and are of great use to him in a hygienic point of view. Animals living in the water are similarly served by minute crustaceans. These sometimes establish themselves on fishes, and, if there are no scales of the epidermis which annoy them, there are mucosities which are incessantly renewed in order to protect the skin from the continual action of the water. Among the insects found on the skins of mammals and birds that yield some return for the hospitality they receive, those belonging to the family *Riciniæ*, and commonly known as ticks, are very numerous. Among the many generic divisions, one of the most interesting has received the name of *Trichodectes;* it contains twenty species, one of which lives on the dog, another on the cat, another on the ox; in a word, there is a distinct species on each of the domestic mammals. The species infesting the dog has lately attracted especial attention, from the circumstance that it lodges the larva of the *Tænia cucumerina*, a tapeworm common to dogs. The cock, the turkey, and the peacock, carry each a distinct species of *Riciniæ*, and oftentimes several species are found on a single bird. Fig. 6 represents a form which infests the pygarg or sea-eagle.

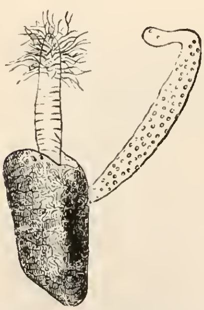


Fig. 5.—Ophiodendrum Abietinum on *Sertularia abietina.*

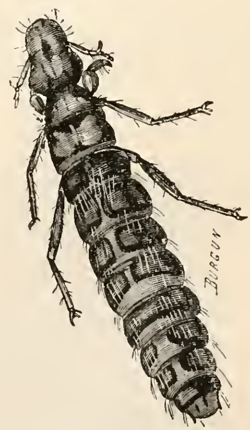
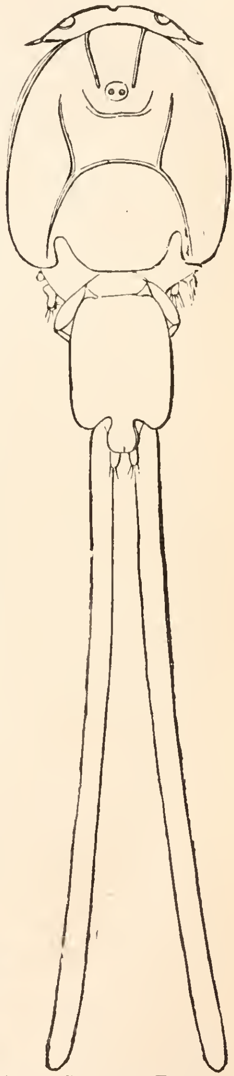


Fig. 6.—Ricinus of the Pygarg.

Fishes harbor crustaceans instead of insects, frequently in enormous numbers. They live on the produce of cutaneous secretions, and thus, like the ticks, are of service to their hosts. The *Caligi* and *Arguli*, known usually as fish-lice, are among the most common of these, and both are elegant forms, that change but little in appearance in the course of their lives, and, although permanent tenants when once established, they retain their fishing-tackle and locomotive apparatus. The greater number of osseous fishes lodge *Caligi* on the surface of their skin, where the tiny creatures fix themselves by means of strong cables. Fig. 7 represents a species that lodges on the cod, and it in its turn affords a resting-place for another form—the *Udonellæ*.

A curious creature, with an equally curious function, that entitles it to a place among mutualists, was discovered some years ago among the eggs of the lobster, by Van Beneden, who thus describes it: "It is known that lobsters, as well as crabs, and the greater part of the crustacea, carry their eggs under the abdomen, and that these eggs remain suspended there until the embryos are hatched. In the midst of them lives an animal of extreme agility, which is, perhaps, the most extraordinary being that has been subjected to the eyes of the zoölogist. It may be said, without exaggeration, that it is a biped, or even quadruped, worm. Let us imagine a clown from the circus, with his limbs as far dislocated as possible, we might even say entirely deprived of bones, displaying tricks of strength and activity, on a heap of monster cannon-balls which he struggles to surmount; placing one foot, formed like an air-bladder, on one ball, the other foot on another, alternately balancing and extending his body, folding his limbs on each other, or bending his body upward like a caterpillar of the *Geometridæ*, and we shall then have but an imperfect idea of all the attitudes which it assumes, and which it varies incessantly. It is neither a parasite nor a messmate; it does not live at the expense of the lobster, but on one of the productions of these crustaceans, much in the same manner as do the *Caligi* and the *Arguli*. The lobster gives him a berth, and the passenger feeds himself at the expense of the cargo; that is to say, he eats the eggs and the embryos which die, and the decomposition of which might be fatal to his host and his progeny. These *Histriobdellæ* have the same duty to perform as vultures and jackals, which clear the plains of carcasses. That which causes us to suppose that such is their appropriate office is, that they have an apparatus for the purpose of sucking eggs, and that we have not found in their digestive canal any remains which resemble any true organism."

Of the Natural Size.



Caligulus Elegans. Female.

Fig. 7.

True parasites are beings entirely dependent on their neighbors for support; unable to provide for themselves, they are fed wholly at the expense of others. It is generally believed that they are an exceptional class of organisms, constituting a group by themselves, and knowing nothing of the world outside the organ which shelters them. This is an error. Representatives of all the principal divisions of the animal kingdom below the vertebrate are found pursuing this mode of life. There are few parasites that are not wanderers at some period of their lives; and it is not uncommon to find some which live alternately as noblemen and as beggars. Many are paupers only during infancy, or at the approach of adult age, living at other times a comparatively free and independent life. Nor are all the members of a species necessarily parasitic; sometimes it is only the female that takes the relation of a dependent, the male continuing his nomad life. Again, there are cases where, the female being provided for, the male relies on her for support, and thus the charitable animal which comes to her help is laid under contribution by the whole family.

Parasites present an extraordinary variety of forms, and differ very widely in size and appearance, these differences being often remarkable between the sexes of the same species. The male of the urubu of Brazil has the usual form of a round long worm, while the female resembles more than any thing else a ball of cotton, not having the slightest analogy with the other worms of the order. As to the enormous proportions parasites may attain, Boerhaave mentions a bothriocephalus 300 ells [1] in length; and, at the Academy of Copenhagen, it was reported that a solitary tapeworm (*Tænia solium*) had been found 800 ells long. Parasites are found in every region of the globe, but, like other animals, they observe the laws of geographical distribution. Some, like the leeches, take their food, and then detach themselves until the demand for food returns, never becoming identified for any length of time with their host. Others, like the lernæans, commence their parasitic existence when approaching maturity, and thereafter are permanent dependents; others, again, like the ichneumons, begin life as parasites, and on reaching maturity assume and maintain an independent existence; while still others, like the tænia, are parasitic from first to last, although changing their abode at a certain stage of development.

All animals, man included, have their parasites, which usually come from without, those entering the body being generally introduced with the food or drink. No organ is exempt from their incursions, as they have been found in the brain, the ear, the eye, the heart, the blood, the lungs, the spinal cord, the nerves, the muscles, and even the bones. Cysticerci have been seen in nearly all these situations, and worms of various kinds are common in the cavities of the body, as well as in many of the solid organs, such as the muscles, liver, and

[1] The Flemish ell is probably meant: this is 27 inches long.

kidneys. As a rule, those which inhabit a temporary host install themselves in a closed organ; in the muscles, the heart, or the lobes of the brain; those, on the contrary, which have arrived at their destination, and which, unlike the preceding, have a family, occupy the stomach, with its dependencies the digestive passages, the lungs, the nasal fossæ, the kidneys, in a word, all the organs which are in direct communication with the exterior, in order to leave a place of issue for their progeny.

A single animal may carry, not only a great number of individuals of the same species, but many different species of parasites, and this, too, without any apparent impairment of health. Indeed, in some countries their presence is considered indispensable to the highest health, the Abyssinians, for example, deeming themselves below par unless they nourish one or many tapeworms. Nathusius speaks of a black stork which lodged 24 *Filariæ* in its lungs, 16 *Syngami tracheales* in its tracheal artery, more than 100 *Spiropteræ* within the membranes of the stomach, several hundred of the *Holostomum excavatum* in the smaller intestines, 100 of the *Distoma ferox* in the large intestines, 22 of the *Distoma hians* in the œsophagus, and a *Distoma echinatum* in the small intestine. In spite of this affluence of lodgers, the bird did not appear to be the least inconvenienced. Krause, of Belgrade, mentions a colt, two years old, which contained more than 500 *Ascarides*, 190 *Oxyures*, 214 *Strongyli armati*, several million *Strongyli tetracanthi*, 69 *Tænia*, 287 *Filariæ*, and 6 *Cysticerci*. Well supplied as these animals appear to have been, when we consider the number of eggs a single worm may produce, the wonder is that parasites are not more numerous than they are: 60,000,000 eggs have been counted in a single *nematode*, and in a single tapeworm more than 1,000,000,000 eggs have been found!

While nearly all animals, including parasites themselves, are made to contribute to the support of others, those to which man gives food and lodging are of greatest interest, and he is by no means scantily provided with this class of dependents. Four different *cestodes*, or tapeworms, live in his intestines; three or four *Distoma* lodge in his liver, intestines, or blood; nine or ten *hematodes*, or round worms, inhabit his digestive passages or flesh; and *cysticerci*, *echinococci*, and *hydatids*, are also among his guests. He provides a living for three or four kinds of lice, for a bug, for a flea, and two ascarides, without mentioning certain inferior organisms which lurk in the tartar of the teeth, or in the secretions of the mucous membrane of the mouth. Some of these are confined to him exclusively, others may also find a home on the lower mammalia; some make his body their home while passing through a single stage of development, beginning or finishing the process, as the case may be, in the body of another animal; and others, again, are but day-boarders, taking their meals at his expense, and finding lodgings elsewhere.

Leeches are true parasites, although asking only food and taking care of themselves in the intervals of their meals. They suck the blood of their victim, and, when gorged to the very lips, fall off and perhaps for many weeks have no further need of assistance. The vampires of South America obtain support in a similar way, and are just as truly parasitic, although otherwise leading an independent life. The best-known leeches are those which prey on man and other mammals; but some are found which attack animals of still lower grade, especially the fishes. The organization of the leech appears always to be proportioned to that of the host which it frequents, the lower the grade of the latter the simpler the structure of the former. Those living on the mollusks are inferior to those found on fishes, and these again rank below the sorts that attack the mammalia. Fig. 8 (1, 2, 3, 4) shows the different appearances assumed by the skin after a leech-bite; Fig. 9 represents the structure of the jaws; and Fig. 10 is a longitudinal section of the body of the leech. The letters

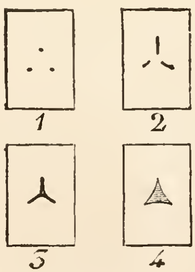



Fig. 8.

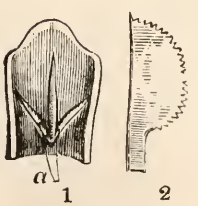



Fig. 9.

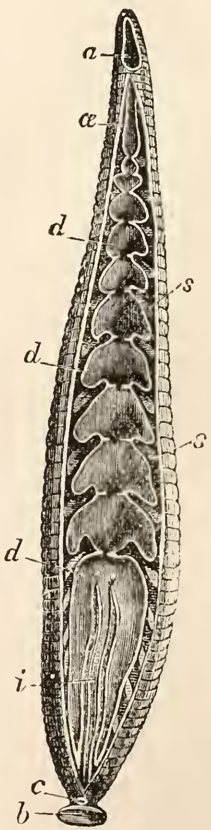



Fig. 10.

Fig. 8.—Different Forms of the Bite of a Leech.
Fig. 9.—1. Sucker, open; *a*. Jaws. 2. One of the Jaws magnified.
Fig. 10.—Section of a Leech: *a*, Anterior Sucker; *b*, Posterior Sucker; *c*, Anus; *d*, Stomach; *œ*, Œsophagus; *i*, Intestine; *s s*, Glands of the Skin.

*d d d* indicate the different cavities of the stomach that are successively filled when the creature feeds. These animals vary greatly in size, appearance, and mode of life. Some are exceedingly minute, and of delicate structure, while others have been seen that were a foot and a half long. Most of them are highly voracious, taking sometimes the weight of their bodies in blood at a single meal. Generally they are aquatic, but a few species are met with in the brushwood and low forest growth of the tropics, where they attack both man and beast when opportunity offers.

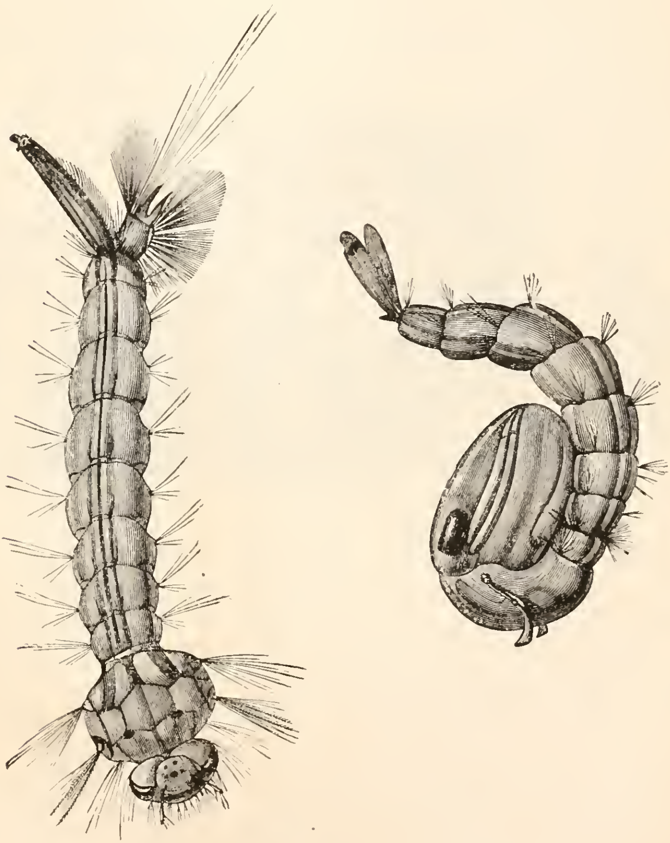


Fig. 11.—Gnat (*Culex pipiens*), Larva and Nymph.

Gnats or mosquitoes are parasites that get their living in much the same way as the leeches, that is, they suck the blood of other animals, man being their most common victim. They differ from the leeches, however, in the fact that only the females are greedy of blood, the males living on the juices of plants. The females pierce the skin by means of an auger with teeth at the end, and after sucking their fill distill into the wound a liquid venom which occasions the irritation that follows the bite. Fig. 11 shows the form of the larva and nymph of this insect. The former will be recognized as the little "wriggler" that may be seen in such numbers in stagnant water in summer. Fortunately, these insects are harmless until they acquire wings, and after that their life is a short one; but, unfortunately, they breed at an enormous rate, and thus maintain the supply, to the infinite annoyance of man and other tender-skinned animals.

Another blood-sucking parasite of both man and beast, whose staying tendencies are proverbial, is the louse. Fig. 12 represents the species that inhabits the head of man. The mouth of this insect consists of a sucker contained in a sheath, without articulations. It is armed at the point with retractile hooks, within which are four bristles

Fig. 12.—Louse of the Head.


Fig. 13.—Louse of the Head. 2, 3, Sucker.

Fig. 14.—Louse of the Head, Claw.

that aid in breaking through the skin. They have climbing feet terminated by pincers, with which they maintain their hold on the hairs. The sucker and claw are illustrated in Figs. 13 and 14. The *nits*, or eggs, hatch in five or six days after they are laid, and in eighteen days more the creature is able to reproduce its kind. Leeuwenhoek calculated that two females might become the grandmothers of 10,000 lice in eight weeks.

A not less annoying parasite that lives on the blood of man and the higher animals is the flea. Both male and female get their living in this way, and even the larvæ are supplied from the same sources by the mother, who sucks for herself first, and then divides with her young ones. The ordinary flea (*Pulex irritans*, Fig. 15) is common in both Europe and North America. It may be called a fly without wings, and, together with others of its kind, forms a distinct family under the name *Pulicidæ*. The four principal species are *Pulex irritans* of man, *Pulex canis* of the dog, *Pulex musculus* of the mouse, and *Pulex vespertilionis* of the bat. Great numbers of human fleas, half as large as the common fly, are found in summer on the sandy shores of the Mediterranean, in the neighborhood of Cette and Montpellier. Their presence in this locality is due solely to the circumstance that large numbers of persons of both sexes and all classes come to these places to bathe, and, laying their clothes upon the sand, leave there a part of their vermin. Van Beneden suggests the surgical employment of the flea as an homœopathic phlebotomist, and recommends this region as an excellent source of supply in case his suggestion is adopted. The largest fleas are found upon the bat; they sometimes annoy the horse, and there is a species peculiar to monkeys.

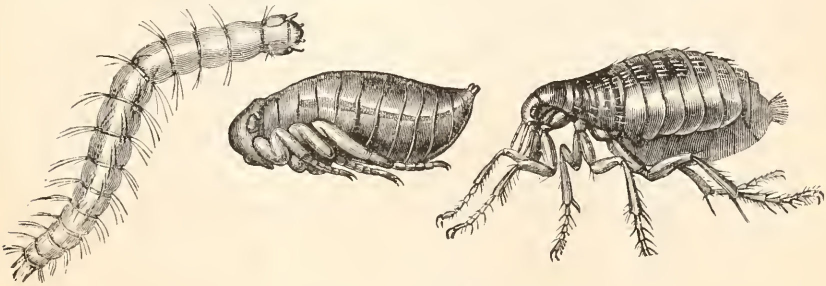


Fig. 15.—Human Flea (*Pulex irritans*).

The minute creatures known as *Acari*, or mites, are most of them parasitic, and they are very widely distributed. They are not true insects, but belong to the *Arachnida*, having four pairs of legs like the spiders, with head and thorax closely united. The group includes those disgusting creatures the itch-mites, magnified representations of which are shown in Figs. 16 and 17. The mammalia have each

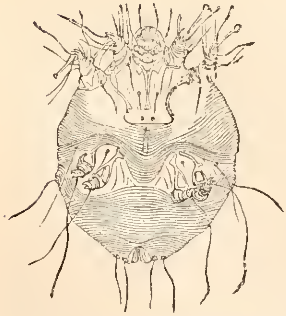


Fig. 16.—Sarcoptes Scabiei, or Male Acarius of the Itch. The Lower Surface.

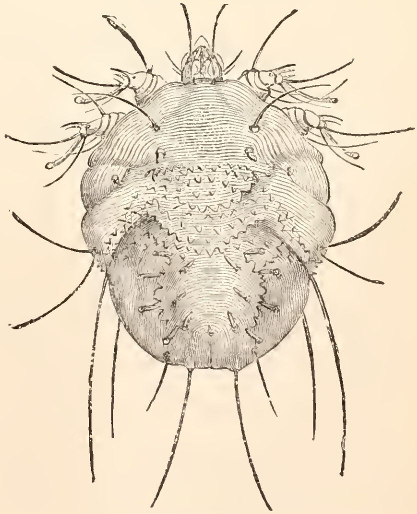


Fig. 17.—Sarcoptes Scabiei, Female. The Upper Surface.

their particular species, which in many cases are the cause of peculiar skin-affections. Since the presence of these animals constitutes the disorder, it may be easily caught; man may communicate it to the domestic animals, and they may also give it to him; it is only the genus *Sarcoptes*, however, that may be thus transferred from animals to man.

The true parasites just described, and many others like them, are nourished by the blood of their neighbors, but they never establish themselves in the organs of their host, being free throughout their lives. There is another class that live in freedom while young, but when arrived at mature age, and the cares of a family are soon to be assumed, they change in appearance, choose a host, and settle down for life. The chigoe, a parasite of man in South America, is one of these. It is only the female, however, that demands both lodging and provisions, the male (Fig. 18) being contented with pillaging his victim as he passes by. It is a small species, which pierces the shoes and clothes with its pointed beak (Fig. 19), and penetrates into the substance of the skin, generally selecting that of the toes. The male, as

Fig. 18.—Male Chigoe.

Fig. 19.—Head of Chigoe.

just remarked, takes his food and resumes his wanderings, but the female seeks a hiding-place for permanent abode, and then grows to such a monstrous size that the entire insect appears to be nothing more than a mere appendage to the abdomen, as may be seen in Fig. 20. Besides man, this parasite infests the dog, the cat, the pig, the goat, the horse, and the mule.

Another form coming within this category, and the terror of travelers on the coast of Guinea, is the Guinea-worm, *Filaria medinensis* (Fig. 21), also found in other parts of Africa, and said by Mitchell to have been observed in South Carolina. It was long supposed that this filaria could introduce itself into the cellular tissue of the body directly through the skin, in the form of a microscopic embryo, but several recent observers concur in the belief that it is transmitted by means of the cyclops, a little fresh-water crustacean. This is swallowed in drinking-water, and at the end of six weeks the presence of the filaria is revealed by tumors, which later develop into open sores, caused not by the worm itself, but by the dissemination of its eggs. The filaria at last is so entirely atrophied that Prof. Jacobson, after seeing it alive on one of his patients at Copenhagen, wrote to Blainville: "This medina worm is not really a worm; it is a sheath full of eggs." In fact, all the internal organs disappear, and nothing is found in their place except the eggs and their embryos.

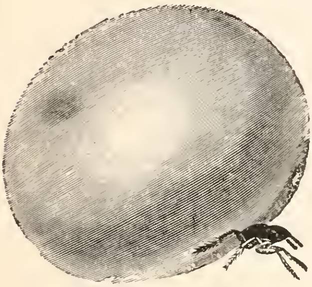


Fig. 20.—Female Chigoe.

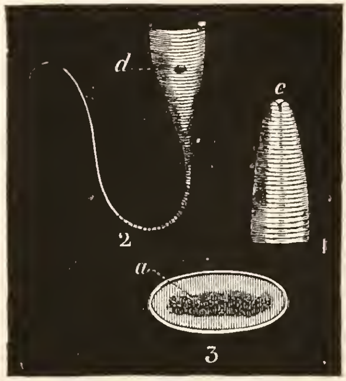
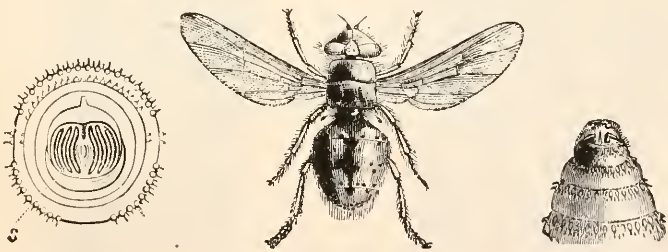



Fig. 21.—Young Filaria of Medina. 1. Anterior Extremity; *c*, Mouth. 2. Caudal Extremity; *d*. Anus. 3. Section of the Body.

The ichneumons and many other insects that lay their eggs in the living larvæ of other species, belong to a class of parasites that begin life as dependents, but that become free and self-supporting on arrival at adult age. The *Œstrus*, or gadfly of the horse (Fig. 22), is



Hinder Part. Fig. 22.—Œstrus of the Horse. Anterior Part.

thus dependent in its early life. But, instead of making their attacks on those of their own class, the gadflies prefer to install themselves on mammals, and sometimes even on man. The eggs are received into some cavity of the body, nostrils, stomach, or a hole in the skin, where they hatch and where the larvæ feed until the adult state is reached, when they escape and afterward live in freedom.

There is a large class of parasites generally known as worms, characterized by the circumstance that during their lives they undergo certain strange transformations that can only take place by the passage of the creature from one animal or host to another. The eggs are swallowed by some animal, usually a vegetable feeder, they hatch within its body, enter its tissues, and remain in a state of incomplete development until transferred to the stomach of another animal which has eaten the flesh of the first one. Here development recommences, and goes on to completion, when the process of reproduction begins. Each species of worm has its particular animals, through the agency of which these changes occur, and, if in its passage it gets off the proper track, that is, enters the wrong animal, it must either perish, or, as sometimes happens, find its way by a second transfer into the body of its destined host. The tapeworm of man, *Tænia solium* (Figs. 23 and 24), is a member of this group, belonging to the *Cestoidea*, or ribbon-like worms. These cestoids are found in all classes of vertebrate animals. They exist in two principal forms. The first or vesicular form resembles somewhat in appearance the finger of a glove partly drawn inward. In this shape they are always lodged in the midst of the flesh, or in a closed organ, surrounded by a cyst, and


FIG. 23.—TÆNIA SOLIUM, OR SOLITARY WORM.
*a*, head, or scolex; *b*, tape formed of many individuals, the last of which, completely sexual, separate under the name of *Proglottides*, and represent the adult and complete animal. Each solitary worm is a colony.


FIG. 24.—*a*, Rostellum; *b*, Crown of Hooks; *c c*, Suckers. 1. Scolex of the Tænia solium. 2. Hooks expanded; *a*, Heel of the Hook.

thus circumstanced the worm is harbored by a host which is to serve as a vehicle to introduce it into its final host. It is a parasite on a journey, and usually bears the name of *Cysticercus* (Fig. 25). In the second shape it is like a ribbon, it attains a great length, always occupies the intestine, and is mainly occupied in producing eggs, which it turns out by the million. A description of *Tænia solium*, the most common tapeworm of man, will enable us to understand all the others. Under its first, or vesicular form, this parasite comes from the flesh of the pig, where it is often found in large numbers, when the pig is said to be "measly." This condition of the pig has been attributed to damp, to feeding on acorns, to hereditary causes, to contagion, and various other influences, but none of these notions are correct. The


FIG. 25.—CYSTICERCUS.
*a*, Upper Part of the Vesicle; *b*, Place where the Vesicle is about to separate: *c*, Neck of the Worm; *d*, The Head, showing the Suckers and the Crown of Hooks.

only true cause is the introduction of the eggs of *Tænia solium* into the intestines of the pig. These eggs, or fragments of tænia containing them, are swallowed by the animal. In the gastric juice of its stomach the eggs are set at liberty, lose their shells, and there issues an embryo singularly armed. It carries in front two stylets, in the axis of the body, and on the right and left sides two other stylets, which act like fins. These embryos bore into the tissues as the mole burrows in the soil. The middle stylets are pushed forward like the snout of the insectivore, and the two lateral stylets act like the limbs, taking hold of the tissues and forcing the head forward. In this manner the embryos perforate the walls of the digestive tube, and find their way, by means of the blood or otherwise, to the organ or tissue which is to become their temporary home. When arrived at this point they surround themselves with a sheath; their stylets, no longer of use, decay; and at one of the extremities appears a crown of new hooks, quite different from the former ones, which will serve to anchor their progeny in the new host to which they are ultimately destined. This vesicular worm, or cysticercus, fully formed, and without undergoing any change, waits till its host, the pig, or that part of him which it inhabits, is eaten, and, if its life has not been destroyed on its way through the frying-pan, it wakes up in some human stomach. Once there, it instantly quits its torpid state, gets rid of its useless envelopes, passes into the intestine, and, by means of its hooks and suckers, attaches itself to the intestinal walls, when it begins to grow with great rapidity, a length of many feet being attained in a few weeks. The part attached is the mother or head of the tænia, and until this is dislodged the worm goes on producing segments, or more properly *proglottides*, each of which is a perfect sexual being loaded with eggs. These are successively detached and escape with the evacuations, to be swallowed, perhaps, by some other pig, in whose flesh a new crop of cysticerci will soon develop. An egg of the *Tœnia solium* may be swallowed by a man instead of passing into the stomach of a pig. It is hatched in his stomach precisely in the same manner, and the embryo takes up its lodging in some inclosed cavity. Some have been found in the eyeball, in the lobes of the brain, in the heart, and in the muscles. Whatever symptoms its presence may give rise to, it obviously has no chance for further progress, having selected the wrong vehicle to travel in. Man harbors not only the *Tœnia solium*, but another species very similar which naturalists have only learned to distinguish from it during the last few years, the *Tœnia medio-canellata*. Its cysticercus is found in beef, and is introduced when the meat is eaten in a raw or partially-cooked state. *Tœnia nana* and *Tœnia lata* are the names of other tapeworms inhabiting man, but both are limited in geographical distribution. The former is found only in Egypt, and the latter is confined to Russia, Poland, and Switzerland.

All these internal parasites, including the *Trichina spiralis*, which we have not space to speak of further, are introduced into the body either with the food or the drink, and a simple and effectual means of avoiding them is, to thoroughly cook the food and carefully purify the water.

## PROFESSOR TYNDALL'S RECENT RESEARCHES.[1]

OBSERVATIONS ON THE OPTICAL DEPORTMENT OF THE ATMOSPHERE IN REFERENCE TO THE PHENOMENA OF PUTREFACTION AND INFECTION.

PROFESSOR TYNDALL began his paper by alluding to a former inquiry on the decomposition of vapors, and the formation of actinic clouds, by light, whereby he was led to experiments on the floating matter of the air. He referred to the experiments of Schwann, Schroeder and Dusch, Schroeder himself, to those of the illustrious French chemist Pasteur, to the reasoning of Lister and its experimental demonstration, regarding the filtering power of the lungs; from all of which he had concluded, six years ago, that the power of developing life by the air and its power of scattering light

[1] Abstract of a paper read before the Royal Society, January 18, 1876. From the *British Medical Journal*.

would be found to go hand in hand. He thought the simple expedient of examining by means of a beam of light, while the eye was kept sensitive by darkness, the character of the medium in which their experiments were conducted could not fail to be useful to workers in this field. But the method has not been much turned to account, and this year he thought it worth while to devote some time to the more complete demonstration of its utility.

He also wished to free his mind, and if possible the minds of others, from the uncertainty and confusion which now beset the doctrine of "spontaneous generation." Pasteur has pronounced it "a chimera," and expressed the undoubting conviction that this being so it is possible to remove parasitic diseases from the earth. To the medical profession, therefore, and through them to humanity at large, this question is one of the last importance. But the state of medical opinion regarding it is not satisfactory. In a recent number of the *British Medical Journal*, and in answer to the question, "In what way is contagium generated and communicated?" Messrs. Braidwood and Vacher reply that, notwithstanding "an almost incalculable amount of patient labor, the actual results obtained, especially as regards the manner of generation of contagium, have been most disappointing. Observers are even yet at variance whether these minute particles, whose discovery we have just noticed, and other disease-germs, are always produced from like bodies previously existing, or whether they do not, under certain favorable conditions, spring into existence *de novo*."

With a view to the possible diminution of the uncertainty thus described, he submitted without further preface to the Royal Society, and especially to those who study the etiology of disease, a description of the mode of procedure followed in this inquiry, and of the results to which it has led.

A number of chambers, or cases, were constructed each with a glass front, its top, bottom, back, and sides being of wood. At the back is a little door, which opens and closes on hinges, while into the sides are inserted two panes of glass, facing each other. The top is perforated in the middle by a hole two inches in diameter, closed air-tight by a sheet of India-rubber. This sheet is pierced in the middle by a pin, and through the pin-hole is passed the shank of a long pipette ending above in a small funnel. A circular tin collar, two inches in diameter, and one inch and a half high, surrounds the pipette, the space between both being packed with cotton-wool moistened by glycerine. Thus, the pipette, in moving up and down, is not only firmly clasped by the India-rubber, but it also passes through a stuffing-box of sticky cotton-wool. The width of the aperture closed by the India-rubber secures the free lateral play of the lower end of the pipette. Into two other smaller apertures in the top of the case are inserted, air-tight, the open ends of two narrow tubes, intended to connect the interior space with the atmosphere. The tubes are bent several times up and down, so as to intercept and retain the particles carried by such feeble currents as changes of temperature might cause to set in between the outer and the inner air.

The bottom of the box is pierced sometimes with a single row, sometimes with two rows of holes, in which are fixed, air-tight, large test-tubes, intended to contain the liquid to be exposed to the action of the moteless air.

On the 10th of September the first case of this description was closed. The passage of a concentrated beam across it through its two side-windows then showed the air within it to be laden with floating matter. On the 13th it was again examined. Before the beam entered, and after it quitted the case, its track was vivid in the air, but within the case it vanished. Three days of quiet sufficed to cause all the floating matter to be deposited on the sides and bottom, where it was retained by a coating of glycerine, with which the interior surface of the case had been purposely varnished. The test-tubes were then filled through the pipette, boiled for five minutes in a bath of brine or oil, and abandoned to the action of the moteless air.

During ebullition, aqueous vapor rose from the liquid into the chamber, where it was for the most part condensed, the uncondensed portion escaping, at a low temperature, through the bent tubes at the top. Before the brine was removed, little stoppers of cotton-wool were inserted in the bent tubes, lest the entrance of the air into the cooling chamber should at first be forcible enough to carry motes along with it. As soon, however, as the ambient temperature was assumed by the air within the case, the cotton-wool stoppers were removed.

We have here the oxygen, nitrogen, carbonic acid, ammonia, aqueous vapor, and all the other gaseous matters which mingle more or less with the air of a great city. We have them, moreover, "untortured" by calcination, and unchanged even by filtration or manipulation of any kind. The question now before us is, can air thus retaining all its gaseous mixtures, but self-cleansed from mechanically suspended matter, produce putrefaction? To this question, both the animal and vegetable worlds return a decided negative. Among vegetables, experiments have been made with hay, turnips, tea, coffee, hops, repeated in various ways with both acid and alkaline infusions. Among animal substances are to be mentioned many experiments with urine; while beef, mutton, hare, rabbit, kidney, liver, fowl, pheasant, grouse, haddock, sole, salmon, cod, turbot, mullet, herring, whiting, eel, oyster, have been all subjected to experiment.

The result is, that infusions of these substances exposed to the common air of the Royal Institution laboratory, maintained at a temperature of from 60° to 70° Fahr., all fell into putrefaction in the course of from two to four days. No matter where the infusions were placed, they were infallibly smitten in the end. The number of the tubes containing the infusions was multiplied till it reached six hundred, but not one of them escaped infection.

In no single instance, on the other hand, did the air which had been proved moteless by the searching beam show itself to possess the least power of producing bacterial life or the associated phenomena of putrefaction. The power of developing such life in atmospheric air and the power of scattering light are thus proved to be indissolubly united.

The sole condition necessary to cause these long dormant infusions to swarm with active life is the access of the floating matter of the air. After having remained for four months as pellucid as distilled water, the opening of the back-door of the protecting case and the consequent admission of the mote-laden air suffice in three days to render the infusion putrid and full of life.

That such life arises from mechanically suspended particles is thus reduced to ocular demonstration. Let us inquire a little more closely into the character of the particles which produce the life. Pour eau de Cologne into water, a white precipitate renders the liquid milky. Or, imitating Brücke, dissolve clean gum-mastic in alcohol, and drop it into water, the mastic is precipitated and milkiness produced. If the solution be very strong, the mastic separates in curds; but, by gradually diluting the alcoholic solution, we finally reach a point where the milkiness disappears, the liquid assuming by reflected light a bright cerulean hue. It is, in point of fact, the color of the sky, and is due to a similar cause—namely, the scattering of light by particles, small in comparison to the size of the waves of light.

When this liquid is examined by the highest microscopic power, it seems as uniform as distilled water. The mastic particles, though innumerable, entirely elude the microscope. At right angles to a luminous beam passing among the particles, they discharge perfectly polarized light. The optical deportment of the floating matter of the air proves it to be composed in part of particles of this excessively minute character. When the track of a parallel beam in dusty air is looked at horizontally through a Nicol's prism, in a direction perpendicular to the beam, the longer diagonal of the prism being vertical, a considerable portion of the light from the finer matter is extinguished. The coarser motes, on the other hand, flash out with greater force, because of the increased darkness of the space around them. It is among the finest ultra-microscopic particles, as the author shows, that matter potential as regards the development of bacterial life is to be sought.

But, though they are beyond the reach of the microscope, the existence of these particles, foreign to the atmosphere but floating in it, is as certain as if they could be felt between the fingers, or seen by the naked eye. Supposing them to augment in magnitude until they come, not only within range of the microscope, but within range of the unaided senses. Let it be assumed that our knowledge of them under these circumstances remains as defective as it is now—that we do not know whether they are germs, particles of dead organic dust, or particles of mineral matter. Suppose a vessel (say a flower-pot) to be at hand filled with nutritious earth, with which we mix our unknown particles; and that in forty-eight hours subsequently buds and blades of well-defined cresses and grasses appear above the soil. Suppose the experiment, when repeated over and over again, to yield the same unvarying result. What would be our conclusion? Should we regard those living plants as the products of dead dust, of mineral particles; or should we regard them as the offspring of living seeds? The reply is unavoidable. We should undoubtedly consider the experiment with the flower-pot as clearing up our preëxisting ignorance; we should regard the fact of their producing cresses and grasses as proof positive that the particles sown in the earth of the pot were the seeds of the plants which have grown from them. It would be simply monstrous to conclude that they had been "spontaneously generated."

This reasoning applies word for word to the development of bacteria from that floating matter which the electric beam reveals in the air, and in the absence of which no bacterial life has been generated. There seems no flaw in this reasoning; and it is so simple as to render it unlikely that the notion of bacterial life developed from dead dust can ever gain currency among the members of a great scientific profession.

A novel mode of experiment has been here pursued, and it may be urged that the conditions laid down by other investigators in this field, which have led to different results, have not been strictly adhered to. To secure accuracy in relation to these differences, the latest words of a writer on this question, who has materially influenced medical thought both in this country and in America, are quoted. "We know," he says, "that boiled turnip or hay infusions exposed to ordinary air, exposed to filtered air, to calcined air, or shut off altogether from contact with air, are more or less prone to swarm with bacteria and vibriones in the course of from two to six days." Who the "we" are who possess this knowledge is not stated. Prof. Tyndall is certainly not among the number, though he has sought anxiously for knowledge of the kind. He thus tests the statements in succession.

And, first, with regard to filtered air. A group of twelve large test-tubes was passed air-tight through a slab of wood coated with cement, in which, while hot, a heated "propagating glass," resembling a large bell-jar, was imbedded. The air within the jar was pumped out several times, air filtered through a plug of cotton-wool being permitted to supply its place. The test-tubes contained infusions of hay, turnip, beef, and mutton, three of each, twelve in all. They are as clear and cloudless at the present moment as they were upon the day of their introduction; while twelve similar tubes, prepared at the same time, in precisely the same way, and exposed to ordinary air, are clogged with mycelium, mould, and bacteria.

With regard to calcined air, a similar propagating glass was caused to cover twelve other tubes filled with the same infusion. The "glass" was exhausted and carefully filled with air, which had passed through a red-hot platinum-tube, containing a roll of red-hot platinum-gauze. Tested by the searching beam, the calcined air was found quite free from floating matter. Not a speck has invaded the limpidity of the infusions exposed to it, while twelve similar tubes, placed outside, have fallen into rottenness.

The experiments with calcined air took another form. Six years ago, it was found that, to render the laboratory air free from floating matter, it was only necessary to permit a platinum-wire heated to whiteness to act upon it for a sufficient time. Shades containing pear-juice, damson-juice, hay and turnip juice, and water of yeast, were freed from their floating matter in this way. The infusions were subsequently boiled, and permitted to remain in contact with the calcined air. They are quite clear to the present hour; while the same infusions, exposed to common air, became mouldy and rotten long ago.

It has been affirmed by other workers on this question, that turnip and hay infusions, rendered slightly alkaline, are particularly prone to exhibit the phenomena of spontaneous generation. This was not found in the present investigation to be the case. Many such infusions have been prepared, and they have continued for months without sensible alteration.

Finally, with regard to infusions wholly withdrawn from air, a group of test-tubes containing different infusions was boiled under a bell-jar filled with filtered air, and from which subsequently the air was removed as far as possible by a good air-pump. They are now as pellucid as they were at the time of their preparation more than two months ago, while a group of corresponding tubes exposed to the laboratory air has all fallen into rottenness.

There is another form of experiment on which great weight has been laid; that of hermetically-sealed tubes. On the 6th of last April, a discussion on the "Germ-Theory of Disease" was opened before the Pathological Society of London. The meeting was attended by many distinguished medical men, some of whom were profoundly influenced by the arguments, and none of whom disputed the facts brought forward against the theory on that occasion. The following important summary of these was given by Dr. Bastian: "With the view of settling these questions, therefore, we may carefully prepare an infusion from some animal tissue, be it muscle, kidney, or liver; we may place it in a flask whose neck is drawn out and narrowed in the blow-pipe-flame; we may boil the fluid, seal the vessel during ebullition, and, keeping it in a warm place, may await the result, as I have often done. After a variable time, the previously-heated fluid within the hermetically-sealed flask swarms more or less plentifully with bacteria and allied organisms."

Previously to reading this statement, the author had operated upon sixteen tubes of hay and turnip infusions, and upon twenty-one tubes of beef, mackerel, eel, oyster, oatmeal, malt, and potato, hermetically sealed while boiling, not by the blow-pipe, but by the far more handy spirit-lamp flame. In no case was any appearance whatever of bacteria or allied organisms observed. The perusal of the discussion just referred to caused the author to turn again to muscle, liver, and kidney, with the view of varying and multiplying the evidence. Fowl, pheasant, snipe, partridge, plover, wild-duck, beef, mutton, heart, tongue, lungs, brains, sweetbread, tripe, the crystalline lens, vitreous humor, herring, haddock, mullet, cod-fish, sole, were all embraced in the experiments. There was neither mistake nor ambiguity about the result. One hundred and thirty-nine of the flasks operated on were exhibited, and not one of this cloud of witnesses offered the least countenance to the assertion that the liquid within flasks boiled and hermetically sealed swarms subsequently more or less plentifully with bacteria and allied organisms.

The evidence furnished by this mass of experiments that Dr. Bastian must have permitted errors either of preparation or observation to invade his work is, it is submitted, very strong. But to err is human; and, in an inquiry so difficult and fraught with such momentous issues, it is not error, but the persistence in error for dialectic ends by any of us, that is to be deprecated. The author shows by illustrations the risks of error run by himself. On October 21st, he opened the back-door of a case containing six test-tubes filled with an infusion of turnip, which had remained perfectly clear for three weeks, while three days sufficed to crowd six similar tubes exposed to mote-laden air with bacteria. With a small pipette, he took specimens from the pellucid tubes, and placed them under the microscope. One of them yielded a field of bacterial life monstrous in its copiousness. For a long time he tried vainly to detect any source of error, and was prepared to abandon the unvarying inference from all the other experiments, and to accept the result as a clear exception to what had previously appeared to be a general law. The cause of his perplexity was, however, finally traced to the tiniest speck of an infusion containing bacteria, which had clung, by capillary attraction, to the point of one of his pipettes.

Again, three tubes containing infusion of turnip, hay, and mutton, were boiled on November 2d under a bell-jar containing air so carefully filtered that the most searching examination by a concentrated beam failed to reveal a particle of floating matter. At the present time, every one of these tubes is thick with mycelium, and covered with mould. Here, surely, we have a case of spontaneous generation. Let us look to its history.

After the air has been expelled from a boiling liquid, it is difficult to continue the ebullition without "bumping." The liquid remains still for intervals, and then rises with sudden energy. It did so in the case now under consideration; and one of the tubes boiled over, the liquid overspreading the resinous surface in which the bell-jar was imbedded. For three weeks the infusions had remained perfectly clear. At the end of this time, with a view of renewing the air of the bell-jar, it was exhausted, and refilled by fresh air which had passed through a plug of cotton-wool. As the air entered, attention was attracted by two small spots of penicillium resting on the liquid which had boiled over. It was at once remarked that the experiment was a dangerous one, as the entering air would probably detach some of the spores of the penicillium, and diffuse them in the bell-jar. This was, therefore, filled very slowly, so as to render the disturbance a minimum. Next day, however, a tuft of mycelium was observed at the bottom of one of the three tubes; namely, that containing the hay-infusion. It has by this time grown so as to fill a large portion of the tube. For nearly a month longer, the two tubes containing the turnip and mutton infusions maintained their transparency unimpaired. Late in December, the mutton-infusion, which was in dangerous proximity to the outer mould, showed a tuft upon its surface. The beef-infusion continued bright and clear for nearly a fortnight longer. The recent cold weather caused me to add a third gas-stove to the two which had previously warmed the room in which the experiments are conducted. The warmth of this stove played upon one side of the bell-jar, causing currents; and, on the day after the lighting of the stove, the beef-infusion gave birth to a tuft of mycelium. In this case, the small spots of penicillium might have readily escaped attention; and, had they done so, we should have had here three cases of "spontaneous generation" far more striking than many that have been adduced.

In further illustration of the dangers incurred in this field of inquiry, the excellent paper of Dr. Roberts on "Biogenesis," in the *Philosophical Transactions* for 1874, is referred to. Dr. Roberts fills the bulb of an ordinary pipette up to about two-thirds of its capacity with the infusion to be examined. In the neck of the pipette he places a plug of dry cotton-wool. He then hermetically seals the neck, and dips the bulb into boiling water or hot oil, where he permits it to remain the requisite time. Here we have no disturbance from ebullition, and no loss by evaporation. The bulb is removed from the hot water, and permitted to cool. The sealed end of the neck is then filed off, the cotton-wool alone interposing between the infusion and the atmosphere.

The arrangement is beautiful, but it has one weak point. Cotton-wool free from germs is not to be found, and the plug employed by

Dr. Roberts infallibly contained them. In the gentle movement of the air to and fro as the temperature changed, or in any shock, jar, or motion to which the pipette might be subjected, we have certainly a cause sufficient to detach a germ now and then from the cotton-wool, which would fall into the infusion and produce its effect. Probably, also, condensation occurred at times in the neck of the pipette; the water of condensation carrying back from the cotton-wool the seeds of life. The fact of fertilization being so rare as Dr. Roberts found it to be, is a proof of the care with which his experiments were conducted. But he did find cases of fertilization after prolonged exposure to the boiling temperature; and this caused him to come to the conclusion that, under certain rare conditions, spontaneous generation may occur. He also found that an alkalized hay-infusion was so difficult to sterilize that it was capable of withstanding the boiling temperature for hours without losing its power of generating life. The most careful experiments have been made with this infusion. Dr. Roberts is certainly correct in assigning to it superior nutritive power. But, in the present inquiry, five minutes' boiling sufficed to completely sterilize the liquid.

Summing up this portion of his inquiry, the author remarks that he will hardly be charged with any desire to limit the power and potency of matter. But, holding the notions he does, it is all the more incumbent on him to affirm that, as far as inquiry has hitherto penetrated, life has never been proved to appear independently of antecedent life.

Though the author had no reason to doubt the general diffusion of germs in the atmosphere, he thought it desirable to place the point beyond question. At Down, Mr. Darwin and Mr. Francis Darwin; at High Elms, Sir John Lubbock; at Sherwood, near Tunbridge Wells, Mr. Siemens; at Pembroke Lodge, Richmond Park, Mr. Rollo Russell; at Heathfield Park, Miss Hamilton; at Greenwich Hospital, Mr. Hirst; at Kew, Dr. Hooker; and at the Crystal Palace, Mr. Price, kindly took charge of infusions, every one of which became charged with organisms. But to obtain more definite insight regarding the diffusion of atmospheric germs, a square wooden tray was penetrated with a hundred holes, into each of which was dropped a short test-tube. On October 23d, thirty of these tubes were filled with an infusion of hay, thirty-five with an infusion of turnips, and thirty-five with an infusion of beef. The tubes, with their infusions, had been previously boiled, ten at a time, in an oil-bath. One hundred circles were marked on paper, so as to form a map of the tray, and every day the state of each tube was registered upon the corresponding circle. In the following description, the term "cloudy" is used to denote the first stage of turbidity, distinct but not strong. The term "muddy" is used to denote thick turbidity.

One tube of the hundred was first singled out and rendered muddy. It belonged to the beef-group, and it was a whole day in advance of all the other tubes. The progress of putrefaction was first registered on the 26th of October. The map then taken may be thus described:

*Hay.*—Of the thirty specimens exposed, one had become "muddy"—the seventh in the middle row reckoning from the side of the tray nearest the stove. Six tubes remained perfectly clear between this muddy one and the stove, proving that differences of warmth may be overridden by other causes. Every one of the other tubes containing the hay-infusion showed spots of mould upon the clear liquid.

*Turnip.*—Four of the thirty-five tubes were very muddy, two of them being in the row next the stove, one four rows distant, and the remaining one seven rows away. Besides these, six tubes had become "clouded." There was no mould on any of the tubes.

*Beef.*—One tube of the thirty-five was quite muddy, in the seventh row from the stove. There were three cloudy tubes, while seven of them bore spots of mould.

As a general rule, organic infusions exposed to the air during the autumn remained for two days or more perfectly clear. Doubtless, from the first, germs fell into them, but they required time to be hatched. This period of clearness may be called the "period of latency," and, indeed, it exactly corresponds with what is understood by this term in medicine. Toward the end of the period of latency, the fall into a state of disease is comparatively sudden; the infusion passing from perfect clearness to cloudiness more or less dense in a few hours.

Thus the tube placed in Mr. Darwin's possession was clear at 8.30 A. M. on the 19th of October, and cloudy at 4.30 P. M. Seven hours, moreover, after the first record of our tray of tubes, a marked change had occurred. It may be thus described: Instead of one, eight of the tubes containing hay-infusion had fallen into uniform muddiness. Twenty of these had produced bacterial slime, which had fallen to the bottom, every tube containing the slime being covered by mould. Three tubes only remained clear, but with mould upon their surfaces. The muddy turnip-tubes had increased from four to ten; seven tubes were clouded, while eighteen of them remained clear, with here and there a speck of mould on the surface. Of the beef, six were cloudy, and one thickly muddy, while spots of mould had formed on the majority of the remaining tubes. Fifteen hours subsequent to this observation—viz., on the morning of the 27th of October—all the tubes containing hay-infusion were smitten, though in different degrees, some of them being much more turbid than others. Of the turnip-tubes, three only remained unsmitten, and two of these had mould upon their surfaces. Only one of the thirty-five beef-infusions remained intact. A change of occupancy, moreover, had occurred in the tube which first gave way. Its muddiness remained gray for a day and a half, then it changed to bright yellow green, and it maintained this color to the end. On the 27th every tube of the hundred was smitten, the majority with uniform turbidity; some, however, with mould above and slime below, the intermediate liquid being tolerably clear. The whole process bore a striking resemblance to the propagation of a plague among a population, the attacks being successive and of different degrees of virulence.

From the irregular manner in which the tubes are attacked, we may infer that, as regards quantity, the distribution of the germs in the air is not uniform. The singling out, moreover, of one tube of the hundred by the particular bacteria that develop a green pigment shows that, as regards quality, the distribution is not uniform. The same absence of uniformity was manifested in the struggle for existence between the bacteria and penicillium. In some tubes the former were triumphant; in other tubes of the same infusion the latter were triumphant. It would seem also as if a want of uniformity as regards vital vigor prevailed. With the self-same infusion the motions of the bacteria in some tubes were exceedingly languid; while in other tubes the motions resembled a rain of projectiles, being so rapid and violent as to be followed with difficulty by the eye. Reflecting on the whole of this, the author concludes that the germs float through the atmosphere in groups or clouds, with spaces more sparsely filled between them. The touching of a nutritive fluid by a bacterial cloud would naturally have a different effect from the touching of it by the interspace between two clouds. But as, in the case of a mottled sky, the various portions of the landscape are successively visited by shade, so, in the long run, are the various tubes of our tray touched by the bacterial clouds, the final fertilization or infection of them all being the consequence. The author connects these views with the experiments of Pasteur on the non-continuity of the cause of the so-called spontaneous generation, and with other experiments of his own.[1]

The tray of tubes proved so helpful in enabling him to realize mentally the distribution of germs in the air, that on the 9th of November he exposed a second tray containing one hundred tubes filled with an infusion of mutton. On the morning of the 11th, six of the ten nearest the stove had given way to putrefaction. Three of the row most distant from the stove had yielded, while here and there over the tray particular tubes were singled out and smitten by the infection. Of the whole tray of one hundred tubes twenty-seven were either muddy or cloudy on the 11th. Thus, doubtless, in a contagious atmosphere, are individuals successively struck down. On

[1] In hospital practice, the opening of a wound during the passage of a bacterial cloud would have an effect different from the opening of it in the interspace between two clouds. Certain caprices in the behavior of wounds may possibly be accounted for in this way.

the 12th all the tubes had given way; but the differences in their contents were extraordinary. All of them contained bacteria, some few, others in swarms. In some tubes they were slow and sickly in their motions, in some apparently dead, while in others they darted about with rampant vigor. These differences are to be referred to differences in the germinal matter, for the same infusion was presented everywhere to the air. Here also we have a picture of what occurs during an epidemic, the difference in number and energy of the bacterial swarms resembling the varying intensity of the disease. It becomes obvious from these experiments that of two individuals of the same population, exposed to a contagious atmosphere, the one may be severely, the other lightly attacked, though the two individuals may be as identical, as regards susceptibility, as two samples of one and the same mutton-infusion.

The author traces still further the parallelism of these actions with the progress of infectious disease. The *Times* of January 17th contained a remarkable letter on typhoid fever, signed "M. D.," in which occurs the following statement: "In one part of it (Edinburgh), congregated together and inhabited by the lowest of the population, there are, according to the corporation return for 1874, no less than 14,319 houses or dwellings—many under one roof, on the 'flat' system—in which there are no house-connections whatever with the street-sewers, and, consequently, no water-closets. To this day, therefore, all the excrementitious and other refuse of the inhabitants is collected in pails or pans, and remains in their midst, generally in a partitioned-off corner of the living-room, until the next day, when it is taken down to the streets and emptied into corporation-carts. Drunken and vicious though the population be, herded together like sheep, and with the filth collected and kept for twenty-four hours in their very midst, it is a remarkable fact that typhoid fever and diphtheria are simply unknown in these wretched hovels."

This case has its analogue in the following experiment, which is representative of a class: On November 30th, a quantity of animal refuse, embracing beef, fish, rabbit, hare, was placed in two large test-tubes opening into a protecting chamber containing six tubes. On December 13th, when the refuse was in a state of noisome putrefaction, infusions of whiting, turnip, beef, and mutton, were placed in the other four tubes. They were boiled and abandoned to the action of the foul "sewer-gas" emitted by their two putrid companions. On Christmas-day, these infusions were limpid. The end of the pipette was then dipped into one of the putrid tubes, and a quantity of matter, comparable in smallness to the pock-lymph held on the point of a lancet, was transferred to the turnip. Its clearness was not sensibly affected at the time; but, on the 26th, it was turbid throughout. On the 27th, a speck from the infected turnip was transferred to the whiting; on the 28th, disease had taken entire possession of the whiting. To the present hour, the beef and mutton tubes remain as limpid as distilled water. Just as in the case of living men and women in Edinburgh, no amount of fetid gas had the power of propagating the plague so long as the organisms which constitute the true contagium did not gain access to the infusions.

The universal prevalence of the germinal matter of bacteria in water has been demonstrated with the utmost evidence by the experiments of Dr. Burdon Sanderson. But the germs in water are in a very different condition, as regards readiness for development, from those in air. In water they are thoroughly wetted, and ready, under the proper conditions, to pass rapidly into the finished organism. In air they are more or less desiccated, and require a period of preparation more or less long to bring them up to the starting-point of the water-germs. The rapidity of development, in an infusion infected by either a speck of liquid containing bacteria or a drop of water, is extraordinary. On January 4th, a thread of glass almost as fine as a hair was dipped into a cloudy turnip-infusion, and the tip only of the glass fibre was introduced into a large test-tube containing an infusion of red mullet; twelve hours subsequently, the perfectly pellucid liquid was cloudy throughout and full of life. A second test-tube containing the same infusion was infected with a single drop of the distilled water furnished by Messrs. Hopkin and Williams; twelve hours also sufficed to cloud the infusion thus treated. Precisely the same experiments were made with herring with the same result. At this season of the year several days' exposure to the air are needed to produce the same effect. On December 31st, a strong turnip-infusion was prepared by digesting in distilled water at a temperature of 120° Fahr. The infusion was divided between four large test-tubes, in one of which it was left unboiled, in another boiled for five minutes, and in the two remaining ones boiled, and, after cooling, infected with one drop of beef-infusion containing bacteria. In twenty-four hours, the unboiled tube and the two infected ones were cloudy; the unboiled tube being the most turbid of the three. The infusion here was peculiarly limpid after digestion; for turnip it was quite exceptional, and no amount of searching with the microscope could reveal in it at first the trace of a living bacterium; still germs were there which, suitably nourished, passed in a single day into bacterial swarms without number. Five days have not sufficed to produce an effect approximately equal to this in the boiled tube, which was uninfected but exposed to the common laboratory air.

There cannot, moreover, be a doubt that the germs in the air differ widely among themselves as regards *preparedness* for development. Some are fresh, others old; some are dry, others moist. Infected by such germs, the same infusion would require different lengths of time to develop bacterial life. This remark applies to and explains the different degrees of rapidity with which epidemic disease acts upon different people. In some, the hatching period, if it may be called such, is long, in some short, the differences depending upon the different degree of preparedness of the contagium.

The authors refers with particular satisfaction to the untiring patience, the admirable experimental skill, the veracity in thought, word, and deed, displayed throughout the inquiry by his assistant Mr. John Cottrell, who was zealously aided by his junior colleague Mr. Frank Valter.

# MUSEUM GODEFFROY.

By Prof. HENRY A. WARD.

IN one of the quarters of the "old city" in Hamburg, untouched by the great fire of 1842, is a little square around which crowd tall, narrow buildings with high, pointed roofs. The quaint architecture, the flat barges in the canal, and the queer trucks with harness enough on each horse to stock a team of four, remind one of the middle ages; but the busy railway-station near by and the forest of shipping on the Elbe bearing the flags of every civilized nation tell us that this is the great commercial port of Northern Europe. Here lives Herr Cæsar Godeffroy, one of the merchant-princes of Hamburg, whose ships for half a century have been sailing over every ocean. His great wealth has been expended liberally and in many ways, as Hamburgers all bear witness. But in one unique method Herr Godeffroy has long been doing a great work for science in Europe—a work that has made his name honored among the *savants* of Germany. This is the originating and sustaining an immense museum, now called after his name; an establishment which has for its object the collection and distribution of zoölogical material, especially in the department of the invertebrates.

Herr Godeffroy had a deep love for the beautiful and rare in Nature, and his captains brought to him contributions from all seas. This plan he encouraged, and finally enjoined it upon them, furnishing them before each departure with nets, dredges, casks of alcohol, and other equipments for collecting largely wherever they went. Most of his ventures were among the South-Sea Islands, and thence came to him splendid crustaceans, mollusks, star-fishes, sea-eggs, holothuria, corals, sponges, sea-fans, and the like. The collection as received increased so overwhelmingly in quantity and variety (for this systematic and princely research had developed a marvelous wealth of new forms), that Herr Godeffroy determined to make it available to science in the fullest manner possible. So he gave up one of his warehouses, fitted it up from cellar to garret for the storage and handling of this material, and engaged curators to assort and put in shape for permanent preservation the fresh arrivals. Specialists were also enlisted to work up each department, identifying the old and describing the new. Thus some of the most distinguished German naturalists were employed in this great storehouse of Nature's wonders. Some of them even found here opportunities for wider comparison of species than in the Royal Museums at home.

In other cases material was sent to the highest authorities in the various classes. Profs. Kölliker and Spengel, for example, have worked up the mammals; Sharpe (of the British Museum) and Drs. Hartlaub, Finsch, and Gräffe, the birds; Prof. Peters, the amphibians; Dr. Günther, the fishes; Semper, the insects; Dunker, Monson, Martens, and Garret, the mollusks; Lütken, the echinoderms; Dr. Kirchenpauer, Kölliker, and Semper, the cœlenterates; and Dr. Ehlers, the protozoans.

This plan, most liberally sustained, has resulted in giving the Godeffroy Museum a high place among the cabinets of Europe for its many type-specimens and novelties. The duplicates were freely distributed to institutions of science in the Fatherland, and to many specialists beyond it. This munificence in thus aiding investigators is a theme of praise among professional zoölogists on the Continent. Many of the discoveries among the lower forms of marine life which have enriched German science during the last two decades may be credited to the Hamburg storehouse. Rarely have wealth and liberality been combined in a way more grateful to working naturalists; and never did science indirectly receive greater material benefit from one not himself an investigator. For Herr Godeffroy is a merchant, spending most of his time in his counting-room and at the Bourse, and superintending cargoes which unite Hamburg with nearly every part of the world. He visits his museum for an hour or two as a weekly recreation, looking over the beautiful forms, and hearing from his corps of workers their most noteworthy observations. It is a phenomenon too rare in America; nor is it common even in more intellectual Europe to find commerce and science thus sharing the attention of the same mind. A Berlin naturalist, who was in a position to know, told the writer that Herr Godeffroy had for many years in the early part of his enterprise expended not less than from six to eight thousand thalers each year in procuring and working up his natural history material. It was perhaps to lessen the burden of this outgo by an income, and to make the institution in part self-supporting and therefore more permanent, that in 1865 (?) the founder decided to offer for sale to European naturalists his stores of duplicate material already acquired and daily coming in. For this purpose a carefully-prepared catalogue of the Museum Godeffroy was issued, with a detailed list of the species in classified order, giving the author and locality, and the catalogue number which follows the specimen when it goes forth. This catalogue is in itself an almost exhaustive list of marine invertebrates in the regions which the Godeffroy collectors have visited; and what gives it peculiar value is its reliable indication of the locality of the specimen, coming as it does from a trained collector sending direct to the establishment. The fifth catalogue, issued in 1874, is a pamphlet of 252 pages, and notes, in close print, the name, author, locality, and price, in Prussian currency, of about 9,600 species of insects, crustaceans, mollusks, echinoderms, cœlenterates, and protozoans, besides several hundred vertebrates. Much of this invertebrate material is in alcohol. The skillful use of this, by both collector and curator, has allowed the preservation of a large series of forms which are seldom offered for sale at a natural history establishment. Such are beautiful coral-polyps and other zoöphytes, physalias, velellas, pyrosomes, salpidæ, ascidians, holothurians, arachnidæ, minute crustaceans, polyzoöans, tunicates, and many other forms of extremest interest to the student, but heretofore rarely obtainable. In a word, the Museum Godeffroy, as now conducted, is a vast storehouse of material available for the cabinets and laboratories of working naturalists and teachers of comparative zoölogy in all parts of the world. It affords a splendid opportunity to our college professors to obtain those forms so needed in a systematic course of zoölogical lectures or in rounding out the ordinal divisions in their museums.

It may be wondered that so little has been known of this Hamburg "Zoölogical Comptoir" in America. The reason is to be found in the extreme (we had almost said unfortunate) delicacy of Herr Godeffroy, who has never been willing in any way to publish this as a commercial establishment; even the catalogue gives only on one page, accidentally as it were, the facts that the objects are for sale.

The enterprise is carried on purely in the interests of scientific discovery at a yearly expense, beyond returns, of several thousand dollars. The staff of collectors, equipped and kept in the field, is very large. Among those specially engaged at present are the following:

Herr Hildebrand is dredging in the southern part of the Red Sea and along the east coast of Africa, and interior in the Somali land, a region whose fauna is little known. Herr Dämel is at work in Eastern Australia, having passed through Queensland and penetrated three hundred miles into the interior, obtaining strange forms of mollusks and that strangest of fishes—the *Ceratodus Fosteri*. Six of these fishes, about two feet long, have been secured by him, and six German museums have got these ichthyological treasures at two hundred Prussian thalers each. Also in Australia, Frau Dietrich, a second Madame Pfeiffer, for the last ten years has been traveling and collecting for the Godeffroy Museum. Her collections of insects are astonishing in the number of new forms brought to light. In the rapturous South-Sea Islands—Samoa, Viti, Pelew, Society, Marshall, and others—Herr Kubarz and Dr. Garret have resided for more than ten years, cruising from island to island and making magnificent collections of polyps, echinoderms, mollusks, and crustaceans. The observations of these educated naturalists are familiar to the readers of the "Transactions" of the German zoölogical societies. For a long time the discoveries of this large party of expert collectors were thus freely contributed to the various scientific publications of Germany and Great Britain. But in 1873 Herr Godeffroy commenced the *Journal of the Museum Godeffroy*, a thick quarto issued in four yearly parts. This journal contains the elaborate report of distinguished naturalists on the series of specimens submitted to them. Thus Milne Edwards, of the Garden of Plants at Paris, has described the crustaceans; and Lütken, of Copenhagen University, the echinoderms; and Dr. Günther, the celebrated ichthyologist of the British Museum, the fishes. The *Journal* is profusely illustrated with colored cuts, and takes high rank for its beauty and scientific value.

Such is the remarkable Museum Godeffroy. As a storehouse of material for the benefit of working naturalists it stands unique; and as an auxiliary to the purest, highest research, it is one of the signs of the times that wealth is not absorbed in material interests; that commerce counts it an honor to contribute to original investigation. May the number of such men increase, and such institutions multiply!

# THE POLAR GLACIERS.

By C. C. MERRIMAN.

THE centre of gravity of the earth is the centre of the sphere formed by the surface of the oceans; or rather, owing to the flattening of the earth at the poles, it is a point equally distant, in opposite directions, from the level of the sea. The waters, being free to move, must of necessity conform themselves to this equidistance from the gravitating centre of the whole mass. Inasmuch, then, as any plane which cuts the earth into two parts through its centre of gravity must equally divide the weight of the whole earth, it follows also that the same plane would exactly bisect the great spheroid of the oceans. In each hemisphere the sea-level in all corresponding parts would be at the same distance from this centre; and whatever land and mountains there might be above the ocean in one half would have to be counterbalanced by land, or an excess of weight of some sort, in the other half. And this counterpoising weight must itself rise above the level of the sea, unless we say that one side of the world is composed of heavier materials than the other, of which there is not the least evidence or probability.

If the plane thus dividing the earth be that of its equator, there will be found in the northern hemisphere about 44,000,000 square miles of land, and in the southern, so far as is known, about 16,000,000 square miles. Now, the great problem in physical geography is, What is there in the southern hemisphere to counterbalance this great excess of land in the northern?

Humboldt has estimated that, if the mountains and highlands of Asia were leveled down and made to fill up evenly the low places, the whole continent would have a uniform height of 1,150 feet above the sea. In like manner, South America would have a height of 1,130 feet; North America of 750 feet; and Europe of 670 feet. The average of the whole he estimates at 920 feet. Of the mainlands not included in the above—namely, Africa, Australia, the polar lands, and islands—about as much is north as south of the equator. So that we may safely estimate that there is in the northern hemisphere an excess of 28,000,000 square miles of land, of the average height above-mentioned, to be counterpoised by something yet to be found in the southern hemisphere.

If there is an excess in the quantity or bulk of water south of the equator over that north of it, then the difference of weight between this excess and so much land, which is about in the proportion of one to two and a half, must be added to the unknown quantity which we are soon to look for above the southern seas. As there is, of course, the same excess of water-surface south of the equator that there is of land-surface north of it, and as we may very safely assume that the oceans have a mean depth of at least 3,220 feet ($3\frac{1}{2} \times 920$) and that the southern waters average as deep as the northern, it follows that our unknown quantity is at the very least doubled by the above considerations. We have, therefore, to seek in the southern hemisphere what will balance 28,000,000 square miles of land at least 1,840 feet high.

We look over the map of the world, and down near the bottom we find some uncertain landmarks with many breaks, but on the whole tracing out very nearly the antarctic circle, and indicating that there is, covering nearly all that zone, an unexplored and scarcely discovered country. This impenetrable region is estimated to be as large as the continent of North America, about 8,000,000 square miles. A very little arithmetic will now prove the bold claim which I here make, that, even supposing the whole of this region to be land of the average continental height, there is still required over it all an average thickness of two and a half miles of solid ice to make the southern hemisphere equal the northern in weight.

This result of calculation is well confirmed by the information which all southern navigators have brought back from those most desolate and ice-bound regions. The zone of the antarctic has been encroached upon only in a small space south of the Pacific. On every other side, so far as has been discovered, mountains of ice block the way on and near the polar circle, which seems to be the great ice-barrier of the south pole. Discoverers suppose what they have looked upon to be land, but rarely have they ever seen any thing but rolling ranges of ice and snow rising higher and higher as far as the eye could reach. In the most open of the south-polar seas, Sir James Ross, in 1841, sailed 450 miles along an unbroken cliff of ice from 150 to 250 feet high, and of unknown depth beneath the water. It was one of the vast antarctic glaciers pushing down into the sea, from which some of those southern icebergs were broken off, that navigators have frequently laid down for islands, while the next sailor that voyaged that way found open water where they were charted.

Not a sign of vegetation, not an indication of thawing, has ever been discovered within or near the antarctic circle, whereas there are aboriginal races and numerous settlements of civilized communities on every side within the arctic circle. The whaleboat or the dog-sledge has traversed the arctics and found the sea-level in almost every degree of high latitude. In the south no adventurer has yet penetrated within probably 1,500 miles of the centre of greatest cold. Whence comes this great difference in the climate and ice accumulations of the two poles of the earth? It is the object of this article to inquire if in the astronomical relations of our planet there are found any sufficient causes for such differences.

The path of the earth about the sun once every year is an ellipse, with the sun in one of the foci or centres. An ellipse is a circular figure having two centres instead of one; that is, the circumference is everywhere equally distant from the two centres taken together—the sum of the two distances is always the same. Therefore, the sun being in one of these centres, the earth is nearer to it in one half of the year than in the other. At the present time the nearest approach, or the perigee, occurs about the 1st day of January; and the earth is at that time 3,200,000 miles nearer to the sun than it is on the 1st day of July.

It is a peculiar property of bodies revolving in elliptical orbits, that they travel faster when near the centre of attraction than when farther away. It follows, from the second of the three great laws of planetary motion discovered by Kepler, that the line connecting the two bodies must pass over equal areas in equal times. The earth passes through our winter portion of its orbit, that is, from autumnal to vernal equinox, in eight days less time than through the summer part of it. In the southern hemisphere, of course, the condition of things is reversed, and the winter there is eight days longer than the summer. Moreover, the sun is at its greatest distance from the earth during the long southern winter, and at its least in the short northern winter.

Of the two causes, I regard the first as of main importance. Distance from the sun, whatever theory may be, does not seem to have much effect upon climate. The southern summers, when the sun is over 3,000,000 miles nearer the earth, are said to be even some degrees cooler than the same seasons in corresponding localities of the northern hemisphere. And to take an extreme example, Mars, which is 50,000,000 miles farther from the sun than the earth is, has snow-lines about its poles which reach no nearer the equator than on our planet in corresponding seasons. But the excess or diminution of eight days, in the winters of climates which even in their warmest seasons barely balance on the thawing point of ice, is a true cause in polar conditions and differences. Considering that these days affect chiefly the period of briefest sunshine, it amounts to quite one-twentieth of the whole power of the sun on a hemisphere. This difference would not be apparent in the warm regions of the globe, where there is always an excess of heat which is carried off by evaporation and ocean-currents; but it would exert nearly its full force in polar regions which are unaffected by those influences.

It cannot be denied that it is the sun's heat which prevents the temperature of the earth from sinking to, or very near to, the absolute zero of cold, wherever in the thermometrical scale that may be. Chemists have produced a cold estimated at 257° below zero, of Fahr.[1] It is not by any means probable that this reaches the entire absence of heat. But, on the supposition that it is so, and that polar regions are unaffected by the air or water currents of the tropics, then an excess of eight winter days would lessen a polar temperature 15°, and unquestionably amount to the difference of an accumulation of ice and snow year after year, instead of the annual thawing during each summer, of the winter's increase.

This is precisely what is, or has been, taking place at the respective poles of the earth. Year after year, probably for a long period, there has been a steady accumulation of ice-material about the south pole, adding weight to that hemisphere. Then, in proportion to this increase, the centre of gravity of the earth has moved a little toward the south; and the waters, always obedient to this controlling point, have gradually gathered into the southern seas, covering the lowlands and plains of islands and continents. At the same time the waters were drawn away from the north-polar regions, uncovering lands, and leaving bays and sounds and inlets innumerable. The geography of the countries fully corresponds to these inferences. The seas of the arctics are comparatively shallow and deeply cut up, and the lands are low-lying. In the antarctics the oceans are deep and bayless, and all the mainlands and islands are precipitous and craggy, as if they were the peaks and table-lands of mountain-ranges.

It is now the question whether this state of things is a permanent arrangement—whether we of the north side are always to have the advantage of extent of territory, of fertile lands and healthful homes

[1] The temperature of stellar space is estimated by Sir John Herschel and others at −239° Fahr.

in middle latitudes, in short, of all that makes the rivalry of nations, and civilization a necessity. To answer this question it will be necessary to turn again to astronomy, and to study for a few moments some of its more abstruse problems.

In addition to the rotation of the earth on its axis once every day, and its revolution about the sun once in a year, there is also a slow, rolling motion of the equator, caused by the attraction of the sun on the excess of matter in equatorial diameters over the polar. It is precisely as when one touches the rim of a top in rapid motion: there is set up at once a slow, gyrating or tilting roll, and the upper end of the stem describes a small circle. Just so the sun lays hold of the protuberant rim of the great terrestrial top, and immediately it begins to oscillate in the long secular period of 25,868 years; while the polar axis, extended to the heavens, describes in the same length of time a small circle of $23\frac{1}{2}°$ radius among the northern or southern stars. This is the motion which occasions what is called the precession of the equinoxes. The plane of the earth's equator crosses the plane of its orbit; and, when the earth is at the points of junction, the days and nights are equal the world over. These two points, therefore, are the equinoxes; and the earth passes through them about the 21st days of March and September. Owing to the rolling motion of the equator, above described, these points, always in the line of intersection of the two planes, pass successively through the twelve signs or constellations, making slowly the entire circuit of the heavens. The vernal equinox, which now points to, or is on a line between, the sun and the constellation of the Fish, after about 26,000 years will have traveled the great circle of the heavens and come back again to point to the same cluster of stars which is now overhead at midnight on the 21st of March.

But the time of this revolution, so far as it affects the climate of the earth, is modified by the following circumstance: The ellipse or oblong circle in which the earth revolves about the sun is itself all the time slowly revolving. The long diameter of it—the major axis—makes a complete revolution in the heavens once in 110,000 years. Now, as this revolution is forward, or in the same direction among the constellations that the sun appears to move, while that of the equinoxes is retrograde, it follows that the extremities of the major axis, which are the perigee and the apogee, advance to meet the equinoctial points; so that the revolutions, or rather the conjunctions, of the equinoxes, which have to do with terrestrial climate, are accomplished in the shorter period of 21,000 years.

Now, all this astronomy amounts simply to this: that in the year of our Lord 1248 the earth was at its nearest approach to the sun on the 21st day of December, our winter solstice; and that in 10,500 years from that time the same thing will happen on the 21st day of July, our summer solstice. In the period comprising the first case, our winters are short and mild, and our summers long and sunny. During the cycle which shall comprise the latter case, our winters will be rigorous and our summers short. The northern hemisphere is now having its great summer. In about 10,000 years it will be in the midst of its great winter; and whatever differences there may be between the two hemispheres, owing to astronomical causes, will then be in full force against the northern.

A distinguished Scotch mathematician, Mr. James Croll,[1] has estimated that the melting of a mile in thickness of the present antarctic ice would raise the sea-level at the north pole 300 feet, and at Glasgow 280 feet. We have calculated, from data which were intended to be under-estimates in every case, that there were at least two and a half miles of average thickness in what geographers call the great ice-cupola of the south pole. If, therefore, not only this were removed, but an equal quantity of ice were deposited at the north pole, there would be a deepening of the sea at the arctic circle of 1,500 feet.

Thus it is seen that, as certainly as terrestrial revolutions continue, in the course of 10,000 years there must come an entire reversal of polar conditions. The southern waters must be drained off to make the oceans of an opposite hemisphere. New lands, enriched with the sediment of a hundred centuries, will rise up to extend the borders of the old south continents, and islands joining together, will expand into mainlands. At the same time the northern continents must be in great part submerged, and their summits and ranges become the bleak islands and the bold headlands of a tempestuous ocean. Central Asia, with its broad table-lands, may still retain the name of a continent; but, beyond a few outlying islands, there will be no Europe, and but little of North America left. The Atlantic waters will stand five hundred feet over Lake Superior, and will wash the base of the Rocky Mountains in all their length. A new Gulf Stream may again, as it must often have done before, flow up the valley of the Mississippi, returning the deltas to the prairies, and remaking the beds of the garden of the world. These are no idle or impossible fancies. Not only are they the results of rigorous calculation, but they accord perfectly with the unmistakable evidences which the ocean has left, all over our land, of its recent work and presence.

The time-honored geologist, Sir Charles Lyell, lays great stress on the quantity of land and the configurations of continents, as chiefly efficacious in the great climatic changes. But it may be pertinently asked, What becomes of his continents and configurations when the seas of one pole advance to the other, as they unquestionably do, as they cannot but do, every 10,500 years, obedient to the transfer of

[1] This article was written before the publication of Mr. Croll's recent work on "Climate and Time." The reference here is to an article published some years since in the *Philosophical Magazine*.

vast ice weights from one end of the world to the other? On all the mountains of New England there are sea-lines at elevations of 2,000 and 3,000 feet, and Lyell himself has recorded the facts. When the ocean was that deep over Boston, there were no continents in the northern hemisphere. Undoubtedly the height and direction of mountain-ranges, the trending of sea-shores, and the course of ocean currents, have much to do with local climates. But, instead of the relative quantity or location of land and sea having any agency in producing the glacial periods, it is these periods which produce the land and the sea.

So much for the causes and conditions which pertain to the geography of the present and the future. When, now, we turn back a few of the leaves which tell of the past condition of our planet, we immediately see that the same causes have been at work in recent geological times on a much more extensive scale—in fact, that they have been the chief agents in composing and modifying the present surface of the earth outside of the tropics. Over all the northern portions of Europe, Asia, and North America, are found the unmistakable evidences of extensive and recent ice-work. Bowlders of every size, some worn and some angular, are scattered in immense quantities over all the country, on the hills, on the plains, in places where the only possible explanation is that they were lifted up, carried, and dropped, just where they are found; and the great iceberg was the carrier. The face of the rock-beds, wherever brought to view, in the valleys or on the mountains, is almost always found to be ground or polished, and, over that, grooved and furrowed with nearly parallel scratches. The Alpine glaciers are doing exactly the same work today. Erratic blocks of foreign origin, and sometimes of enormous dimensions, are frequently found perched on the very tops of hills, or stranded high up the mountain-sides; and the quarries from which they came are invariably found to the northward, sometimes fifty or even a hundred miles. It is argued that nothing but polar glaciers could thus have moved them in uniformly meridional lines. The scrapings of grounding ice-floes, the marks of ancient sea-shores, and marine relics and shells, are found at elevations of several thousand feet above the present ocean-level. There is no escaping the conclusion that the northern continents have been, in not remote ages, deeply submerged beneath an ice-laden sea; and that the entire polar and north temperate regions, extending in some places south of the fortieth parallel of latitude, have been capped with one massive covering of ice of great thickness. Precisely the same evidences are found in South America, and, according to Agassiz, even much nearer the equator than in North America. We have again to search our astronomy for causes many times more powerful than any thing we have yet found, for differences of polar temperatures.

The earth is made to revolve in an orbit drawn out of the circular form by the combined attractions of the other planets, Jupiter carrying the controlling influence. When the average of all these forces for long periods is more in one direction than in another, our planet is drawn away from the sun on that side. Now, it must occasionally happen, with the various periods of revolution of the planets, that they unite at times to produce extreme irregularities. The present difference between the nearest and farthest distance of the sun from us is 3,200,000 miles. It is found, by calculating back the planetary orbits and conjunctions, that this focal distance has been as much as 14,000,000 miles. There was, then, an excess of thirty-nine winter days during each year of the great secular winter of either pole. This exceptionally high eccentricity occurred, according to the calculations of Mr. James Croll, about 850,000 years ago. But it is now generally thought that we have no need to go back as far as that for the period of the last glacial epoch: 200,000 years ago the focal distance was 10,500,000 miles, and the winter excess twenty-eight days. This, on the supposition heretofore made of the absolute zero of cold being at least 257° below the freezing-point, would lower the mean temperature in polar regions 50° Fahr., and would unquestionably extend the permanent ice-limits far into the temperate zone. From that time, down to 70,000 years ago, the eccentricity was continually from two to four times greater than now. Since about 70,000 years ago, it has been nearly all the time less than at present. Thus it may fairly be concluded that the great glacial period of the Post-tertiary era came to an end with the fourth secular winter in the past, or B. C. 67,000.

This is a very interesting date to us of the genus *homo;* for it must have been about this time, according to all accounts, that our forefathers made their appearance on the earth. Man, with the long-haired mammoth, the woolly rhinoceros, the huge cave-bear, the great horned reindeer, and numerous other species now extinct, followed close upon the retreating ice-fields of the bowlder period. Our primeval ancestors were a race of hunters, and they subsisted on the most abundant and magnificent game that the world has ever seen. They lived in caves or under projecting ledges, and with only flint-headed weapons contested their lives and homes with savage beasts. They cracked the bones of animals for their marrow, or crushed them in stone mortars for the fats and the juices which they contained. It was the lingering carnivorous instinct to gnaw the bones of their prey. They had fires at their funeral feasts, but there is little evidence of their indulging often in the luxury of cooked meats. It was a rude life, and a hard struggle they must have had for it; but their history is read in the drift-beds and cave-deposits of Europe, as plainly as if there had been an Herodotus to write it.

The effect and bearing of the great ice periods on geological work and time will be further considered in a second article in continuation of this.

# MODERN PHILOSOPHICAL BIOLOGY.

By Dr. E. CAZELLES.

TRANSLATED FROM THE FRENCH BY J. FITZGERALD, A. M.

II.

NOT all matter is capable of performing vital acts. Those substances alone possess this property which, owing to their peculiar composition, readily undergo molecular changes; that is to say, whose parts are grouped in very unstable equilibrium, and which are always ready to form other combinations. This state of instability is the result of complex combinations of six simple bodies, which at common temperatures have a very weak affinity for one another, but a strong affinity for elements outside of these combinations. Of the six, four, namely oxygen, hydrogen, carbon, and nitrogen, enter into these combinations in large proportions, while of the other two, namely sulphur and phosphorus, only a few atoms enter; and these latter elements are so readily oxidized that their presence increases the instability of the compound. Besides, the atoms of these simple bodies, though occurring in identical proportions, may be grouped according to different modes of aggregation (isomerism and polymerism), and the organic compounds which they make up stand midway between liquids and solids; their molecules are highly inconstant, whence result two well-known properties: the plasticity of organic matter, and its permeability to other substances. These properties are further causes of instability, inasmuch as they expose the organic substances to a number of disturbing influences. Thus, organic matter is not only subject to decomposition by light and heat, but also by the direct or indirect chemical action of bodies entering it, or acting on it from without. In such cases the effect of the disturbance is to cause the organic substance to pass from a state of relative instability to one of relative stability, or even to the state of compounds the most stable in the organic world.

At the same time that it undergoes the action of these external forces—and among external forces we include those developed in organized beings, but applied to other tissues than those producing them—at the same time that under the action of these external forces organic matter suffers decomposition, it becomes the scene of notable reactions. Even very inconsiderable changes in the external forces, which serve as its conditions, produce in it new molecular arrangements which offer a contrast, in their extent and importance, to the comparative insignificance of their cause. These new arrangements, being succeeded by more stable combinations, in turn bring about a disengagement of a great amount of force, in passing from a less stable to a more stable equilibrium. The atoms of the organic substance lose part of their latent motion, which is manifested externally under the form of heat, electricity, light, nervous force, or mechanical motion, according to circumstances. Be the cause which produces these changes necessary or not, they are, of necessity, accompanied by a disengagement of force; and we can affirm of any force whatever expended by an organ of a living being, that it is the equivalent of a force acting from without upon that being. This is a consequence of the law of the persistence of force, and it may be presented under two forms: First, in order that a certain amount of force may be expended by a living being, there must have taken place, within that being, a transformation, by decomposition, of a quantity of organic substance capable of holding that force in the latent state; and, secondly, there can be no transformation of organic matter holding force in the latent state, without an expenditure of force which shall manifest itself in some shape externally.

In general terms, what we have to consider in living things is, first, a substance of special composition, and then expenditures of force by that substance; and this, too, is what we have in general terms to consider, in non-living things. The former are distinguished from the latter by the fact that the changes which constitute their history are heterogeneous; that they form many series which are simultaneous, correlative, held together by a tie of mutual dependence, the result being a high degree of complexity, a phenomenon belonging to one series having antecedents and consequents in other simultaneous series; and above all, that these changes form clearly-defined combinations. This *ensemble* of characteristics not only enables us to distinguish living from non-living things, but also to distinguish between living things themselves and to class them according to their *degree of life*. Thus a thing stands all the higher in the vital scale in proportion as, from the beginning to the end of its vital manifestations, it exhibits a larger number of successive and simultaneous changes, and as these changes are more heterogeneous and more closely linked together, and in more definite relations to one another. Between the lowest animals, rhizopods, planaria, etc., and the highest, the birds of prey, mammalia, carnivora, man, there is an enormous dissimilarity; still the definition applies to them all, and serves to define the difference which separates them, as also the difference of the numerous species lying between these extremes of the animal series.

Though this definition is a good one, inasmuch as it applies to all living things, and to them alone, nevertheless it is defective in that it omits the most distinctive peculiarity, namely, the element known as activity, in other words, those operations whereby living beings adapt themselves to their conditions of life. The definition should include the general relations of the living thing to its environment. The environment, too, has its successive and correlative changes which, though very diverse, present no definite combinations. Its composition, no doubt, is definite, and equally so its properties; but they are variable, and its variations alter the relations of the environment to the living being. To all changes of the environment there are corresponding changes in the living being, otherwise it would perish. These changes, which follow the laws of vital changes, inasmuch as they are in a definite combination, constitute the activity of the animal; the more numerous and frequent they are, the more active is the life and the higher the rank of the living being in the scale of life. The degree of correspondence between the living thing and its environment is also its degree of life, inasmuch as in effect it connotes an increase in the number and in the mutual dependence of the vital changes which constitute life. A perfect correspondence would imply a perfect life. If to all changes of the environment there were opposed, as a counterbalance, changes in the living thing, natural death would be no more, nor death by disease or by accident, all of which are signs of a lack of correspondence.[1]

A definition of life which possesses these characters, and which expresses in a general formula the law of the changes of structure, and of the changes of function accompanying them; that is to say, which expresses the heterogeneity, the coördination, and the ever-increasing mutual dependence of these changes; and which at the same time expresses the ever-increasing correspondence which attaches them to the changes of the environment by an operation of equilibration—such a definition makes life to be an evolution, a succession of states of unstable equilibrium tending to perfect equilibrium; not

[1] We must here point out an erroneous statement made by Claude Bernard. In his article on the "Definition of Life" (*Revue des Deux Mondes*, 15 Mai, 1875, p. 345), this eminent physiologist offers as a complete definition of life a portion of Spencer's definition, as found in the "Principles of Biology." "The following definition," says he, "is proposed by Herbert Spencer: 'Life is the definite combination of heterogeneous changes, both simultaneous and successive.'" And he goes on to say: "Under this abstract form the English philosopher would specially indicate the idea of evolution and of succession observed in vital phenomena." If M. Claude Bernard had made this quotation from the "Principles of Biology" itself, he would have read immediately after this passage the following words: "This is a formula which fails to call up an adequate conception. And it fails from omitting the most distinctive peculiarity—the peculiarity of which we have the most familiar experience, and with which our notion of life is, more than with any other, associated. It remains now to supplement the definition by the addition of this peculiarity" (p. 71). Those who have studied Mr. Spencer's writings know how cautiously he sets about making a definition. He completes a formula, first expressed in very general terms, by the successive addition of essential characters, and for each of these characters he makes a minute analysis. Thus, having given as a preliminary result the formula quoted by M. Claude Bernard, Mr. Spencer adds that it needs to be completed, and a few pages further on (p. 74) he adds these words: "In correspondence with external coexistences and sequences." Again (p. 80), he writes: "The broadest and most complete definition of life will be—The continuous adjustment of internal relations to external relations." It is evident that M. Claude Bernard did not derive from the "Principles of Biology" the definition he quotes, and which he condemns. But ought he not to have taken it from that work?

only an evolution of the individual from the moment when it became more heterogeneous by the differentiation of parts and functions, but also an evolution of the *ensemble* of living beings, from the first appearance of life in its least differentiated form up to the highest degree of complexity in structure and function.

If life is an evolution, of what is it an evolution? If the question refers to an individual of any given species, the answer is easily given, for we can study the history of its life from the germinal cell to the period of its full development, and to the end of its life. But if the question refers to the *ensemble* of living Nature, only the middle portion of which is known to us, and the beginning of which we have no idea of save in imagination, then the reply must be only an hypothesis. We find groups differing from one another by their respective degrees of vital evolution, and we regard them as being, not as it were links of one chain, but rather the result of an evolution which has taken different directions owing to different circumstances. Hence we can admit only one starting-point, though the goals are many. The divergent lines which we find in the development of the forms of living things, in the history of life, warrant our supposing the starting-point to be one, and at this point the evolution hypothesis must place the formation of primordial organic matter, whose reactions with its environment present the first crude examples of vital function.

The hypothesis which accounts for the production of life by the spontaneous generation of a complete organism from simple protoplasm is irreconcilable with evolution; this would suppose something more than an evolution, in fact a *beginning* in the absolute sense, an enormous hiatus between the causes and their supposed effects. But on the theory of evolution we can conceive of another mode of formation. It is possible that even now, under existing cosmical conditions, organic matter is produced; but it is more probable that it was formed in an epoch when the cosmical forces now known to us, especially heat and light, had on earth a greater intensity than at present. The first types must have been more simple, less definite, less fixed in form and structure, than the lowest rhizopods of our day. Indeed, they must have been more nearly allied to protoplasm than even Haeckel's *Protogenes;* and, before evolution could derive from these types our present infusoria, ages and ages must have elapsed. Strictly speaking, we cannot call the first living thing an organism at all, in the true sense of that term; it is stretching the meaning of words to speak of types in connection with beings whose form must have been perfectly unstable, and whose organization had no structure.

Of this quasi-organism we have merely a symbolic conception, formed by combining two positive, empiric elements, viz., transformations of substances strictly evolutive, such as we see in the laboratory of the chemist, where organic matter goes through a series of gradual modifications by which it is adapted to new artificial conditions; and, on the other hand, facts observed in the lowest orders of animals by the biologist. We conceive that, in the primordial world, as now in the laboratory, higher types of organic substance were formed at the expense of lower types, and that gradually, after repeated reactions and under favorable conditions, they resulted in organizable protoplasm, a substance which is very susceptible of modification. Protein, as we know, may exist in upward of one thousand isomeric forms, and, by combination with itself and with other substances, it yields products still more complex, and in countless numbers. Hence we can easily conceive how, under the conditions of heat and light then existing on earth, and with the aqueous, mineral, and atmospheric environment of that epoch, protein may have undergone metamorphoses without end. Under conditions which we can conceive as possible, though we may not be able to define them exactly, products may have been evolved fitted to exhibit the rudimentary vital reactions. In this way we fill up the chasm which divides the positive chemical facts of the higher organic combinations from the biological phenomena of the lower forms of life.

But another hypothesis is still necessary. "When we come down to the substances out of which living bodies are formed, we find groups and sub-groups of manifold and divergent compounds, the units of which are large, heterogeneous, and unstable in a high degree. Why should we suppose that these combinations must stand still at the complex colloids which enter into the composition of organic matter? Is it not more probable that, in addition to these colloids, there are developed by a higher combination atoms still more heterogeneous and compounds still more numerous? If colloids are unstable, extremely modifiable by very slight incident forces, and incapable of assuming the equilibrated form of crystallization, then *a fortiori* these new organic atoms are unstable, very modifiable, and of many different species." They would surpass protein in instability and plasticity as much as protein surpasses organic matter. Furthermore, these atoms would possess one fundamental property, without which no explanation is possible in biology, viz., the property of arranging themselves in certain forms peculiar to the various groups to which they belong—a property but little understood, though its existence is unquestionable. We call it *polarity*, for want of a better term, to indicate the power of manifesting actions in a certain fixed direction. These atoms we denominate *physiological units*. They are developed in every living thing, differentiating themselves from one another in different organisms by the same causes which differentiate the organisms themselves, and in this way acquiring a diversity which corresponds to that of the creature they constitute by their aggregation. They follow, step by step, in their modifications the modifications of the aggregate to which they belong. They undergo the influence of the environment, though indirectly, through this aggregate. Their modifications are new directions, amplitudes of new vibrations, which place them in equilibrium with the forces which the *ensemble* of the aggregate, as modified by the environment, brings to bear upon them. These modifications endure as long as equilibrium endures, and are ever transmitted to the new units which spring from the former ones, until, on the equilibrium being disturbed, a new breaking-up of the existing relations necessitates others.

The hypothesis of physiological units is a necessity, not only in order to fill up the gap which separates the highest products of organic chemistry from those irreducible elements revealed by the microscope which we call morphological elements, but also in order to furnish a substratum for the positive property which serves to account for the great facts of biology, and to refer them, by formulæ expressed in terms of mechanics, to first principles.

Let us now consider the great facts of biology.

The *growth* of an organism is an operation essentially like the growth of a crystal. "Around a plant there exist certain elements that are like the elements which form its substance; and its increase of size is effected by continually integrating those surrounding like elements with itself. Nor does the animal fundamentally differ in this respect from the plant or the crystal. Its food is a portion of the environing matter that contains some compound atoms like some of the compound atoms constituting its tissues; and, either through simple imbibition or through digestion, the animal eventually integrates with itself units like those of which it is built up, and leaves behind unlike units."

Organic growth differs from inorganic in this, that it has limits. All conditions remaining the same (a proviso that must always be made in biology), and the quantity of integrated substance not varying, we find that, by the principle of the persistence of force, the growth of the living being must depend on the expenditure. The only portion of the integrated substance that can serve for growth is the unexpended residue, the excess of nutrition over expenditure—a quantity which is essentially variable, and which transfers its variations to the growth, limiting it and diminishing it more or less rapidly from the moment when the body of the living thing has attained its full development. Experience shows that the limit of growth is fixed for those organisms which have large expenditure, and that for those which have hardly any expenditure this limit gradually recedes; of this the crocodile is an instance. But there is another element which must be taken into account, namely, that the definitive volume of an organism, being the sum of its initial volume and of its successive increments, must depend upon the initial volume. The definitive volume depends also on the organization, which enables the living thing to assimilate substances in large quantity and to dispose of an amount of nutrition in excess of the expenditure, just as a large capital, while it gives the means of undertaking great enterprises, at the same time yields increased profits.

The integration by an organism of substances homologous with its own has for its effect a segregation which increases the difference between the organism and the environment, and at the same time makes this difference stable. While the organism is being integrated, at the expense of the environment, by deriving from it special materials, each organ is being integrated at the expense of the organism, from which it derives, as from an environment, its special materials. Like the organism, each organ diverges more and more, by a gradual segregation, from the organs around about it. The organic units which constitute it attract other units with the same polarity, diffused throughout the fluids. This is not always the case, and homologous units do not always exist ready made in the nutrient fluid. More generally the organic units find in the fluids only the elements necessary for the production of homologous units, and segregation is perfected by a phenomenon of the nature of a genesis. Still in this case, as in the preceding, the result is a more perfect differentiation of the parts of the organism, an increase of heterogeneity, and augmentation of the distinction between the different parts, and ultimately the formation of a structure and of an actual organism. This result is called *development.*

Expressed in general terms, development is the transition from a state of incoherent homogeneity to a state of coherent and definite heterogeneity; from a state wherein the parts are all alike, or rather, where there are no distinct parts, to a state wherein there are parts clearly defined, with fixed forms and attributes. The bud of a plant consists of a hemispherical or subconical projection which, at its apex especially, is made up of a transparent mass of cells not yet organized into tissues. This mass grows owing to the rapid multiplication of the cells, lengthens, sends forth other similar projections having a like homogeneous structure; from this come leaves. As the branch develops, the cells, which at first were identical, assume different characters, till at last they lose all resemblance to one another. The same thing takes place in man. His arm is at first simply a little budding prominence on one side of the embryo, consisting of simple cells without any signs of arrangement. Soon there appear vessels, and later the cartilaginous parts from which are produced the bones, the gelatin-like bands which afterward are transformed into muscles, etc. In the individual we see the first phase of existence characterized by a state of homogeneity wherein nothing is distinct, and we follow step by step the gradations of its transition to a greater complexity, and to states characterized by increasing distinction of parts, as their dissimilarity becomes greater. And what is true of the individual animal or plant is equally true of the whole organic world. Baer's law would lead us to suppose that the organic world has developed like the individual; that, starting from homogeneity, it has resulted in heterogeneity. In the early stages of their existence, all organisms are alike in most of their characters; somewhat later their structure resembles that found at the corresponding period in a smaller group; at each subsequent stage the organism acquires traits which distinguish the developing embryo from one after another of the groups which before it resembled; till finally the class of organisms which it resembles includes only the species to which the embryo belongs. Thus, in the process of differentiation, the embryo first acquires those characters which determine the *sub-kingdom* to which it belongs, then the *class*, then the *genus*, finally the *species*. In the series of organisms we should thus find a succession of states like those which constitute the history of the individual, with this difference, that in the individual we can make out the link which connects the primitive homogeneity with the final heterogeneity, while in the series of organisms all we can do is to connect, with a considerable degree of probability, the hypothetical starting-point with the positive goal.

Side by side with heterogeneity and distinction of parts in the structure, we have a correlative result of this same segregative operation, viz., differentiation, which tends to produce heterogeneity and distinction of functions. The expenditure of the force that is stored up in the shape of materials takes place through the parts of the organism, however little heterogeneous these may be supposed to be, and this force is in fact for the parts an incident force which, by the law of the multiplication of effects, must break up in the process of differentiation, when applied to heterogeneous parts. The functions are simply the variously-modified forms assumed by the forces disengaged by the organism as they traverse specialized parts; and, the more diversified the organs, the more diversified are the functions they manifest. Of these some may be denominated static, inasmuch as they serve only to withstand external forces by equilibrating them; such, for example, are the functions of the woody axis in plants and of the skeleton in the vertebrata; others may be called dynamic, as producing motion and giving it direction; such, for example, are the functions of the circulatory apparatus and its belongings in both kingdoms of the organic world, and of the muscular apparatus in animals.

Like structure, function obeys the law of evolution; it proceeds from the homogeneous, the undefined, the incoherent, to the heterogeneous, the definite, the coherent. Like structure, function proceeds from the simple to the composite, from the general to the special. An important corollary results from this law—one that settles the dispute which has so long divided physiologists upon the question as to which precedes the other, function or structure. If the starting-point be homogeneity, and if the transition from a structureless to a structural state is a phenomenon of vital action, then vital action precedes structure. Life is a system of internal actions adapted to equilibrate external actions; actions are the substance of life, its form comes from structure. Hence action must of necessity precede the fixation of the structure, which produces the adaptation and gives definite form to the function. From first to last, function is the determining cause of structure. But in justice to those who maintain the precedence of structure, it must be added that function, which, as we hold, is anterior to structure, nevertheless, regarded as an activity modified and different from what it was, assumes its differential, distinguishing characters only in proportion as the adaptation becomes perfect, and as equilibrium is established between that portion of internal reaction which it represents and the external action which it withstands.

At first there are only two functions, corresponding to the structural distinctions of endoderm and ectoderm, viz., the functions of accumulation and of expenditure of force. In proportion as each of the apparatus and each of the corresponding functions become differentiated and subdivided into specialized parts, a third function appears and takes root; at first this is a very simple affair, and it employs an ill-developed apparatus, but gradually it becomes more complex, and ultimately, in the higher animals, is divided into very definitely specialized parts. This is the circulatory apparatus, which performs those operations whereby materials containing latent force are distributed throughout the organism.

But differentiation is not the only change produced in the organism. The functions, as they multiply and are better defined, combine, become dependent on each other, are *integrated.* Labor is divided, as they say in political economy, but it is also centralized, and coördinated. Alongside of division of labor we have coöperation: an organ does not work for itself alone; it has a special function, but this function serves to facilitate, or even to render possible, the special function of some other organ.

As the formation of an organ depends on the function, so the growth of an organ depends on the growth of the function, and when once produced it is maintained only when the increase of function persists. And not only its growth, but also its development (including the differentiation of structure which accompanies it), depends on the development of the function, or, in other words, on the differentiation of the reactions of the organism to the forces of the environment.

We shall all the better understand the mechanism of the adaptation and of the modifications produced in one another by function and structure, if we consider what must of necessity occur when an augmentation of function in an organ answers to an augmentation of the demand for work made by the external conditions. In virtue of the law of universal rhythm, the result of excess of function is excess of wear, and consequent relative impotence of the organ. Thus excess of function in the organ A cannot go on forever unless the losses are constantly made good, the wear compensated, its power renovated; and this cannot be without an augmentation of function in one or more organs, B, C, D, etc., on the activity of which its own activity depends. The increase of function in these organs once established by a definite structure, the organ A not only can preserve its increase of structure and function, but it has now a firmer basis for growing still more, for producing another excess of function, and for going farther in the same direction than otherwise it could have gone. But adaptive modifications have a limit, and it is always near at hand, though it slowly retreats from generation to generation. This we learn from the mechanism of adaptation. As the function of an organ cannot be permanently increased save on condition that the functions of those organs on the action of which it depends have gained a permanent increment, and as they in turn are conditioned on a permanent increment in the functions of other organs, it is plain that there is needed nothing short of a reconstruction of the whole organism upon a plan which shall insure normal provision for the organ that is subject to an excess of function, and in which this excess of function shall be in fact a normal process. If equilibrium be disturbed at one point, it is reëstablished only by propagating its own disturbance to all the internal equilibria; and, in order that it may itself endure, it must not be disturbed by a perturbation of reaction from within; the internal equilibria must be restored at the expense of the forces developed by the nutrition, and must be fixed by modifications of structure.

So long as this rearrangement of the internal equilibria remains unconsolidated by a reconstruction of the general structure, so long will the equilibrium produced by the adaptive modification, at the point affected by the initial disturbance, remain instable. And if, now, the disturbing conditions from without cease to exist, then the new structure, no longer sustained, so to speak, by an excess of temporary function, and receiving from the auxiliary organs, which are not yet adapted to this service, no permanent excess of function, can only furnish the same amount of action which it furnished originally. Little by little the imperfectly modified parts return to their original functions, and the whole scheme of adaptation comes to naught. Thus we see that, in virtue of the general laws set forth in the "First Principles," an adaptive change must quickly find a term beyond which it cannot progress save slowly—a fact which explains the apparent fixity of species, or the inconsiderableness of such deviations from a type as can occur during the periods over which our observations extend. It is plain that a modifying cause, the action of which persists only for a short time, can produce only a transient modification; that the complexity of the internal equilibria and their reciprocal dependence constitute the one great obstacle to the permanent change of structures and functions; that a disturbing influence, even though it were to extend to many generations, can only modify a race superficially; and, finally, that, the instant that this cause ceases to be, the race resumes, slowly but surely, its original characters.

In fact, the environment is ever changing, and in the enormous cycles of changes in the conditions surrounding organic life upon the earth the same conditions have never occurred a second time. Organisms must follow this movement of variation; they must be ever undergoing a process of adaptation, in order to be in equilibrium with the altered conditions around them. In this necessity for adaptation we recognize a consequence of our first principles. The state of homogeneity must give way to a state of heterogeneity: a species must be ever growing more and more varied in its forms; old species must be ever breaking up into new. If at one time a species consisted of individuals alike in all respects, the action of the various forces of the environment would soon put an end to this uniformity; at the same time, however, leaving tokens of relationship. But let us go further, and suppose the conditions to be still more profoundly altered, owing, for instance, to a climatic perturbation of the habitat, or to an emigration of the species into other habitats; in that case there will be different sets of conditions, and the groups of individuals will resemble one another, or be unlike, according to the likeness or unlikeness of the conditions. The connection between changes in the conditions, changes in function, and changes in structure, is a consequence of the persistence of force.

The law of heredity, which is antagonistic to the law of variation, may also be traced back to our first principles. This law represents the element of fixity in the domain of life. All the organisms of a given type are descended from organisms of the same type. If we consider heredity in a succession of organisms, it appears to be inexplicable. Many still deny the existence of heredity, and explain the resemblance of the child to its parentage by a special intervention of the creative power of Nature. But, if we compare the heredity of the individual with certain phenomena occurring in the individual, for example, the repair of tissues, the reproduction of worn-out or lost parts—a process which in some animals goes so far as to reproduce highly-complex organs or groups of organs (for instance, in lizards, the reproduction of feet and tail; the reconstruction of the fresh-water hydra; the restoration of the plant *Begonia phyllomaniaca* from a fragment of its leaf)—we shall perceive that there exists a tendency to reproduce like products, and that the two orders of phenomena are related. We must suppose them both to be due to the tendency of the physiological units of an organism to arrange themselves in the form proper to that organism. But we need not recognize in this tendency any such mystic entity as an *Archæus* or a *vital* *principle.* Sound philosophy should discredit all such fanciful ideas. The tendency merely signifies that these polarities, being complexes of the physiological units, can find equilibrium only in the form of the adult organism to which they belong. To this equilibrium they tend, not only by an internal impulsion, but also under the combined action of external forces: the latter represent the force which arranges the units in a new order, and the former the direction in which this force is exerted. Now, the cells which go to reproduce an organism are in a state of unstable equilibrium and of minimum heterogeneity: but they are not indifferent substances; they are the vehicles of physiological units derived from the parents, and they follow only the tendency impressed upon them by their polarities. The same is to be said of the elements of the plasma from which a tissue or an organ is reproduced. Thus we see that the resemblance of an organism to the organisms from which it is sprung is the result of the tendencies proper to the physiological units which have come from the parents.

In the fecundated germ there are two groups of physiological units, presenting in their structures slight differences, so that by their fundamental resemblance they conspire to form an organism of the species to which the parents belong, and by their differences they give to this organism traits peculiar to each of the two parents. In this way, simultaneously with transmission of generic and specific characters, we have transmission of those which are peculiar to the individual. Further, we see that characters due to variations called accidental or spontaneous, because we are unable to assign their true cause, must also be transmitted as a tendency of the physiological units, provided this character has gained in the individual such a degree of stability as henceforth to find its place in that individual's state of equilibrium. The action of the surrounding conditions will determine whether the tendency of the physiological units is to be realized or frustrated. The tendency of the physiological units expresses an internal equilibrium, and hence heredity is a consequence of our first principles.

One character of living things is the faculty of reproducing themselves, i. e., of emitting parts of themselves which develop into perfect individuals. This property, in all respects analogous to that which reproduces tissues, differs from the latter only as regards the production of new individuals, or only parts of the same individual. There is an analogy between the operation of generation and that of repair, but there is also a difference. In repair the new products are aggregated around the same axis as the old, whereas in generation the new product soon becomes itself the axis around which the increments of nutrition group themselves. In reality, the contrasts are in excess of the analogies; generation is at bottom an operation of disintegration. This is very well seen in those low organisms which produce new generations by fission, and abdicate their individuality in favor of a greater or less number of new individualities. It is also to be seen in those organisms on whose surface a new organism is formed by the process of budding. Here the disintegration is perfect, or nearly so, but in the higher organisms the disintegration affects only an insignificant portion of the parent.

Why this special disintegration? Biology can give no answer, unless we suppose that the genesis of individuals belongs as a genus to a class of facts including all the phenomena of general disintegration which attend growth, and which mark the gradual decline of the organism. This supposition finds its warrant in the fact that, as a general rule, reproduction does not take place until growth and structural development approach their term, when the molecular forces of the physiological units find themselves in equilibrium with the forces of the organism as a whole, and with the forces from without. Disintegration would now set in, or, to speak more exactly, disintegration would now begin to show an excess over integration, for, ever since the earliest vital phenomenon, disintegration has constantly accompanied integration. Among the various modes in which the decline of the organism is gradually brought about, there is one which resembles all the others, inasmuch as it constitutes a loss to the individual, but which differs from them in that it gives rise to new organisms. In a large number of cases among individuals of the lower orders of organisms, units combined in a certain group, and carrying away with them, as we have seen, their own proper tendency to find the equilibrium of their forces in arrangements similar to those in which they were originally integrated, become detached, and form the centre of a new integration. But in a very large number of organisms, and in all higher organisms of both the organic kingdoms, reproduction takes place by the mixture of two products, the one germinal, the other spermatic, coming from slightly different physiological units. In virtue of a property found in the simplest organic elements, and still more markedly present in the complex organic elements of living things, the mixture of substances which differ little from one another gives rise to products that are less stable than their constituent elements. Accordingly, the result of this mixture, namely, the fecundated germ, is farther from the state of equilibrium than were the units emitted by each of the parents, in the shape of germinal and spermatic cells. The faint tendency which existed in each of these groups to produce evolutional phenomena is intensified with the instability of the mixture. From this we may infer, if not the impossibility, at least the difficulty of an agamic genesis, and the necessity of a genesis by concurrence of different sexes. This conclusion, derived from the law of equilibrium, which itself flows from the law of persistence of force, seems to be hardly in agreement with facts, since unquestionably there exists such a thing as agamic genesis. But agamo-genesis is not habitual in organisms of very simple structure, which exhibit the first steps in evolution, and in which the absence of highly-specialized tissues shows that integration still possesses its full intensity, and is far removed from equilibrium. Besides, those more complex organisms which exhibit the phenomenon of agamo-genesis, from time to time reproduce by way of gamo-genesis. After a series of agamic generations, the units of the organism will find themselves in an attitude approaching that of mutual equilibrium. The groups of units emitted as germs will no longer be able to assume arrangements which shall give them the form proper to their species, and agamo-genesis will be impossible, or very difficult. The series would come to an end did not sexual generation intervene periodically, restoring a state of instability, which gives back to the organism the power of evolution. Another conclusion, which at first sight appears to contradict the facts, is this, that an organism needs, in order to reproduction, the concurrence of another organism differing slightly from it. This is true of the higher organisms ; but lower down in the animal scale, and in most phanerogamous plants, hermaphrodism is apparently the rule. But, not to speak of the fact that most frequently fecundation takes place in monœcious organisms by the intervention of another individual, so that such authors as Huxley and Darwin regard this intervention as the law of reproduction, the hypothesis which we maintain affords an explanation of hermaphrodism in those exceptional cases where it appears to exist beyond question. On the same principles which account for the variable results of the union of near kindred, we can understand how, in the case of hermaphrodites, there may exist simultaneously groups of physiological units coming from each parent, keeping their proper tendencies, which find only partial equilibrium, permitting one or other side to be in excess, and there undergoing the operation of segregation, which produces groups so differentiated that fruitful germs result from their mixture.

Considered in the light of this hypothesis, generation appears as a fact of disaggregation, occurring in an organism in process of equilibration : as a fact of disaggregation, which ever renews the evolution of the species, and which retards its equilibrium by multiplying the conditions under which the species may, under the influence of the incident forces of the environment, undergo a more perfect elaboration, the result of which shall be a better adaptation of the organism to its surroundings. Generation is in fact antagonistic to equilibrium, but this antagonism is only temporary, and causes the organic evolution to obey the law of universal rhythm.

[*To be continued.*]

# THE CHARACTER OF MODERN KNOWLEDGE.[1]

By J. L. W. THUDICHUM, M. D.

THE science of the present age is distinguishable from the learning of past ages by many important features. By these it has indeed somewhat altered the sense originally attributable to its name, and science has become a word of greater precision, and therefore of a less broad significance than what may be termed mere knowledge. This is so little understood, that when lately a great statesman and orator met some of his constituents in a southeastern suburb of this metropolis, he informed them, among other things, that science was merely another term for knowledge. Even if it had been so originally, and the Latin word *scientia* had been merely the equivalent of the Saxon word knowledge, it would have to be admitted that the relations have changed by one of those conventions which are silent and convenient. We hold that the systemic enunciation of mere knowledge is doctrine; that science is a kind of knowledge, but that not all knowledge is science. Science is that kind of knowledge the correctness and truth of which can be proved by evidence convincing to all healthy understandings. Science is a series of potentialized axioms, which when once mastered are as evident as the simple axioms in mathematics, which are said to be so self-evident as to require no proof. By this definition a very large amount of human knowledge or doctrine is at once excluded from the domain of science. The learning of past ages was mainly imitative, little observant of new phenomena. Those ages had too much work on hand, first in the development of their languages, in which they used imitations countless in number, next in the shape of securing the conditions of social life in the form of communities and states. But even where these may be said to have been secured, e. g., at the height of power of the Roman Empire, science was not developed, and it may be said that this absence of scientific treatment of the common problems of life has been one of the principal causes of the downfall of that, and of many other states. Famines, epidemics, among men and cattle, and wars, are made possible or necessary only by the absence or faulty application of the principles taught by science. Science, by teaching that, and how, these evils are to be avoided, has a field in this generation, of which the past had not even a distant conception. Imitative learning shows itself mainly as art, buildings, sculptures, paintings; all the mass of temples and gods which fill the world's history and imagination are of this kind. There is no science about a Greek or Egyptian temple, simply because there is no value in it; it does not satisfy, to

[1] Introductory remarks to a course of lectures on the "Life and Labors of Prof. Liebig.

our present mode of thinking, one single demand of the understanding. There is no science about our present homes, or how could they get filled with sewer-gas, be devoid of arrangements for ventilation, and have square chimneys. Architecture, so called, is not a science, but an imitative art, beautiful but blundering. Manufactures have, too often, been carried on with great disregard of science, with the result that either empiricism was, for the time, successful enough, or that the manufacture went simply out of existence. It is the same with commerce. These arts have worked by tradition, by prescription, by precedent. They all wait for an infusion of the scientific method, the method of principle based upon natural laws immutable and indestructible. While not often scientific themselves, these branches of human knowledge, administering all the time, for a consideration of gain to be paid by the recipient, to important human wants, have yet indirectly advanced science by either finding and bringing, or by producing some of its materials.

Antiquity, then, possessed no science, except alone the results of meditation, which have been termed metaphysics, and which, if allowed to include ethics and logic, have no doubt attained in the treatment of philosophers a high degree of development. The contemplation of Nature, however, in its inorganic and organized shape, and of the causes determining all motion and development, was not greatly developed. The power of distinction, the mother of all knowledge, was not applied to all things, and consequently they termed a process such as fire an element, and allowed some all-pervading material to exist under the name of the quintessence. Bodies fell to the ground because they possessed weight; but that the falling was a reciprocal action between the earth and the body falling upon it escaped their observation, and was only found by science.

Mere observation is not science, but only the beginning of science. When a person, sitting in the railway-train, beholds the traveling shadow, he makes an observation. He begins a scientific inquiry, when he asks whether the shadow travels as quickly as the train, so as to be in a line falling from the sun past the train or whether the shadow is not a little later. If once the question has arisen, it is immaterial where it is solved, whether upon the railway-train, or the satellites of Jupiter—the question must lead to the idea that light requires time for traveling; exact science determines this time by measuring space. Science began its development with the elucidation of celestial phenomena, and became astronomy, or the doctrine of the laws according to which heavenly bodies move. Copernicus is from this point of view the father, the creator of science. Kepler, Galileo, and Newton, reduced the observations of these phenomena to expressions of regularity which we call laws. The method once found was applied to other branches of knowledge; then arose the physiology of the animal and vegetable world, based upon anatomy as a science.

Harvey made physiology a science, and so on in all branches of knowledge.

Now, let us see what was the method by which these results were obtained. Meditation had of course the inciting share, but furnished no materials. Observation accumulated the materials of which reflection might weave a tissue, the test was experiment. If from a knowledge of conditions a result can be predicted, then there is certainty. Such certainty is science; it consists of observation, meditation, knowledge of conditions, knowledge of their results, and therefore of the connection between results and causes; these being regular, immutable, within the time accessible to our perceptions, and coercing everything under their sway, are called natural laws.

Of science, it is allowed that no part comes out of the human brain alone, not even the ideas of God and Immortality, which Kant claimed as innate ideas, while allowing all others to be the result of observation and reflection. The celebrated joke, that, if an Englishman and a German were asked to produce a camel each, the Teuton would evolve one out of his inner consciousness while the Briton would produce a camel of flesh and bone, is a good satire upon innate ideas. Science did not progress until it rejected all innate ideas or phantasies, and applied itself deeply to its proper methods, to observation, to meditation on the correlation of forces, and to experiment. Work, work, and again work, were the three main features of its success. The search for the philosopher's stone, for the medicine that should make young, healthy, happy, and rich, was also work, enormous in amount and extension, but it was not based upon observation. It left results which science gathered, the main result being that we cannot prolong our lives forward, but we can, as Kopp has beautifully said, prolong them backward indefinitely, and see the changes of enormous spaces of time pass before our admiring eyes and minds.

There are three kinds of history, that of our planetary system in the theory of Laplace, that of our earth in geology, that of living things in the theory of Darwin. No serious person doubts now that the teachings of geology deserve the title of an exact science, and that compared to its coercing character upon the mind of man the convictions derived from written history are feeble in the extreme, and all contradictory writings, however old, mere nullities. The youngest of the sciences or branch of science is chemistry, founded by Lavoisier and Dalton; developed by thousands of clear heads and nimble hands, it has in half a century become a recognized power in the affairs of man. It has materially improved his estate, and enlarged his mind to conceptions of an elevating nature; it has become a ready test of his reasoning and working power. It has become the handmaid of almost all the elder sisters of astronomy, teaching the composition of distant stars; of geology, teaching the composition and changes of strata and minerals; of physiology, vegetable and animal, teaching about food, nutrition, growth, changes, death, and decay; of the healing art, teaching the nature of evils in the shape of disease, and the means of curing or mitigating them. This science, too, was developed by work, work, work—physical and mental; its ways were often rugged; its endeavors misapprehended, opposed, suppressed. And the great men whose names are inscribed upon the roll of its principal promotors will be considered by posterity as benefactors akin to Hercules, removing evils, establishing the good and true. If we cannot now inscribe their names and likenesses among the stars, and transfer them to an Olympian abode, yet we can honor them by admiring their works and lessons, by sharing and continuing their work, by, as it were, living their lives with them over again, and thus prolong their memory forward while we prolong our own in the inverse direction. We ought to honor them out of gratitude no less than out of the desire to benefit continuously man's estate. Such feelings have been instrumental in the cases of those who described the greatness of your Davy, of your Faraday. Such feelings shall now be the guiding principle in the consideration of the life, works, and philosophy of Justus Liebig. But I must beg you to understand that I shall proceed by a severe process, that of analysis, for nothing less than the results of analysis of work done can establish as proved what many feel as a sentiment. You will understand both the censure and the acclamation of what we will call the world; you will see the necessity for a reform in the philosophy of many of us; you will see how the life and labor of one man have produced vast applications and industries, improved or created a large commerce, and enhanced or engendered art; how they have soothed the pain and anguish of hundreds of thousands under the most severe trials of human organization, and how they have left a growing harvest in the hearts and minds of men all over the world.

## THE RELATIONS OF SEX TO CRIME.[1]

By ELY VAN DE WARKER, M. D.

SEXUAL cerebration may here and there be seen coming to the surface, amid the complex array of circumstance and causes which affects woman's criminal career. If I am correct in the use of the term, and it surely has the merit of expressing the idea designed to be conveyed by it, we may perceive two forms of sexual mental action, one normal and the other abnormal. Its action in the normal phase may be seen in favoring or obstructing her career in crime, in relation to particular offenses; while its abnormal manifestations may be perceived in certain crimes, existing as a direct outcome of its pres-

[1] Argument continued from January MONTHLY.

ence. It must be observed that sexual cerebration in its relation to crime is not confined in its operation to the female sex. Its influence on men may be observed in many of the crimes in which they exceed their usual ratio of excess over women. Man's tendency to belligerency evidently accounts in a measure for his great excess in the crimes of murder and assassination. Attempts have been made to explain this by the frequency of drunkenness, and the street brawls which it leads to among men; but, when we take into consideration the fact that the ratio of the sexes for drunkenness in England is, 1 woman to 1.49 men (Quetelet), we perceive that this cause can but act to a very limited extent. The sexual mental tendency of man to the wager of battle, his physical strength, the almost unlimited opportunities afforded by the greater range of his activities, enable man to exceed his usual ratio of excess over woman in these two crimes. Crimes against property, such as robbery from the person or highway robbery, also offer evidence of the innate cerebral traits of the male. In this offense man stands almost alone. It requires for its successful perpetration bravery and daring. These are qualities belonging peculiarly to men. In view of the intensity of feeling which attends all discussion of matters in which women are concerned, either socially or sexually, I think it better to qualify the last sentence, by calling the attention of the reader to the very proper distinction between moral and physical courage. The first exists as the result of intellectual qualities, education, and moral training; the last is purely a phase of sexual cerebration. Some of the most beautiful examples of moral courage are constantly offered by women. It is the possession of physical courage which is requisite to the commission of the crime alluded to, and not its higher prototype, moral courage. This form of sexual cerebration in the male is the coefficient of belligerency in the perpetration of many crimes, and united to physical strength is, aside from opportunity, capable of explaining many of the circumstances attending man's excess over woman as a criminal.

The action of sexual cerebration in its normal expression, as affecting the relation of men to crime, has been traced far enough to demonstrate its important influence. Its operation in men is more easily detected than in women. Man's career as a criminal is attended by fewer complicating conditions. By the broader field of his activities, he is directly exposed to criminal influences, while woman is hedged in by the circumstances of her position. She lives in an atmosphere of restraining influences, each one of which tends to obscure the effect of the subtile yet potent sexual mental traits which characterize her as a woman. The extent to which woman conforms to a common mental type may be more surely measured by contrasting her as a criminal with man in his relation to crime, than by studying her alone in her usual social relations. Crime reveals to us some of the primeval tendencies of society. By crime, notwithstanding all the varied results of civilization—a scion, as it were, grafted upon the parent trunk—humanity is wedded to its original savagism. Certain sociologists of the religious school teach that crime is the outcome of civilization, that it increases or decreases in proportion to the extent and quality of religious teaching; but an examination of the criminal returns of various peoples shows that crime exists at nearly a fixed ratio without regard to religion, be it what it may. Some forms of crime are, beyond doubt, increased by the artificial needs of society in its civilized form, infanticide and abortion, for example; yet even these crimes prevail universally among the most primitive races. Civilization has not modified the crime, it has simply changed the motive. With the tendency to crime existing at the ultimate fibres of man's psychical life, the expression of sexual cerebration in the criminal conduct of women assumes a naturalism called forth by no other social relation. As I have separately examined the matter of sexual mental types in a former article, all that is necessary here is, to apply the conclusions there reached to woman's tendency to crime.

The crime of poisoning, with its remarkable ratio, has been used a few pages back to illustrate the influence of the physical factor. It was called the weapon of weakness. This weakness is twofold, physical and mental. Women possess moral courage, but not physical. Timidity, a shrinking from bodily danger, a fear of combat, each an analogue of the other, appear as mental traits in the average woman. Here is an offense gauged to woman's mental and physical aptitudes. By means of poison, a fatal blow may be given by the weakest arm without the fear of combat, or of physical hurt. To a mind with criminal tendencies, hampered by the reflex consciousness of weakness, the security, the secrecy, are charming. The result is that, as a poisoner, woman nearly equals man. This equality among the lists of crime nowhere else appears except in offenses against the currency, a crime also remarkable for its secrecy, and freedom from personal encounter during its perpetration. If a further extension of the statistics of crime against the currency confirms the ratio of the sexes deducible from Mr. Neison's tables, it will amount to nearly a demonstration of the fact here shadowed forth, that woman tends to equal man as a criminal in those crimes which require neither physical courage nor strength as conditions of their perpetration. The crime of vagrancy is the only exception that offers itself, and which loses its force as an exception under the law of criminal analogies. From the crime of poisoning, the climax of the criminal tendency, downward through the lighter shades of offense, this phase of sexual cerebration may be detected. If it were possible to give to woman the physical strength of man with this mental trait existing in its present force as a sexual characteristic, I doubt if it would alter essentially the known ratio of the sexes for murder and the wounding of strangers—9 to 100. I venture this prediction merely for the purpose of illustrating the potency of this mental factor touching woman's criminal relations. In robbery from the person, although the enormous disproportion in the ratio is in a measure explained by differences in physical strength, yet there remains much of this excess of men to be explained by other means. That which remains to be explained by means other than that of sexual differences of physical strength may be stated in this way: The ratio of the strength of the two sexes being fixed at 16 to 26, and the ratio for crimes in general against property being 26 to 100, we nevertheless find that for the crime mentioned the ratio is reduced to 8 in 100. Here is a difference in ratio between two classes of the same division of crime of 18 to 100. Evidently, it is too largely in excess of the ratio of strength of the sexes, to be entirely accounted for by that alone. This phase of sexual cerebration, together with woman's social conditions, is competent to explain the differences remaining unaccounted for. The crime of self-murder also brings out quite distinctly the action of this mental trait in women. An examination of the methods of self-destruction reveals sexual peculiarities. Men prefer cutting instruments and fire-arms, while women select poison, and hanging and drowning (Quetelet). A collection of nearly five thousand cases of suicide, by M. Brierre de Boismont,[1] reveals the fact that hanging occurs more frequently among women than men, by a large percentage. It will be noticed that women select those modes of suicidal death which take the matter out of their own hands. They offer a surety for their fainting spirits by closing the avenue of escape behind them. However painful may be the death they seek, after the fatal draught, the fall, or the plunge, all voluntary power of escape is beyond their reach. Is it not from the consciousness that lack of physical courage, or timidity, would involuntarily cause them to escape from the pangs of death, that they select a method of destruction which after the painless first step renders such a return impossible? Cortes, who knew the temper of his men, burned his ships upon the shore; and in the same way women assure themselves of the impossibility of return ere they attempt suicide.

The influence of the excess of the emotional life in women over men, upon their criminal career, is not so marked as that of the psychical traits just considered. I stated in a former chapter that there was evidence which rendered it probable that those emotions or passions which serve as the incentives to crime approached in intensity the same mental conditions in man. In that portion of these contributions devoted to "Sexual Cerebration," emphasis was given to the fact that the emotional life of woman exceeded that of man. At this point in the study we can give this practical significance. The emotions offer vulnerable places in woman's moral armor. These mental sexual attributes which give such grace and beauty to woman's character cannot exist except at the expense of rigidity and sternness of

[1] "Recherches Medico-Légale sur Suicide," Paris, 1860.

mind. Through all Nature may be found analogies which give probability to this. Nature, in her forms of fixity and power, is massive and rugged in her outlines; it is only in her phases of changing, transient life, that she assumes lines of beauty, delicacy of shape, and clothes her proportions in the subtile harmonies of color. I do not deny woman firmness of character; but surely, whatever firmness she possesses, it is not by reason of her emotions that it exists. Nor do I wish to be understood as saying that any excess of emotion woman may possess over man is necessarily the cause of inherent weakness of character; but, the idea I intend to convey is, that excessive development of the emotions affords a way of approach to the firmer characteristics of her mind of those exciting causes of crime, which, without these avenues, must act with less force as criminal factors. The evidence of this lies in the tendency of woman to exceed in a marked manner her ratio to crimes in general against the person when exposed to the action of causes which act more or less directly upon her emotional life. Women perpetrate crimes, involving human life, more frequently within the circle of their domestic relations than men (Quetelet). In view of this fact, let us inquire as to the probable motives which cause women to exceed men in crimes against persons within this restricted area. If we were to explain it as the result simply of the great opportunity women have of perpetrating crime in the family, it leads to the conclusion that women's criminal tendencies exceed those of men under favorable opportunities, and which men in the same relation possess to an equal extent. This we know is a wrong conclusion; therefore, while we must allow the great facilities afforded to women a certain value as a factor in this excess, yet it is not adequate to explain the fact. It is in the family that woman finds a field for the free action of her emotional life. It is as an outcome from these emotions that the family exists; it is through these emotions that the most deadly wounds may be inflicted upon her morality and self-respect. In the majority of cases, if through her error, or that of others, the family is a failure, the woman of the family is a failure also. In this can be found the strongest argument for encouraging woman to become expert in some form of labor, so as to enlarge the field of her self-dependence, that she may be able to secure safety for herself in the trying hour of domestic misfortune. While the family is called into existence by reason of the most potent sexual mental traits, and finds its strength and permanency in a temperate use and even balance of the emotions, it may become the source of the most active criminal impulses. Conjugal incontinence, jealousy, a misplaced love, may create the most deadly strife in the family circle. Especially is this true if the criminal tendency exists latent, as an inherited taint, in the members of the family, and ready to be kindled into life by emotions which, in others, free from inherited vice, would not pass beyond the control of the moral faculties. Man, whose activities are less confined within the area of domestic life, is more able than woman to resist the action of the emotions. Another cause, which comparatively releases man from the criminal tendencies which grow out of a violated emotional life, is the weaker hold these emotions have upon his conscious life. These are my reasons for concluding that this excess over men, as a criminal against persons, within these limits, is the result of the more active development of the emotions in women.

Considering that, in the purely sexual relations of men and women, the male is the active and the female the passive one, the ratio between the sexes for the crime of adultery offers additional confirmation of the foregoing. For this purpose I shall select the statistics of M. de Marsangy, than whom none can be selected more favorably disposed to women. This author places the ratio for men at 528, and women at 472 to 1,000.[1] As these were cases which came under the notice of the public prosecutor, it is reasonable to suppose that the circumstances attending them were in both sexes of a flagrant character, so that possibly the usual attitude of the sexes toward each other in this offense was reversed. These ratios render the assumption safe that it is in crimes which grow out of the acute and excessive emotional life of women that they tend to equal men as criminals. If it were any tendency to crime, growing out of sexual mental traits possessed more equally in common than the emotions, which causes the tendency to equality above referred to, it would be reasonable to expect to find the sexes occasionally approaching a common ratio in crimes against property, and which could be traced to the same mental traits. But a careful survey of the field shows this not to be so. Woman's delicacy and keenness of emotional life, when their undue exercise or unbalanced proportions seek expression in the criminal act, lead to crimes against persons, not against property. Even incendiarism, so commonly practised by men from motives of revenge, is but seldom attempted by women. The enmities of women are never general. They are roused by particular persons and special acts; hence their revenge takes an individual direction, not against the property, but against the person of the enemy. The wounding of parents, and parricide, exceeding by so large a ratio all other acts of violence against the person, I believe can be explained in no other way. Admitting, as I have already done, that the great opportunity afforded of making attempts upon the persons of parents has some value as a factor, yet we must bear in mind that, from the nature of their domestic life, women have opportunities equally as great of inflicting injury upon others. It follows that opportunity as it affects parents must be given exceptional value, in order to account for their being the objects of criminal attempts on the part of daughters, over that of other persons holding a domestic relation. The ratio of crimes against parents also makes it very probable that the purely sexual emotions are

[1] *Loc. cit.*, table, p. 147.

not particularly important as factors in the grave class of crime now under consideration. So far as it relates to parents, these emotions may be excluded. Other emotions must in parricide be called into action. But, in poisoning and crimes affecting others beyond parental relation, I believe the purely sexual emotion is the main ingredient in the motive. M. Quetelet states that adultery, domestic quarrels, and jealousy, cause nearly an equal number of poisoning in both sexes; but in murder the number of women by the husbands exceeds the number of husbands by the wives. In poisoning, with the ratio of 91 to 100, for all motives and against unspecified persons, we perceive that when the crime is brought within the domestic circle and against persons bearing a very close relation to women and narrowed down to these motives, all differences between the sexes disappear. This is brought out in order to make clear the fact that women are not worse than men, but that under conditions favorable to their more restricted sphere of activities, and from motives operating in the direction of their peculiar psychical traits, they will equal men in the perpetration of those crimes suited to their strength. Crime, as it relates to men and is perpetrated by them, conforms in an equal manner to their physical and mental characteristics, and exists in a ratio with the sphere of their activities. While a difference of morality may exist between the sexes, it is not equal to explain the constantly varying ratios of the sexes to crime. Whatever the differences of morality may be, it is not sufficient to create any difference in the tendency to crime, when the crime conforms to the conditions just stated. The abnormal action of mental sexual traits is more often met with among women than among men. M. Prosper Despine assigns great importance to the moral perversions which accompany the hysterical tendency in women, and regards it as one of the marked characteristics of sex in crime. Hysteria in its myriad forms, when it disturbs cerebral function, appears to be a perversion of the emotional faculties. An offense committed during an attack of hysterical insanity is not of course a crime, as I am here studying it; but it is a grave question, to what extent may the criminal habit grow out of the perversion of morals which may attend the hysterical state of mind? In the course of two years' acquaintance with criminal female convicts, I became impressed with the fact that nearly every one of them gave evidence of possessing hysterical tendencies. In connection with this tendency, another significant fact was observed—the power to control the expression of the feelings and emotions was much less in them than in the average woman. Women who are liable to attacks of hysterical perversion of the emotions are usually under the direct influence of the diseased action but a short time, so that the possibility of criminal attempts at such times is comparatively limited. It is not therefore the presence of an actual attack of hysteria which promotes the tendency to crime; but the impaired control over the desires and emotions which coexists with the hysterical temperament may lead to this. Which is the cause, and which the effect, it is difficult to assert. From the prevalence of hysteria among prostitutes—a class who habitually permit the desires and emotions to pass beyond healthy control of the will—I infer that this precedes the actual attack of the disease. In some cases, however, hysteria results from organic derangement, usually of the sexual organs, and then the lack of emotional control may be a secondary instead of primary condition. The criminal resultant, in my experience, is confined to crimes against property, false accusation, and infanticide. It rarely leads to the more serious crimes against persons, for the reason that the wrongs of the hysterical are fancied rather than real, which disappear with the usually prompt return of judgment.

The following history of a false accusation reveals the defective control over the feelings and the perversion of the sexual emotions which coexist with the hysterical tendency: Esther was a young convict, about twenty years old, committed for a term of years to the Onondaga penitentiary for a second offense of stealing. She married very young, and lived with her husband but a short time. Her occupation was that of a domestic, and when not employed always went to her home, which was respectable. She gave considerable trouble in the shops, by her moody and disobedient ways, and would often refuse her food, and was then taciturn and desponding. Her cell was situated near the centre of the block, on the second gallery, and was lined with pictures cut from the illustrated newspapers. The collection was remarkable from being made up of the pictures of men and women, some of them neatly framed with straws. A cross, made of the thin shavings of wood used to light cigars with, was prominent among the decorations. She gave me considerable trouble with her great variety of fancied ailments, and I believe the girl actually believed in her diseases. The keepers believed her to be a "beat," a most unfortunate reputation for one to earn while under the discipline of a penitentiary. Esther startled the prison officials one morning, by charging the night-watch—a most estimable young man—with visiting her cell at night. From the method of locking the cells, this appeared to the officers nearly an impossible thing for the watchman to do. A careful examination of the inmates of the adjoining cells failed to elicit any confirming evidence; yet Esther persisted in her charge, to the great distress of the young man. As Leander nightly buffeted with the waves of the Hellespont for the love of Hero, it was thought possible that love might contend not less successfully with patent locks and prison-bars. It was therefore considered the safest course to remove the young man. When Esther was informed of the effect of her charge, she at once retracted. Now, the motive of this accusation constitutes the essence of the story. Esther loved the night-watch. She had for months fed her passion on the sight of the young man. The class of people to whom this woman belonged do not possess imaginations sufficiently acute to invest love with any charm. Their relation with an object of love is emotional; their only gratification is possession. As possession was impossible, there was yet a way to establish a link between herself and wished-for lover. She brought a false charge against a man who had never spoken a word to her in his life. She took pride in the fact that his name was associated with hers in a manner most congenial to her emotions. It was the nearest approach to possession possible. This girl was very properly placed upon bread and water for her offense; but I am quite confident that such a false accusation, except for purposes of revenge, is only possible in a woman of hysterical tendencies, and in whom the emotions have passed beyond the inhibitory power of the moral sense. A false accusation of this nature is not a very rare one for women to make, and it is usually accompanied by two noteworthy circumstances—the woman is generally very young, and the man in some way nearly unattainable by the accuser.

To the liability of insanity to accompany the hereditary transmission of crime, I have already made sufficient reference; but the class described above are not insane, they simply lack the normal equipoise between the different faculties of mind. As to how far this may affect the relations of women to the different classes of crime we have no means of forming an opinion. As it is a mental characteristic more frequently observed in women than men, it is reasonable to suppose that it has some influence. Its effect upon the votaries of the social evil is, however, very great, and careful study will be made of it in the chapter devoted to woman's crime against her sex.

Particular stress has been laid by other authors upon the fact that the great excess of men over women in certain crimes against the person, as murder and assassination, was the result of intoxication and brawling to which men are addicted. If this is one of the factors of such excess, it will be interesting to know it. If this is any explanation, it follows that one sex must so greatly exceed the other in the matter of intoxication and disorderly conduct, as it is termed by the police courts, as not only to include the ratio between the sexes for crimes mentioned, but also to include the chances of no such result following, as but a small percentage of debauches and brawls results in either murder or assassination. As it is in great cities that men addicted to disorderly conduct are mostly to be found, and as there also they are more liable to terminate in crimes against the person, I shall select statistics from cities touching upon this matter, bearing in mind, however, that a perfect contrast between the sexes cannot be secured, as the offenses under analysis include drunkenness and fighting in the male, and both those, with the addition of prostitution, in the female. The ratios are based upon the statistics furnished by the report of the Commissioners of Public Charities and Correction. For the period covered by the reports, 90 per centum of those arrested for disorderly conduct and intoxication were women.[1] It becomes evident at once that the excess of men over women, in crimes against the person, cannot to any extent be accounted for by the proneness of men to intoxication and disorderly conduct, and which we perceive does not so greatly exceed that of women. Instead of searching among accidental qualities for the causes of this difference, rather ought we to examine the mental and physical qualities which exist inherently in man. From the same source we may gain an idea which bears in another direction upon this matter. The ratio of drunkenness and disorderly conduct to total crime, for the sexes separately, furnishes nearly positive proof that it has but a restricted influence upon the tendency to crime in general. Thus, these offenses furnish 41 per centum of the total crime committed by men; while, of the total crime committed by women, 80 per centum is of the same nature. While the number of drunk and disorderly among men is larger by a small excess than the number of women so addicted, yet women considered by themselves exhibit twice the tendency to these offenses that men do. Here, the sex which affords the least measure of total crime gives the largest ratio, relatively to her own sex, of those offenses which are so generally supposed to underlie the criminal tendency. The explanation I would offer of this rather unexpected result is, that intoxication and disorderly conduct are offenses closely allied to vagrancy and its analogue, prostitution; that this class represents the effete among men and women who gravitate into vice from total lack of vitality and energy to keep themselves up to the level of the average. The active criminal requires mental and physical energy in order to pursue his course. Any of the conditions of life which depress the physical powers and deplete mental energy tend to remove those with criminal tendencies from the order of active criminals, and place them among those addicted to the minor degrees of crime. While habitual intoxication and disorderly conduct lead to the lighter offenses against property, the more serious crimes against property and persons are comparatively unaffected by these causes, either among men or women.

## CAROLINE LUCRETIA HERSCHEL.

By ELIZA A. YOUMANS.

MOST people in this country have heard of Miss Caroline Herschel the astronomer. Without knowing much about her, she has been vaguely regarded by the public as a profound scientific genius, the strong-minded peer and coadjutor of her brother, the

[1] "Reports of the Prison Association of New York," Tables "C," "D," "E," "F," 1867, and Tables "C," "D," "E," "F," "G," "H," 1871 and 1873.

illustrious Sir William Herschel. It is supposed that she rose above the narrow sphere of woman's usual domestic life, and spent her time in studying the universe and making astronomical discoveries. She has been often cited, in the recent discussions of the woman question, as an illustration of the intellectual equality of the sexes and as demonstrating to the world what woman is capable of doing in science when she gets a fair opportunity.

Miss Herschel's memoirs have just appeared, made up mostly from her diary and correspondence, edited by Mrs. John Herschel. In this interesting volume we get a view of her real character, and discover that the notions generally accepted are widely mistaken. We learn from her diary and letters that, while she was a thrifty and interested housekeeper, she had neither the taste, the ambition, nor the mental qualities, that would have insured distinction in an independent intellectual career. It is seen that she became an astronomer by accident, as it were, and through the strength of her affection rather than of her intellect. When she found that her brother had resolved to take her as his assistant in his astronomic labors, it made her miserable for a time; and he chose her instead of either of his brothers, not because of her brilliant mind, but on account of her persevering devotion to his interests and her dexterity and readiness in doing an assistant's work.

The lesson of this book is very important to ambitious girls who despise domestic concerns, and long for an "intellectual" career. Her science, as such, gave Miss Herschel no great enjoyment; her happiness came from her womanly devotion to her brother's ambitious work; and the book will be found painfully interesting as it discloses the suffering she also experienced as the penalty of this unselfish devotion.

Miss Herschel lived to the great age of ninety-seven years and ten months, and retained her faculties bright to the last. We give a portrait, taken from the biography, which represents her at the age of ninety-two. In the following sketch we shall let her speak for herself, as far as practicable, as nothing can exceed the graphic simplicity of her diary. But, as she was a German, and did not begin to study English till she went to England, at the age of twenty-two, there are defects in her writing, for which the reader will make due allowance.

Caroline Lucretia Herschel was the eighth of a family of ten children, four of whom died in childhood. Her father was band-master in the regiment of Guards at Hanover, and all his children had musical genius. He took great pains to cultivate his sons in music, and sent them to the garrison school for their routine education. As they grew up they all became musicians and joined the regiment band. At Dettingen, in 1743, the father was wounded and left all night in a wet furrow, and he had ever after an impaired constitution and an asthmatical affection. This event cast a shadow upon the family, and when Caroline was born, in 1750, in the gloomy period of the Seven Years' War, the mother's temper seems to have been already warped by trouble.

Her turn of mind was practical and plodding, while the father was intellectual and aspiring. It is abundantly evident that Caroline had a bitter and desolate childhood. Expressions of affection or regard from her relatives were very rare in her experience, while her own sympathies had a most precocious development. It is said that when only three years old she was deeply concerned about family troubles.

Her only sister, the oldest child of the family, was married to a musician named Griesbach. Jacob, the eldest brother, was organist at the garrison church; and William, four years younger, was already remarkable for his splendid talents, apart from music. In the following passage from her diary we have a picture of the family at this time:

"My brothers were often introduced as solo performers and assistants in the orchestra of the court, and I remember that I was frequently prevented from going to sleep by the lively criticism on music on coming from a concert, or conversations on philosophical subjects, which lasted frequently till morning, in which my father was a lively partaker and assistant of my brother William by contriving self-made instruments. . . . Often I would keep myself awake that I might listen to their animating remarks, for it made *me so happy to see them so happy.* But generally their conversation would branch out on philosophical subjects, when my brother William and my father often argued with such warmth that my mother's interference became necessary, when the names of Leibnitz, Newton, and Euler, sounded rather too loud for the repose of her little ones, who ought to be in school by seven in the morning. But it seems that on the brothers retiring to their own room, where they shared the same bed, my brother William had still a great deal to say; and freqnently it happened that, when he stopped for an assent or reply, he found his hearer was gone to sleep; and I suppose it was not till then he bethought himself to do the same.

"The recollection of these happy scenes confirms me in the belief that, had my brother William not then been interrupted in his philosophical pursuits, we should have had much earlier proofs of his inventive genius. My father was a great admirer of astronomy, and had some knowledge of that science; for I remember his taking me into the street to make me acquainted with several of the most beautiful constellations, after we had been gazing at a comet which was then visible. And I well remember with what delight he used to assist my brother William in his various contrivances in the pursuit of his philosophical studies, among which was a neatly-turned four-inch globe, upon which the equator and the ecliptic were engraved by my brother."

But this little household was soon broken up, the regiment of Guards being ordered to England in 1755. The parting scenes are thus described:

"In our room all was mute, but in hurried action; my dear father was thin and pale, and my brother William almost equally so, for he was of a delicate constitution, and growing fast. Of my brother Jacob, I only remember his starting difficulties at every thing that was done for him, as my father was busy to see that they were equipped with the necessaries for a march. The whole town was in motion, with drums beating to march; the troops hallooed and roared in the streets, the drums beat louder. Griesbach came to join my father and brothers, and in a moment they were all gone. My sister fled to her own room. Alexander," [her third brother] "went with many others to follow their relatives for some miles, to take a last look. I found myself now with my mother, alone in a room all in confusion, in one corner of which my little brother Dietrich lay in his cradle; my tears flowed, like my mother's, but neither of us could speak. I snatched a large handkerchief of my father's from a chair, and took a stool to place it at my mother's feet, on which I sat down, and put into her hands one corner of the handkerchief. reserving the opposite one for myself. This little action actually drew a momentary smile into her face."

They were gone a year, and of this period of separation she gives no recollections; but in her account of their welcome home we see how affectionate she was and how neglected she felt, and the kind treatment of her brother William could not fail to make a deep impression upon her susceptible nature:

"My mother, being very busy in preparing dinner, had suffered me to go all alone to the parade to meet my father, but I could not find him anywhere, nor anybody whom I knew; so at last, when nearly frozen to death, I came home and found them all at table. My dear brother William threw down his knife and fork and ran to welcome, and crouched down to me, which made me forget all my grievances. The rest were so happy at seeing one another again that my absence had never been perceived."

In 1757 it became apparent that William had not the strength to stay in the Guards in war time, and his parents, with no small difficulty, sent him away to England.

When very young, Caroline went to the garrison school till three in the afternoon, and then to another school to be taught knitting. From the time she was six or seven years old, she says:

"I was fully employed in providing my brothers with stockings, and remember that the first pair for Alexander touched the floor when I stood upright, finishing the front. Besides this my pen was frequently in requisition for writing, not only my mother's letters to my father, but many a poor soldier's wife in our neighborhood to her husband in camp."

From 1757 till 1760 there is another gap in the record, several pages having been torn from her manuscript belonging to this period. In 1760 her father came home for good, broken in health and worn out with hardships, and we are again furnished with some details of the family history. He devoted himself for the rest of his life to the musical education of his children, and gave lessons besides to the numerous pupils who sought his instruction. Next to her brother William, her father was the object of her dearest love. She was her mother's companion and, assistant, and, as the income was straitened, they together did all the housework. The mother was a diligent spinner, and kept the family well stocked with household linen. Her sister had not a patient temper, and was sometimes left, with her goods and chattels, to be taken care of by her mother. As to Jacob, who was often at home, and who developed into a dandy while in England, she speaks of him as follows:

"When he came to dine with us it generally happened that before he departed his mother was as much out of humor with him as he was at the beef-steaks being hard, and because I did not know how to clean knives and forks with brick-dust." And again: "When he honored the humble table with his presence, poor I got many a whipping for being awkward at supplying the place of footman or waiter."

It is said that his love of luxury was shown in the specimens of English goods and English tailoring he brought back with him from England, while all that William brought back was a copy of Locke "On the Human Understanding," which took all his private means.

When her father came home to stay he helped her some, and yet, poor man, he did it under difficulties. The parents had never agreed upon the subject of her education. She says:

"My father wished to give me something like a polished education, but my mother was particularly determined that it should be a rough but at the same time a useful one; and nothing further she thought was necessary but to send me two or three months to a seamstress to be taught to make household linen. Having added this accomplishment to my former ingenuities, I never afterward could find leisure for thinking of any thing but to contrive and make for the family, in all imaginable forms, whatever was wanting; and thus I learned to make bags and sword-knots long before I knew how to make caps and furbelows. . . . My mother would not consent to my being taught French, and my brother Dietrich was even denied a dancing-master, because she would not permit my learning along with him, though the entrance had been paid for us both; so all my father could do for me was to indulge me (and please himself) sometimes with a short lesson on the violin, when my mother was either in good-humor or out of the way. Though I have often felt myself exceedingly at a loss for the want of those few accomplishments of which I was thus, by an erroneous though well-meant opinion of my mother, deprived, I could not help thinking but that she had cause for wishing me not to know more than was necessary for being useful in the family; for it was her certain belief that my brother William would have returned to his country, and my eldest brother not have looked so high, if they had had a little less learning. . . . But sometimes I found it scarcely possible to get through with the work required, and felt very unhappy that no time at all was left for improving myself in music or fancy-work, in which I had an opportunity of receiving some instruction from an ingenious young woman whose parents lived in the same house with us. But the time wanted for spending a few hours together could only be obtained by our meeting at daybreak, because by the time of the family's rising, at seven, I was obliged to be at my daily business. Though I had neither time nor means for producing any thing immediately, either for show or use, I was content with keeping samples of all possible patterns in needlework, beads, bugles, horsehair, etc., for I could not help feeling troubled sometimes about my future destiny; yet I could not bear the idea of being turned into an abigail or housemaid, and thought that with the above and such like acquirements, and with a little notion of music, I might obtain a place as governess in some family where the want of a knowledge of French would be no objection."

As year by year passed by, William's attachment to England grew stronger. But the poor father, who was failing in strength, became more and more eager for his return, and on the 2d of April, 1764, to the great joy of the family, he made his appearance. The visit was brief, and gave no hope that he would settle in Hanover. In describing it, Caroline is spoken of as "the poor little unnoticed girl," and the event as standing in her memory "fraught with anguish too deep for words." She was disappointed in her hope of enjoying this visit of her brother, for it came at the time of her confirmation. She says:

"With my constant attendance at church and school, besides the time I was employed in doing the drudgery of the scullery, it was but seldom I could make one of the group when the family were assembled together."

The Sunday fixed for his departure was the very day on which she was to receive her first communion:

"The church was crowded and the door open. The Hamburger post-wagon passed at eleven, bearing away my dear brother, from whom I had been obliged to part at eight o'clock. It was within a dozen yards from the open door; the postilion giving a smettering blast on his horn. Its effect on my shattered nerves I will not attempt to describe, nor what I felt for days and weeks after. I wish it were possible to say what I wish to say, without feeling anew that feverish wretchedness which accompanied my walk in the afternoon with some of my school-companions, in my black-silk dress and bouquet of artificial flowers, the same which had served my sister on her bridal day. I could think of nothing but that on my return I should find nobody but my disconsolate father and mother, for Alexander's engagements allowed him to be with us only at certain hours, and Jacob was seldom at home except to dress and take his meals."

The last years of her father's life are thus described:

"Changes of abode, not always for the better; anxieties, on account of Alexander's prospects, and Jacob's vagaries; disappointment at seeing his daughter grow up without the education he had hoped to give her—were the circumstances under which the worn-out sufferer struggled through the last three years of his life, copying music at every spare moment, assisting at a concert only a few weeks before his death, and giving lessons until he was obliged to keep wholly to his bed. He was released from his sufferings at the comparatively early age of sixty-one, on the 22d of March, 1767, leaving to his children little more than the heritage of his good example, unblemished character, and those musical talents which he had so carefully educated, and by which he probably hoped the more gifted of his sons would attain to eminence."

Caroline was now seventeen, with only the barest rudiments of education, and for the next two years the time passed uneventfully in household occupations; but at the age of twenty a new turn was suddenly given to her thoughts by the arrival of letters from William, proposing that she should join him at Bath, in England.

"To make trial if by his instruction I might not become a useful singer for his winter concerts and oratorios, he advised my brother Jacob to give me some lessons by way of beginning; but that, if after a trial of two years we should not find it answer our expectation, he would bring me back again. This at first seemed agreeable to all parties, but, by the time I had set my heart upon it, Jacob began to turn the whole scheme into ridicule, and, of course, he never heard the sound of my voice except in speaking, and yet I was left in the harassing uncer tainty whether I was to go or not. I resolved at last to prepare as far as lay in my power for both cases by taking every chance, when all were from home, to imitate, with a gag between my teeth, the solo part of concertos, *shake and all*, such as I had heard them play on the violin; and I thus gained a tolerable execution before I learned to sing. I next began to knit ruffles, etc. For my mother and Brother Dietrich, I knitted as many stockings as would last two years at least."

During all this time she was sorely troubled about her duty in the matter of leaving her mother, and she thus speaks of her feelings:

"In this manner (making prospective clothes for them) I tried to still the compunction I felt at leaving relatives who, I feared, would lose some of their comforts by my desertion, and nothing but the belief of returning to them full of knowledge and accomplishments could have supported me in the parting moment. . . . My brother William, at last, quite unexpectedly arrived. . . . His stay at Hanover could at the utmost not be prolonged above a fortnight. . . . My mother had consented to my going with him, and the anguish at my leaving her was somewhat alleviated by my brother settling a small annuity on her, by which she would be enabled to keep an attendant to supply my place. . . . But I will not attempt to describe my feelings when the parting moment arrived and I left my dear mother and most dear Dietrich, on Sunday, August 16, 1772."

After a dismal journey of six days and nights, in an open post-wagon through Holland, and a stormy passage across the Channel, she arrived in England on the 26th, bareheaded, her bonnet having been blown into a canal from the post-wagon, and the first part of her "Recollections" ends with an account of her experiences in London at this time.

Before resuming Miss Herschel's diary it is needful to explain that, at the time she came to live with him, William Herschel was an eminent teacher of music at Bath, an organist with a choir under his management, a composer of anthems, chants, etc., and director of public concerts. But he followed music solely for the income it afforded; every leisure moment he could get by night or by day being devoted to the study of astronomy. He was known among his music-pupils as an astronomer, and some of them had lessons from him in this science as well as in music. He early applied his inventive talents to the improvement of telescopes. He began by getting from one of the shops a two-and-a-half-foot Gregorian telescope which served for viewing the heavens and for studying the construction of the instrument. Then he began to make instruments himself, which he went on improving and enlarging till at last the mirror for his great forty-foot telescope resulted. Such were the occupations of the brother whom Miss Herschel came to England to help. What she did and with what success is told in the following extracts from her "Recollections:"

"On the afternoon of August 28, 1772, I arrived with my brother at his house at Bath, No. 7 New King Street. I knew no more English than the few words which I had on our journey learned to repeat like a parrot, and it may be easily supposed that it would require some time before I could feel comfortable among strangers. But, as the season for the arrival of visitors to the baths does not begin till October, my brother had leisure to try my capacity for becoming a useful singer for his concerts and oratorios, and, being very well satisfied with my voice, I had two or three lessons every day, and the hours which were not spent at the harpsichord were employed in putting me in the way of managing the family. . . . On the second morning, on meeting my brother at breakfast, he began immediately to give me a lesson in English and arithmetic, and showed me the way of booking and keeping accounts of cash received and laid out. . . .

"My brother Alexander, who had been some time in England, boarded and lodged with his elder brother, and with myself occupied the attic. The first floor, which was furnished in the newest and most handsome style, my brother kept for himself. The front-room, containing the harpsichord, was always in order to receive his musical friends and scholars at little private concerts or rehearsals. . . . Sundays I received a sum for the weekly expenses, of which my housekeeping book (written in English) showed the amount laid out, and my purse the remaining cash. One of the principal things required was to market, and about six weeks after coming to England I was sent alone among fishwomen, butchers, basket-women, etc., and I brought home whatever in my fright I could pick up. . . . My brother Alexander used to watch me at a distance, unknown to me, till he saw me safe on my way home. I knew too little of English to derive any consolation from the society of those who were about me, so that, dinner-time excepted, I was entirely left to myself."

Of the progress of her musical education, we are told that she was much hindered by being continually called upon to assist in the manufacture of telescopes :

"It soon appeared that my brother was not contented with knowing what former observers had seen, for he began to contrive a telescope eighteen or twenty feet long, and I had to amuse myself with making the tube of pasteboard for the glasses, which were to arrive from London, for at that time no optician had settled at Bath. . . . My brother wrote to inquire the price of a reflecting mirror for, I believe, a five or six foot telescope. The answer was, there were none of so large a size, but a person offered to make one at a price much above what my brother thought proper to give. . . . About this time he bought of a Quaker at Bath, who had made attempts at polishing mirrors, all his rubbish of patterns, tools, hones, polishers, unfinished mirrors, etc., but all for small Gregorians, not above two or three inches in diameter.

"Nothing serious could be attempted, for want of time, till the beginning of June, when some of my brother's scholars were leaving Bath; and then, to my sorrow, I saw almost every room turned into a workshop. A cabinet-maker making a tube and stands of all descriptions in a handsomely-furnished drawing-room; Alexander putting up a huge turning-machine (which he had brought in the autumn from Bristol, where he used to spend the summer) in a bedroom, for turning patterns, grinding glasses, and turning eye-pieces, etc. At the same time music durst not lie entirely dormant during the summer, and my brother had frequent rehearsals at home, where Miss Farinelli, an Italian singer, was met by several of the principal performers he had engaged for the winter concerts. . . . He composed glees, catches, etc., for such voices as he could secure. As soon as I could pronounce English well enough I was obliged to attend the rehearsals, and on Sundays at morning and evening service.

"But every leisure moment was eagerly snatched at for resuming some work which was in progress, without taking time for changing dress, and many a lace ruffle[1] was torn or bespattered by molten pitch, etc., besides the danger to which he continually exposed himself by the uncommon precipitancy of all his actions, of which we had a sample one Saturday evening, when both brothers returned from a concert between eleven and twelve o'clock, my eldest brother pleasing himself all the way home with being at liberty to spend the next day (except a few hours' attendance at chapel) at the turning-bench; but, recollecting that the tools wanted sharpening, they ran with a lantern and tools to our landlord's grindstone, in a public yard, where they did not wish to be seen on a Sunday morning. But my brother William was soon brought back fainting by Alexander, with the loss of one of his finger-nails. . . .

"My time was much taken up with copying music and practising, besides attendance on my brother when polishing, since, by way of keeping him alive, I was constantly obliged to feed him by putting victuals in his mouth. This was once the case when, in order to finish a seven-foot mirror, he had not taken his hands off from it for sixteen hours together. Generally I was obliged to read to him, while he was at the turning-lathe or polishing mirrors, 'Don Quixote,' 'Arabian Nights Entertainment,' the novels of Sterne, Fielding, etc.; serving tea and supper without interrupting the work, and sometimes lending a hand. I became in time as useful a member of the workshop as a boy might be to his master in the first year of his apprenticeship. But, as I was to take a part the next year in the oratorios, I had for a twelvemonth two lessons per week from Miss Fleming, the celebrated dancing-mistress, to drill me for a gentle-woman (God knows how she succeeded!). So we lived on, without interruption."

On her first public appearance as the leading treble singer in the oratorios, her brother gave her ten guineas for her dress, and on the occasion the proprietor of the theatre pronounced her an ornament to the stage. If she had chosen to persevere, her biographer says her reputation as a singer would have been secure, but, like a woman, she thought more of securing her brother's success than her own. She steadily declined to sing in public unless he was conductor. Besides regular Sunday services, she sang in concerts and oratorios at Bath and Bristol, all the while carrying on her housekeeping with one servant. In this way for ten years at Bath she went on "singing when she was told to sing, copying when she was told to copy, lending a hand in the workshop," and sympathizing with all the intensity of her nature in the course of events, which ended by her brother becoming "the king's astronomer." She sang with him for the last time at Bath, on Whitsunday, 1782.

The following extract narrates the course of events that led to her becoming her brother's constant assistant in his astronomical work:

"My brother applied himself to perfect his mirrors, erecting in his garden a stand for his twenty-foot telescope. Many trials were necessary before the required motions for such an unwieldy machine could be contrived. Many attempts were made by way of experiment against a mirror, before an intended thirty-foot telescope could be completed, for which, between-whiles (not interrupting the observations with seven, ten, and twenty foot, and writing papers

[1] She means her brother's ruffles. In those days lace was worn by gentlemen, and she elsewhere speaks of knitting ruffles for her brother.

for both the Royal and Bath Philosophical Societies [1]), gauges, shapes, weights, etc., of the mirror were calculated and trials of the composition of the metal were made. In short, I saw nothing else and heard nothing else talked of but about these things when my brothers were together. Alexander was always very alert, assisting when any thing new was going forward, but he wanted perseverance, and never liked to confine himself at home for many hours together. And so it happened that my brother William was obliged to make trial of my abilities in copying for him catalogues, tables, etc., and sometimes whole papers which were lent him for perusal. I was thus kept employed when my brother was at the telescope at night. When I found that a hand was sometimes wanted, when any particular measures were to be made with the lamp, micrometer, etc., or a fire to be kept up, or a dish of coffee necessary during a long night's watching, I undertook with pleasure what others might have thought a hardship."

Although the sister's references to the labors and discoveries of her brother are full of interest, we have no space for them here. Suffice it that, after the discovery of "the Georgium Sidus in 1781, the name of William Herschel became famous, and he was soon released from the necessity of giving any of his time to music. He was sent for to come with his seven-foot telescope to the king, and the result was that he was chosen royal astronomer, at a salary of £200 a year." One or two extracts, from the letters written by William Herschel to his sister during this preliminary visit to London, will give some idea of the intimate relation she held in his life. He writes on May 25th:

" . . . . Yesterday I dined with Colonel Walsh, who inquired after you. There were present Mr. Aubert and Dr. Maskelyne. Dr. Maskelyne, in public, declared his obligation to me for having introduced to them the high powers, for Mr. Aubert has so much succeeded with them that he says he looks down upon 200, 300, or 400, with contempt, and immediately begins with 800. He has used 2,500 very completely, and seen my five double stars with them. All my papers are printing, with the postscript and all, and are allowed to be very valuable. You see, Lina, I tell you all these things. You know vanity is not my foible, therefore I need not fear your censure. Farewell.

"I am your affectionate brother, WILLIAM HERSCHEL."

And again, June 3d, he writes:

"DEAR LINA: I pass my time between Greenwich and London agreeably enough, but am rather at a loss for work that I like. Company is not always pleasing, and I would much rather be polishing a speculum. . . . I am introduced to the best company. To-morrow I dine at Lord Palmerston's, next day with Sir Joseph Banks, etc., etc. Among opticians and astronomers nothing now is talked of but *what they call* my great discoveries. Alas! this shows how far they are behind, when such trifles as I have seen and done are called *great*. Let me but get at it again! I will make such telescopes and see such things—that is, I will endeavor to do so."

The letter ends abruptly.

Such, in brief, was the intellectual and moral preparation of Miss Herschel for the life of an astronomer. An account of her experiences in this field will be given in our next number.

[1] He was elected a Fellow of the Royal Society December 6, 1871.

# CORRESPONDENCE.

## LEX TALIONIS.

*To the Editor of the Popular Science Monthly.*

THE authors of "The Unseen Universe" tell us, as appears in a note in your January number, "It is probable that, before many years have passed, electricity will be called upon by an enlightened Legislature to produce absolutely indescribable torture, thrilling through every fibre of such miscreants"—in referring to "human brutes who vent their despicable passions in murderous assaults on women and children."

Evolution by reversion is not encouraging.

The refinement of scientific training, indicated by the above extract, is hardly in the direction of improving civilization.

It is suggested that the "human miscreants" are not the products of accident. May they not be examples of inherited disease, and therefore properly fit subjects for insane asylums, or other similar reformatories? How far may not society itself, in the locality of these human monsters, be responsible for their existence?

May we not hope that an "eye for an eye" is, in the order of healthy evolution, to disappear entirely from our penal correctives, including that relic of barbarism, capital punishment, even now rapidly disappearing from our statute-books, and in most States inflicted only for one grade of crime?

What is the object of all rational punishment? Certainly not vengeance—not vindictiveness.

Is it not, rather—1. Restitution to society or to individuals, so far as possible, for loss or injury caused by criminals? 2. Protection of society from repetition of criminal acts? and, 3. Reformation of the culprit?

If the gallows, and "absolutely indescribable torture, thrilling through every fibre," provided by *enlightened* Legislatures, are the only infallible remedies, then, indeed, is our vaunted civilization a sad failure.

Let us *revert* to scientific inquisition at once, and have a commission of *savants* in this Centennial year of grace, to resurrect the beauties of Torquemada. Why not?

B.

RICHMOND, INDIANA, *January* 10, 1876.

# EDITOR'S TABLE.

## *MARTINEAU'S REPLY TO TYNDALL.*

ONE of the great characteristic elements of scientific knowledge is that it is progressive, and the nature of that progress is to arrive gradually at the establishment of truth. Science having fixed upon its methods—methods that have been vindicated in its history—goes on with the exploration of phenomena in all fields, by beginning with imperfect evidence and gradually working out its investigations to the completeness of proof and the firm establishment of facts and principles. This being so, it follows that those who lead in science, who are active in its preliminary work, are naturally the most obnoxious to all those classes who rest contented with the existing state of opinion and are the conservators of traditional belief. It has always been so. In every phase and stage of advancing science, it is those that push on with the pioneer work, who begin to question opinions long rooted, trusting to the wholesomeness of inquiry, and the validity of long-tested scientific procedure, that encounter denunciation as disturbers of the world's intellectual peace. It was those who initiated investigation in astronomy, geology, physiology, and the various branches of natural phenomena; and it is those who are now pushing scientific methods of thought into fields where they have hitherto been unrecognized, that are most obnoxious to criticism as meddlers, disturbers, and destructives. The world at length accepts the work, and when it is accomplished will even applaud those who began it; but it as yet by no means recognizes the necessity of sharper questioning, of exploration in new fields, of a more inexorable scrutiny of old opinions, or the necessity of accepting the initial work of pioneer thinkers as legitimate and indispensable.

And so it is that intrepid scientists like Prof. Tyndall, who push on the front and give battle right and left, must take the consequences, as their predecessors have done in the past. The President of the British Association took a step forward at Belfast, and has been in hot water ever since. He assumed the broad, advanced ground that the exploration of the universe, so far as it is accessible to human faculties, belongs to science; and that every system, doctrine, or belief, that has hitherto been put forth regarding the nature, origin, or government of the universe which lays claim to the character of knowledge, must submit its pretensions to be passed upon by the tribunal of science. Science having given to man the universe as we know it, has established its claim to be intrusted with the whole field of intellectual exploration into its methods and laws. It was undoubtedly a bold step for President Tyndall to take, but it was inevitable by the logic of the history of thought. That the batteries should have been opened upon him all around was quite natural, and is but the repetition upon a somewhat larger scale of what has been going on in a smaller way ever since the scientific study of Nature began.

One of the controversies which grew out of the position taken by Tyndall, before the British Association, was with Dr. James Martineau, who is carrying it on vigorously and expansively. He first attacked the Belfast Address in a discourse entitled "Religion as affected by Modern Materialism," delivered to the theological college of which he is principal. To this Prof. Tyndall replied in a new preface to the "Fragments of Science," which appeared in the MONTHLY of last December. Dr. Martineau now rejoins in the February *Contemporary*, in an elaborate article, with more to come. We should be glad to print his paper if it were within limits practicable for the MONTHLY. But twenty-three pages, with the expectation of as many more, would consume more space than we can spare, and it is of less importance that we should issue it, as Mr. Putnam, Dr. Martineau's American publisher, will shortly furnish it to interested readers.

We may, however, briefly take note of Dr. Martineau's general position. He assumes that mischiefs arise, to both science and theology, from confusing their boundaries, and these he attempts to define. He seems to regard them as coördinate departments of investigation, and "that, in their dealings with phenomena, science investigates the 'How,' and theology the 'Whence.'" But on this view theology becomes obviously but one division of science, and is swallowed up by it. In investigating the "how" of things we are simply inquiring into one phase of their order, and in investigating their "whence" we are but inquiring into another phase of the same order. Moreover, we are finding that the investigation of the "how" involves the investigation of the "whence;" so that both procedures are directed to the solution of a common problem. Where are the defining boundaries when one thing is lost in another?

The more common theological position takes the "whence" out of the field of scientific inquiry by relegating it to the supernatural, and assuming it to be settled by an infallible preternatural inspiration, which is above the sphere of science that deals only with the natural. Orthodoxy plants itself upon the divine, infallible record, which by its nature and source is claimed to be above the reach of science. But Dr. Martineau is heterodox and cannot take this ground. His position is, that the Bible is sacred, but not infallible—sacred like the sacred books of other religions. He says: "I am asked how, after giving up the Old Testament cosmogony, I can any longer speak of 'sacred books,' without informing my readers where to find them . . . . Can a literature, then, have nothing sacred unless it be infallible? Has the religion of the present no roots in the soil of the past, so that nothing is gained for our spiritual culture by exploring its history and reproducing its poetry, and ascending to the tributary waters of its life? The real modern discovery, far from saying there is no sacred literature, because none oracular, assures us that there are several; and, notwithstanding a deepened, because purified attachment to our own 'origenes' in the Jewish and Christian Scriptures, persuades us to look with an open reverence into all writings that have embodied and sustained the greater pieties of the world."

By this position the absorption of theology into science is complete. For if Christianity has no other or different claims for the validity of what it offers than half a dozen other religions have—and impliedly a hundred other religions—what remains but to accept the phenomena of religions as a part of the phenomena of Nature open to scientific exploration? And, if thrown upon Nature, we encounter unity and evolution, and must study the genesis of religious beliefs, the development of superstitions, and the derivation of theological systems, as we study the unfolding of life, or the origin and progress of human institutions. The underlying principle of evolution is continuity, the lowest being connected with the highest by unbroken lines of unity and causation. But though committed, as we think, to this view by the position he has taken, Dr. Martineau affirms a break in the upward movement, so abrupt and total that science cannot cross it. He says, "Nature, in respect of its higher affections, compassion, self-forgetfulness, moral obligation, is constructed in harmony with a world divinely ruled," and this is the sphere of intuition and theology where science does not belong. But does the divine rule necessarily rule out science? and are not intuitions in this higher realm as open to be inquired of scientifically as instincts in the lowest sphere? The writer's declarations that it is the office of theology to explore the "whence" of things, and that it pertains to the "upper zone" of human nature, do not quite clear up the confusion of its boundary relations to science.

Dr. Martineau labors to point out, in his present essay, the difficulties that the "materialist" must encounter in explaining things by the atomic hypothesis; and in his next article he promises to show the deficiencies of the dynamic hypothesis for the same purpose. It is unnecessary to say that, as a writer, Dr. Martineau is an accomplished master of rhetorical effect.

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### *A LIBEL UPON THE INDIANS.*

It is an interesting question how the different races of mankind rank as liars. Is the capacity to falsify a constant quantity in all the varieties of men, or does it vary like other qualities; and, if variable, is it subject to development, and how do the various tribes of men stand upon the scale?

A United States Senator has given us his decisive *dictum* upon the subject, and there ought to be wisdom in a senatorial *dictum.* Mr. Windom, of Minnesota, is reported as recently saying in the Federal Senate that "the Indians are the greatest liars and vagabonds upon the face of the earth." With their rank as vagabonds we have no immediate concern, but in regard to their grade as liars we think the Senator is in error; he is over-modest; the "greatness" which he so freely accords to the savages, in this respect, belongs preeminently to his own race. The rivalries of falsehood between races, like other rivalries, must depend upon capacity, culture, and opportunity; and, in any competition for honors in deception, the Yankee has proved from the beginning to be much "smarter" than the Indian. Our Senator, indeed, if the reports can be trusted (and they are white, not Indian reports), might be taken as a living and conclusive illustration of the superiority of the superior race in perpetrating falsehood on an imposing scale. He is said to have advocated a breach of the treaty by which the "Black Hills" are reserved to the Sioux, so as to let in all the white adventurers that choose to go there; that is, to break the faith and pledge of the Government, and turn the whole nation into liars by virtue of our representative system. This brings out the exalted advantages in the practice of falsification possessed by the dominant race over the uncultivated savages. We can perpetrate deceit by official machinery. Even in the smallest way, in the hand-to-hand competition of a huckstering trade, the Yankee may be trusted anywhere to circumvent, that is, to outlie the Indian. But when we consider the case in its broader aspects, where the two sorts of people work freely in their separate social spheres, the Indians are not to be named as competitors of the whites in the art of mendacity. Granting the disposition, they lack the resources and capacity. Mentally, they are children, with but little knowledge, scanty ideas upon a few subjects, and limited intellectual operations. They lack the scope, the cultivation, the facilities for exercise in deceit which are possessed by the civilized race. Without books, newspapers, advertisements, highly-organized party politics, diplomacy, lawsuits, complex business rivalries, sectarian strifes, big enterprises, and fashionable society, what can they do in the way of duplicity, fraud, imposition, misrepresentation, artifice, cheating, forgery, perjury, and the thousand forms, and grades, and variations of lying, in which the dominant race is so proficient? The civilized man multiplies his capacity of falsehood through division of labor. He not only lies with his tongue, but with his hands, manipulating falsehood into his manufactures. He lies by machinery, and swindles by steam. By the printing-press he scatters deceptions like snow-flakes over the continent. Your civilizee lies with enterprise, through an army of agents by post and by telegraph. What can the "poor Indian," with his "untutored mind," do in comparison with this? There was more lying in the management of the Northern Pacific Railroad than ten tribes of Indians could perpetrate in a generation. There is more lying in one presidential campaign than all the North American tribes could perpetrate in a century. The Indians are no more "the greatest liars on the face of the earth" than they are the greatest lawyers, politicians, editors, merchants, and manufacturers, on the face of the earth. Fraud, falsification, dissimulation, insincerity, trickery, overreaching, and the innumerable grades and shades of humbug, are vices of the civilized man, and he must accept this with all his other forms of greatness. The Indian has undoubtedly a rudimental capacity for lying, which gets somewhat developed along the borders, by his intercourse with the whites, but he cannot aspire to the unenviable eminence which Senator Windom ascribes to him.

### *HOW SCIENTIFIC EDUCATION IS EVADED.*

Of the two great phases of educational reform, the improvement of its quality, and the increase of its quantity, in our judgment, as we have frequently said, the former is much the most important. We have abundant evidence on all sides as to how easy it is to extend education, or that which passes under its name. And the evidence is equally abundant and clear of the great difficulties of improving the quality of that which is established under the name of education. And the more it is extended and organized, and officialized, the more formidable are the obstacles to any change of method that shall make it increasingly rational. A fresh illustration of the tenacity of traditional ideas, and the ingenuity with which reforms of great and conceded importance are evaded and turned to naught, was lately furnished by Sir John Lubbock in pointing out the tactics of the leading English universities by which the study of science and the modern languages is escaped. To show how the subject stands as a matter of *reason* he first called attention to the views put forth by the several English commissions appointed to inquire into the management of the higher institutions. The commission of 1861, which took up the great public schools, reported that more time should be devoted to the study of modern languages, while, as regards science, that it was practically excluded from the education of the higher classes in England. "Education," they say, "is, in this respect, narrower than it was three centuries ago, while Science has prodigiously extended her empire, has explored immense tracts, divided them into provinces, introduced into them order and method, and made them accessible to all. This exclusion is, in our view, a plain defect, and a great practical evil. It narrows unduly and injuriously the mental training of the young, and the knowledge, interests, and pursuits, of men in maturer life. Of the large number of men who have little aptitude or taste for literature, there are many who have an aptitude for science, especially for science which deals, not with abstractions, but with external and sensible objects; how many such there are can never be known, as long as the only education given at schools is purely literary, but that such cases are not rare or exceptional can hardly be doubted by any one who has observed either boys or men."

In 1868 another commission was appointed to examine the management of the English endowed schools. In their report they say: "We think it established that the study of natural science develops, better than any other studies, the observing faculties, disciplines the intellect by teaching induction as well as deduction; supplies a useful balance to the studies of language and mathematics, and provides much instruction of great value for the occupations of after-life."

Finally, a third commission was appointed, under the presidency of the Duke of Devonshire, to inquire into the state of scientific instruction in Great Britain, and they report that "though some progress has no doubt been achieved, and though there are some exceptional cases of great improvement, still no adequate effort has been made to supply the deficiency of scientific instruction pointed out by the commissioners of 1861 and 1864. We are compelled, therefore, to record our opinion that the present state of scientific instruction in our schools is extremely unsatisfactory."

These are well-matured views put forth with the weight of a large number of the most eminent names in England. The claims of scientific men for time to be devoted to scientific studies have been moderate. Assuming the number of study-hours in a week to be thirty-eight, Dr. Hooker, Prof. Huxley, and Dr. Carpenter, ask only for six hours to be devoted to science, while Prof. Tyndall demands only eight. The recent commission has shown by a large number of returns from the endowed schools that, when science is studied at all, not more than two hours a week are given to it, while in a large number it is entirely ignored. Out of one hundred and twenty of the larger endowed schools, in more than half no science whatever is taught, and out of the whole number only thirteen attach any weight at all to scientific subjects in the examinations.

It is by the skillful working of these "examinations" that the adherents of the older studies resist the educational progress of science. The Universities of Oxford and Cambridge, backed by the immense authority of these great institutions, have recently appointed a joint board to undertake the examinations of schools. The studies are distributed in four groups: 1. The languages; 2. Mathematics; 3. Scripture knowledge, history, etc.; 4. The sciences. But the certificates are awarded under such conditions that the modern languages and the sciences are virtually suppressed. As Sir John Lubbock says, "the result will be to discourage the teaching of French and German," while "the nominal introduction of science is under the circumstances little more than a hollow mockery;" the effect being that "boys may obtain university certificates while they know nothing of history, nothing of geography, nothing of any modern language, or of any branch of science."

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### *VIVISECTION VINDICATED.*

There was a loud and passionate outcry a year ago in England, which had its echoes in this country, about the fiendishness of physiologists in their experiments upon living animals. They were represented as devoid of all humanity, indurated and indifferent to suffering, and as delighting to torture poor dumb creatures for mere amusement or class-room show, and on the most frivolous pretexts of helping on the progress of science. There was a great deal of screaming about it, and Hutton, of the London *Spectator*, led the crusade, demanding governmental interference to restrain the brutalities of the scientists and protect the helpless victims of their barbarity. And so, as is wont with the English, a commission was appointed to inquire into the matter, and Hutton was among the commissioners. It was a sensible body, and raked together every thing that claimed to be evidence upon the subject. Of course, the stories of horrors which got such wide credence, turned out to be absurd exaggerations. Brought to book, the secretary of the "Royal Society for the Prevention of Cruelty to Animals" acknowledged that he did not know a single instance of wanton cruelty. The case of the agitators broke down signally, and after the most patient examination of the whole subject the commissioners declare that "a general sentiment of humanity on this subject appears to pervade all classes in this country." They point out how much science is indebted, and how much the world owes, to experiments upon living animals, and they recognize that in the further progress of medical science this means of knowledge cannot be avoided. The commission, in fact, accepts the position taken by the physiologists themselves at the British Association in 1871, and demands only "the reasonable superintendence of constituted authority." The legislation asked for will not in any way alter the existing facilities for research or impede its progress, while it will calm needless apprehension, and put an end to the odious misrepresentations which have recently been rife upon the subject. Perhaps the friends of the lower animals, who have been so ardent in attacking and denouncing men of science, will now turn their attention to the butchers, the hunters, and the fashionable people who torture their horses in the broad day in the open streets, and at all hours, in the sight of everybody, by the use of bearing-reins and gag-bits.

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## LITERARY NOTICES.

Descriptive Sociology. By Herbert Spencer. Numbers Three and Four. Folio. Price, $4.00 per No. D. Appleton & Co.

To those who care only for politics on account of its gossip, personalities, and passing excitements, or who study it merely as an art for the attainment of their own selfish ends, these works need not be commended; but those who are interested in working out the principles of a science that underlies all politics will be glad to learn that the "Descriptive Sociology" of Herbert Spencer is making fair progress, the fourth number being now published. This work is not at all known even by the most intelligent portion of the American people. They talk much about society, speculating upon its origin, declaiming against its evils, and proposing endless nostrums for its relief and regeneration, but give no attention to the most serious, thorough, and successful effort yet made to elucidate the natural laws of social phenomena. If the value and importance of Spencer's "Descriptive Sociology" were at all understood, it would be found in every public library, in many private ones, and in all higher educational institutions. It is nothing less than a series of representations, almost pictorial in their clearness, of the constitution of human societies, of all forms, types, and grades, the world over. It gives the whole range of social facts that characterize each community in such an ingenious scheme of representation that they can be compared with extreme facility, and their elements considered either separately or as existing together; and either as advancing by themselves, or as moving on connectedly and under mutual influence. The industrial, economic, domestic, civil, military, æsthetic, moral, religious, and intellectual condition of each community, is given in a systematic way, which brings out the relations of these social factors; and the whole is carefully authenticated by copious and classified extracts from the best authorities by which the social facts in the several cases have been described. Without critical examination no one can form an idea of the enormous labor that has been expended upon these works, nor of their value to the students of social affairs. Nothing worthy the name of social science, that is, embracing wide inductions and comprehensive principles, can ever come from the examination of one example or form of society only; and, in the wide sweep of his inquiries, Mr. Spencer is the first to have given to the problem of social philosophy its full breadth of scientific basis.

In the first number of this general work Mr. Spencer gave us the social history of England. In the second number he gathered up and organized what is known of the social life of the extinct or decayed American civilizations. Number Three, now before us, is devoted to the lowest types of the social state—the Negritto races and the Malayo-Polynesian races. This was compiled and abstracted by Prof. David Duncan, a collaborator with Mr. Spencer in the execution of his enterprise. It represents the social life of the Fuegians, Andamans, Veddahs, Australians, Tasmanians, New Caledonians, New Guinea people, Fijians, Sandwich-Islanders, Tahitians, Tongans, Samoans, New-Zealanders, Dyaks, Javans, Sumatrans, and Malagasy. The environments, inorganic, organic, and sociological of these communities, and the physical, emotional, and intellectual characters of each people are given, and whatever is known or accessible regarding their social habits, peculiarities, and modes of life.

Number Four, which is just published, also elaborated by Prof. Duncan, is devoted to the African races. He delineates the social aspects of the Bushmen, the Hottentots, the Damaras, the Bechuanas, the Caffirs, the East Africans, the Congo people, the Coast Negroes, the Inland Negroes, the Dahomans, the Ashantis, the Fulahs, and the Abyssinians.

We cannot republish these works in the Monthly, although in the number for April, 1874, we gave a sample of the tables that are used, and which necessitated the large folio form of publication. But those who will take the pains to consult and compare these works now issued will quickly see that we are entering upon a new stage of social ideas and knowledge. "The proper study of mankind is man," but it is far from being the same study in different ages.

A Text-Book of Human Physiology. Designed for the Use of Practitioners and Students of Medicine. By Austin Flint, Jr., M. D. Illustrated by Three Lithographic Plates and 313 Woodcuts. Pp. 978. Price, $6. D. Appleton & Co.

This work is an abridgment or condensation of Dr. Flint's large treatise upon physiology, in five volumes. The bibliographical and historical features of the larger work are mostly omitted, and various subjects, which are there much elaborated, are more concisely presented in the single volume. The more extensive treatise will retain its place for purposes of reference, as giving a full account of the literature of physiology, and a systematic representation of its facts and principles. Out of this Dr. Flint has educed a complete working manual, which brings the treatment of the subject within convenient limits for students, while it is much more complete as a representation of the present state of the science than any other book we know upon this topic. A marked feature of the work is its illustrations, which are large and especially fine. Many of them are new, and all are executed in the best style of the engraver's art. The book is beautifully printed and is most attractive in appearance; it may be commended to all who desire a comprehensive and trustworthy work up to the latest date, by authority, on the interesting and important subject of physiology.

Animal Parasites and Messmates. By J. P Van Beneden, Professor at the University of Louvain. With 83 Illustrations. Pp. 274. Price, $1.50. D. Appleton & Co. No. XIX. of the "International Scientific Series."

We give in the body of the Monthly a sample of the curious and interesting information on the economy of animal life to which this book is devoted. It opens a new chapter of strange things in the field of life, to the common reader, and will be perused with avidity by all lovers of natural history. The names of most of the little creatures described will be found somewhat new to general readers; but the lively, familiar, and graphic style of the writer will go far to compensate for this drawback, as he is not without a very decided sense of the comical and humorous side of his remarkable subject. The author is an eminent authority in zoölogy, and the work is largely the result of his own observations and studies. It is one of the most original monographs in the series to which it was contributed.



Life Histories of Animals, including Man: or, Outlines of Comparative Embryology. By Dr. A. S. Packard, Jr. New York: Henry Holt & Co., 1876. Pp. 243. Figures 268.

Since the translation of Siebold's "Comparative Anatomy of the Invertebrata," by Dr. Burnett, accompanied by the valuable investigations of the translator, and the publication of "Mind in Nature," by Prof. H. James Clarke, there has been no general work published in this country equaling in importance the one before us. Indeed, we cannot now recall any work which covers the same ground; and as an evidence of its value it may be stated that the English magazines of science have repeatedly made liberal quotations from some of the chapters, as they originally appeared in the *American Naturalist*.

Dr. Packard has not only brought together and richly illustrated a *résumé* of the labors of the leading embryologists of Europe—Kowelevsky, Schultze, Schneider, Metschnikoff, Salensky, Cienkowski, and others equally distinguished—and also the work of American naturalists, too, but has contributed much original matter from his own published works on insects and crustacea. The various classes are conveniently but not too rigidly grouped in a natural sequence, commencing with the *Monera*, and ending with *Man*.

It is refreshing to get hold of a general work which is strictly in accordance with the latest interpretations of science, and it must remain for many years the one standard work on the subject.

The author, as is the case with ninety-nine hundredths of the leading investigators, is an evolutionist, and indeed it would be difficult to conceive a work of this nature presented in any other light, unless it were given as a bare descriptive catalogue of details.

With each group (considered as a special study) are given a brief sketch of the structure and habits of some of its leading forms, their affinities, embryology, and a very useful table of the literature of the subject. A list of the authors referred to indicates clearly how few Americans have contributed to a knowledge of the subject.

The advanced character of the work is seen in the adoption of Haeckel's terms for different conditions of the embryo, such as the *morula stage*, *planula stage*, *gastrula stage*, etc. The ascidian stage is also recognized in the development of Vertebrata. *Amphioxus* is considered separately from the fishes, the *Brachiopoda* are placed among the worms. Altogether it forms one of the most valuable works of science yet published in this country, and it is safe to say that no working naturalist can do without it.

As a second edition of the work must soon be demanded, we trust it may be accompanied by a table of contents.

Abstract of Results of a Study of the Genera Geomys and Thomomys, with Addenda on the Osteology of Geomyidæ. By Dr. Elliot Coues. Washington: Government Printing-Office, 1875. Pp. 74.

This is a reprint from Major J. W. Powell's report of his explorations of the Colorado River, giving a full scientific account of the little animals known on the Western prairies as Pocket *Gophers*. Regarding the two genera *Geomys* and *Thomomys* as constituting a perfectly natural group of the grade of a family, *Geomyidæ*, the author describes them as "among the heaviest for their inches of any animals in this country, of squat, bunchy shape, with short, thick limbs, a short tail, very small or rudimentary ears, small eyes, no appreciable neck, and thick, blunt head; and they are as completely subterranean as the mole itself. They are rarely or momentarily seen above the ground; they excavate endless galleries in the earth in their search for food, frequently coming to the surface to throw out the earth in heaps, but plugging up these orifices as soon as they have served their purpose."

*Geomys* contains five (some authors say seven) well-defined species; *Thomomys* but a single species, including three recognizable races, out of which, by the process of species-mongering so common with earlier naturalists, a dozen separate species were made. While in *Geomys* the links have disappeared and the species are well-pronounced, in *Thomomys* the separation is incomplete, and the connecting forms still visible. "The genus appears to be working into a number of species, but the process is still far from completion." Adopting modern philosophical views, the author's tendency is to reduce the number of species, seeing only races or varieties where others claim to have found well-defined species. The several species constituting the family are separately described. The cranial and dental characters of the group are afterward treated, and the work closes with a further description, communicated by Prof. G. Brown Goode, of *Geomys tuza*, a form confined to Florida, Alabama, and Georgia, and there known as Salamanders.

Prof. Coues has the rare faculty of making even technical descriptions interesting, and for this reason the work commends itself to the attention of other than scientific readers.

Practical Hints on the Selection and Use of the Microscope. By John Phin. New York: The Industrial Publication Co., 1875. Pp. 131. Price, 75 cts.

In the preface to this little book the author tells us that it is intended for beginners in the use of the microscope, a purpose that appears to have been kept well in mind in the subsequent pages, as the explanations are clear, the directions explicit and suitably detailed; and nothing has been attempted that lies beyond the understanding of any intelligent girl or boy of fifteen. After pointing out the numerous applications of the instrument, that are every day extending, the simple and compound microscope, and the essential parts of each, are described. The various forms in use are next enumerated, with brief descriptions of the most noted; and then follow practical directions for the selection of a microscope, and the requisite accessory apparatus. Illumination, the manipulation and care of the instrument, and the collection and mounting of objects, take up the remainder of the book. The student is referred to the larger works of Carpenter and others for a knowledge of the principles involved in the construction of the microscope, and of the course of procedure in the several departments of study to which it is applied.

Four Thousand Miles of African Travel. By Alvan S. Southworth, Secretary of the American Geographical Society. With Maps and Illustrations. Baker, Pratt & Co., New York. Price, $3.50.

The volume of Mr. Southworth is an interesting contribution to our knowledge of one of the most important regions of Central Africa. It is the well-told account of a journey made by the author as traveling correspondent of the *New York Herald* for the purpose of exploring the countries of the Upper Nile—their aspects, resources, and populations.

The journey commenced at Cairo on the 27th of December, 1871. "At noon on the 6th of February," says the traveler, "our Soudan *dahabeah* was parting the dark, rippling waters of the Blue Nile from the muddy flow of its sister confluent, the White Nile, and by one o'clock the solitary minaret of Khartoum was seen above the palms and acacias!" This city contains 40,000 inhabitants, is the capital of the Soudan, and is the finest provincial city of Central Africa.

The chapters in which the author gives an account of his trip up the White Nile through the heart of the Soudan are full of interest. The country is described as wonderfully fertile. With its present wretched cultivation it is more productive than the well-tilled fields of Italy. It abounds in cattle and camels, as well as wild animals. Under the present government the progress toward civilization has been immense. Within fifteen years we are informed, 30,000,000 people have been brought in some degree within the circle of semi-civilization. But only incipient steps are taken. The slave-trade and all the depressing influences of savagism still bear upon the people. It is believed that no country in the world is better adapted to the raising of cotton than the Soudan.

The author turned back from his travels at Arbah Island, 300 miles southward from Khartoum, and nearly 2,000 miles from the Mediterranean.

The volume is enlivened by vivid descriptions of natural scenery and phenomena. On the Nubian Desert the mirage sometimes breaks the dreary view. "On the 17th of January we were seemingly encompassed by this imponderable mirror. In the glowing heat the bed of the desert would seem to rise in rippling waves, and a line of rocks, at 200 yards distance, kept common time and looked like a regiment of men marching off the field in line of battle." The simooms, sand-storms, and sand-spouts, as well as the gorgeous tropical scenery, are vividly described. The horrors of the slave-trade, and the means by which this and other barbarisms may be overcome, are prudently and judiciously treated. Dr. Southworth has done excellent service in publishing this volume.

The American Journal of Microscopy and Popular Science. Issued by the Handicraft Publication Company, 37 Park Row, New York. Subscription price, 50 cents a year

This is a twelve-page monthly devoted mainly to the interests of microscopy. Its purpose, as expressed in the prospectus, is to diffuse a knowledge of the best methods of using the microscope, of valuable improvements in the instrument, and its accessories; of new methods of microscopical investigation, and of the most recent results of microscopical research. Besides general articles, of which the number before us offers a pleasant variety, some of them illustrated, there is a "Young Folks' Column," "Our Work-Table," "Book-Table," "Notes and Queries," etc.

Report of the Michigan Board of Health, 1874. Lansing: W. S. George & Co. Pp. 254.

Among the subjects treated in this report are the entailments of alcohol, draining for health, poisonous paper, relation of schools to health, resuscitation of the drowned, cerebro-spinal meningitis, meteorology of Central Michigan. Of the eight special reports, five were drawn up by Prof. R. C. Kedzie, M. D., whose labors are well known to all who take an interest in sanitary science.

A Guide to the Microscopical Examination of Drinking-Water. By J. D. Macdonald, M. D., F. R. S. Pp. 113. With twenty-four Lithographic Plates. Price, $3. Philadelphia: Lindsay & Blakiston. 1875.

This volume is an important contribution to our knowledge of the extent and nature of the impurities found in drinking-water, and the most ready means of detecting and classifying them. In clearness of method and statement, and style of its illustrations, the work is admirable. The author does not attempt to link particular forms of impurity with specific sanitary effects, but says further observation may show their deep sanitary significance.

No one now hesitates to condemn a water containing bacteria and fungi, or swarming with the lower forms of life.

The means by which sediments and floating impurities in water may be best obtained and studied is pointed out in a brief introduction.

Section 1 treats of the mineral matters found in drinking-water; section 2 gives an account of the dead and decaying, section 3 of the living forms found in water.

The twenty-four plates comprise over four hundred figures; frequently, however, the same object is presented under different forms. The volume is an excellent hand-book, and will greatly facilitate the study of the important subject of which it treats.

Exploration of the Colorado River of the West and its Tributaries in 1869, 1870, 1871, and 1872. Washington: Government Printing-Office. Pp. 291.

This is the first installment of Major J. W. Powell's exploration and survey of the Colorado River region. The book consists of three parts, in the first of which we have a journal of the exploration of the cañons of the Colorado in the year 1869; in the second, an account of the physical features of the valley of the Colorado; and in the third, three chapters on the zoölogy of the region explored. The two chapters of the second part were published in the Monthly last summer, Major Powell kindly permitting us to copy from advanced sheets, and supplying us with the woodcuts. The present volume is an exceptionally interesting and instructive description of the strange and picturesque country explored.

The Cholera Epidemic of 1873 in the United States. Pp. 1025. Washington: Government Printing-Office.

Contains reports made to the Treasury Department by Dr. Woodworth, superintendent surgeon of the Marine Hospital Service, and to the War Department by Dr. J. K. Barnes, Surgeon-General U. S. Army. Dr. Woodworth's report is brief, and traces the history of the introduction of cholera through the agency of the mercantile marine. The War Department report is divided into three parts, the first being written by Dr. Ely McClellan, U. S. Army. This gives a history of the epidemic of 1873 in the United States. The second part, by Drs. J. C. Peters and Ely McClellan, is devoted to the history of the travels of Asiatic cholera. In the third part is given the bibliography of cholera by Dr. J. S. Billings, U. S. Army.

Notes on Certain Explosive Agents. By Walter N. Hill, S. B. Boston: John Allyn, 1875. Pp. 71.

This pamphlet contains a large amount of practical information about several of the more important explosives now in common use, such as nitro-glycerine and its various preparations, gun-cotton, and the picrates and fulminates. Their chemical composition, mode of preparation, manner of firing, and the reactions which occur during explosion, are clearly set forth, and tables are also given exhibiting their relative explosive power.

The Taxidermist's Manual: or, The Art of collecting, preparing, and preserving Objects of Natural History. By Thomas Brown, F. L. S. New York: G. P. Putnam's Sons. Pp. 150. Price, $1.25.

This is a practical guide to the art of taxidermy, giving detailed directions for all the operations required in the preparation and mounting of natural history specimens. It contains several plates and a full index.

Soul Problems, with Other Papers. By Joseph E. Peck. New York: Charles P. Somerby. Pp. 63. Price, 70 cents.

The problems considered in this essay are the materiality or immateriality of the mind, and future personality.. The other papers are on "The Theological Amendment," and "The State Personality Idea."

Startling Facts in Modern Spiritualism. By N. B. Wolfe, M. D. Chicago: Religio-Philosophical Publishing House. Pp. 571.

Dr. Wolfe tells us that he has been for twenty-five years an observer of modern spiritualism. Had he not published this book, the world might never have known the extent of his gullibility. He has only himself to blame.

Contributions from the Laboratory of the State University. By P. Schweitzer, Ph. D. Jefferson City, Mo.: Regan & Carter. 1875. Pp. 38.

Two papers by Prof. Schweitzer, printed from the Catalogue of the University, comprise this pamphlet. One is upon the "True Composition of Coal," and the other on the "Water-Supply of Columbia, Boone County," with analyses. Both papers are of value, giving in detail the results of faithful and well-directed laboratory work.

Views and Interviews on Journalism. Edited by Charles F. Wingate. New York: F. B. Patterson. Pp. 372.

Mr. Wingate allows some of the prominent newspaper editors of the United States to express their opinions on journalism, its limits, its tendencies, its perils, its prospects. In some instances the editors are catechised in an interview, in others their views are ascertained by reference to the journals they edit.

The Lower Forms of Life found within the Oral Cavity. By C. N. Peirce, D. D. S. Pp. 23. Lancaster, Pa.: *Pennsylvania Journal of Dental Science.*

The forms of life here spoken of are six in number, five of them being vegetal growths, and the sixth an animal organism, a genus of infusorium. They are all microscopic organisms.

The Prospector's Manual. By W. J. Schofield. Boston: W. J. Schofield & Co. Pp. 96. Price, 50 cents.

Intended as a guide to the discovery of quartz and placer indications of gold and silver mines. The book further gives descriptions of metalliferous rocks of various kinds in the New England States and the neighboring provinces of Canada.

Journal of the American Electrical Society. Vol. I., No. 1. Chicago: Lakeside Publishing Co. Pp. 98.

The American Electrical Society, whose official organ this *Journal* is, has for its object the interchange of knowledge and the professional improvement of its members, the advancement of electrical and telegraphic science, and the establishment of a central point of reference. The articles which appear in the *Journal* consist chiefly of papers read at the meetings of the society, but papers from other sources on telegraphic and electrical subjects are also given. In the present number, the first article, which is well illustrated, is by Mr. Elisha Gray, on "The Transmission of Musical Tones telegraphically." There is also an illustrated article on "Quadruplex Telegraphy." Among the selected articles we may name one on Edison's "New Force," by Dr. Beard, and a sketch of Sir Charles Wheatstone. The Publishing Committee, in a note prefixed to the present number, state that a second number may be issued in three or four months. Price, $1.50 per number.

Geological and Natural History Survey of Minnesota (1874). By N. H. Winchell. Pp. 36. St. Paul *Pioneer Press* print.

In this, his third annual report, the State geologist of Minnesota gives the results of his researches on the geology of the two counties of Freeborn and Mower. In the former county there is an abundance of peat, most of the marshes being peat-bearing. This peat is of the best quality, and is gradually coming into use for fuel. Geological maps of the two counties accompany the report.

Bulletin of the United States National Museum. By J. H. Kidder, M.D. Washington: Government Printing-Office. Pp. 51.

The present number of the "Bulletin" is devoted to a description of the ornithological specimens brought from Kerguelen Island by the Transit-of-Venus Expedition of 1874–'75. The number of species described is twenty-one, belonging to six families — *Procellaridæ*, *Spheniscidæ*, *Laridæ*, *Phalacrocoracidæ*, *Anatidæ*, and *Chionididæ.*

Bulletin of the Buffalo Society of Natural Sciences. 1875. Buffalo, N. Y.: The Courier Company, Printers. Pp. 120.

This issue is No. 4 of Vol. II., and comprises nine articles, with an index to the volume. The articles are No. 16 to No. 24 of the series, eight of which are upon subjects of entomology, and all of value to specialists in that science.

No. 18 is a check-list of the North American sphinxes by Aug. R. Grote, and No. 20 is a valuable paper by Dr. Scudder, being a synonymic list of the butterflies of North America north of Mexico.

Article No. 22, by M. C. Cooke, M. A., of London, is a synopsis of the discomycetous fungi of the United States, in which very full credit is given to American mycologists for assistance rendered.

Necessity of a Mechanical Laboratory. By Prof. R. H. Thurston. Pp. 10.

Prof. Thurston here defines what a mechanical laboratory ought to be, its province and its methods. Such a laboratory the trustees of the Stevens Institute of Technology, he informs us, have consented to establish. Such bodies as the Railway Master-Mechanics' Association, the Society of Civil Engineers, and the Iron and Steel Association, have pledged themselves to give aid and advice in promoting the enterprise.

Some Account of Zapus Hudsonius and Lagopus Leucurus. By Dr. E. Coues. Washington: Government Printing-Office. Pp. 14.

*Zapus* is the name given by Dr. Coues to a genus which includes only one species, the "long-legged mouse of Hudson's Bay." This animal, usually referred to the *Muridæ*, differs from the Muridæ, says Dr. Coues, to a degree warranting the recognition of a family *Zapodidæ*. With respect to *Lagopus leucurus* (the white-tailed ptarmigan), Dr. Coues remarks upon its breeding-habits, its nest, and its eggs.

The Mammoth Cave of Kentucky. By W. S. Forwood, M. D. Philadelphia: Lippincott. Pp. 241.

This is an excellent account of the great Kentucky Cave. It is not only a trustworthy guide for the visitor, but something far better than an ordinary guide-book—an historical and descriptive account of the Mammoth Cave, giving explanations of the causes concerned in its formation, its chemistry, geology, etc., together with full scientific details of the eyeless fishes. The volume has twelve lithographic illustrations, also an original map.

Geological Notes. By Prof. William B. Rogers. Pp. 13.

The two papers contained in this pamphlet are reprinted from the "Proceedings of the Boston Society of Natural History." The first of the papers treats of the Newport conglomerate, and the second of the gravel and cobble-stone deposits of Virginia and the Middle States.

Weights, Measures, and Money, of All Nations. By F. W. Clarke, S. B. Pp. 117. New York: D. Appleton & Co. Price, $1.50.

This is a very useful little volume, enabling the reader to reduce to United States standards the money, measures, and weights of every commercial nation in the world. The work is divided into two parts, in the first of which we have a classification according to countries, arranged alphabetically, and, in the second, a set of tables, giving the value of each unit both in English and in metric standards.

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## PUBLICATIONS RECEIVED.

Washington Astronomical and Meteorological Observations (1873). Washington: Government Printing-Office. Pp. 429.

Reconnoissance of Northwestern Wyoming. By W. A. Jones, U. S. A. Washington: Government Printing-Office. Pp. 332.

Algebraical Equations. By J. Macnie, A. M. Pp. 194. New York: A. S. Barnes & Co. Price, $2.50.

History of the United States. By J. A. Doyle. Pp. 404. New York: Holt & Co. Price, $1.40.

Beliefs of the Unbelievers. By O. B. Frothingham. New York: Putnams. Price, $1.

French Political Leaders. By E. King. Pp. 326. *Same publishers.* Price, $1.50.

Filth-Diseases. By J. Simon, M. D. Pp. 96. Boston: James Campbell. Price, $1.

Percy Bysshe Shelley as a Philosopher and Reformer. By C. Sotheran. Pp. 51. New York: Somerby. Price, $1.25.

Algebra for Beginners. By J. Loudon, M. A. Pp. 158. Toronto: Copp, Clark & Co.

Report on the Public Schools of Columbus, Ohio. Pp. 428. Columbus: S. A. Glenn.

The Textile Colorist (Monthly). For sale in New York by Wiley & Son. Price, $1 per number.

Report of New York City Superintendent of Schools (1875). Pp. 77. New York: Cushing & Bardua print.

Report on the Harvard Museum of Comparative Zoölogy (1875). Pp. 58. Boston: Wright & Potter print.

Message of Governor Tilden (January, 1876).

Chemical Analyses of Fertilizers. Published by the Georgia Commissioner of Agriculture. Pp. 44.

The Bible and Science. By J. Weiss. Pp. 22. Boston: Cochrane & Sampson print.

Sheep-Husbandry in Georgia. Pp. 24. Atlanta: Harrison & Co. print.

Sympathy of Religions. By T. W. Higginson. Pp. 38. Boston: Free Religious Association. Price, 10 cents.

The Financial Problem. By Hon. E. Ward. Pp. 18. Washington *Congressional Record* print.

Charities of New York (1876). Pp. 69. New York: Putnams.

Sketch of the Life of J. A. Lapham. By S. S. Sherman. Pp. 80. Milwaukee: *News* Co. print.

Man's True Relation to Nature. By T. P. Wilson, M. D. Pp. 26. Cleveland, Ohio: L. H. White.

Sanitary Condition of Towns. Pp. 32 (Legislative Document). Albany: Weed, Parsons & Co. print.

Elements of Life-Insurance. Pp. 32. Boston: Wright & Potter print.

Variation in Strength of a Muscle. Pp 6. *Also*, New Form of Lantern Galvanometer. Pp. 3. By F. E. Nipher. Reprint from *American Journal of Science.*

Specimens of Milk from Vicinity of Boston. By S. P. Sharples, S. B. Pp. 7.

Valedictory Address to the Medico-Legal Society of New York. By C. Bell. Pp. 22.

Meteorology and Health. By W. Blasius. Pp. 5.

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## MISCELLANY.

**Trichinous Pork.**—*Trichina spiralis* was first discovered by Owen, in 1835, in human muscular tissue. Some twenty years later the parasite, as seen by Owen, namely, as a minute worm coiled up within a cyst, was found by Herbst to be the larva of a thread-like worm. The latter passes its life in the intestinal canal, the former inhabits the muscular tissue. When the flesh of animals infested by the larvæ is taken into the stomach, the immature trichinæ quickly multiply, and in the course of a few days millions of the encysted larvæ may be found in the muscles. As has been shrewdly conjectured, it is not improbable that the prohibition of pork as food, a prohibition enforced not only among the Jews, but among various races inhabiting widely-separate regions of the earth, had its origin in an observation of injurious consequences attending the use of swine's flesh. Dr. Sutton's "Report on Trichinosis," noticed in our January number, is worthy of the attention, not only of medical men, but of the public. We give herewith the result of his observations on the cases of the disease which came under his notice, and of his examination of hundreds of specimens of pork:

1. He found that all the cases which came under his observation were produced by eating uncooked or imperfectly-cooked pork. 2. He reiterates the uniform teaching of medical observers that the vitality of the trichinæ can be destroyed only by thorough cooking of the meat, and that the eating of merely smoked or dried pork is dangerous. 3. From microscopic examinations of pork killed in Southeastern Indi

ana, he found from three to sixteen per cent. of the hogs affected with trichinæ, the number of hogs diseased varying greatly in different localities. 4. That ninety per cent. of the disease produced by trichinous pork appears as gastero-enteritis, diarrhœa, or dysentery, ten per cent. only representing the cases of trichinosis proper.

**Penetrating Power of Different Colored Lights.**—An experiment was lately made at Trieste, to determine how far lights of different colors penetrate darkness. Half a dozen lanterns with carefully-selected glass, and all furnished with oil and wicks of the same quality, were lighted on the beach, and then observations were made by a party in a boat. At the distance of half a league, the dark-blue lantern was invisible, and the deep-blue one nearly so; hence it appears that blue lights are not adapted for use in lighthouses, or as signals. Of all the colors the green was visible for the longest distance, with the exception of the red, which ranked next to the white in power of penetration. The conclusion is, that only the green and the red are suitable for signals; and the green light the Trieste observers only recommend for use in conjunction with white and red lights, inasmuch as, when viewed from a short distance, an isolated green light begins to look like a white one.

**Curious Freak of the Curly-Willow.**—The following curious facts are communicated by Dr. S. Lockwood to the *Botanical Bulletin:* "We have two pendent willows, known as *Salix Babylonica* (more correctly *S. pendula*, Mœnch.), the weeping-willow, and *Salix crispa*, the curly-willow. On the grounds of Hon. E. W. Scudder, Trenton, New Jersey, is a fine specimen of each, the two having a clear distance of twenty-five feet between their nearest branches. The topmost branch of the curly-willow, on the side of the tree next the weeper, is about ten feet long, and six feet thick, and is densely covered with leaves. The curious fact is, that while the rest of this entire tree has the perfect habit of *S. crispa*, this large branch has the perfect habit of *S. Babylonica.* The long pendent branchlets, and every leaf, are in all respects those of the weeping-willow. This is true not only of the form and habit of the leaves, but with positive exactness also of the color. The true *crispa* leaves are a very dark and shiny green above, and almost a chalky white underneath. The pseudo-*Babylonica* leaves are a pale yellowish-green above, and still paler, perhaps pea-green, on their under sides. I compared them carefully with the leaves of the neighboring *Babylonica*, and, excepting perhaps that the leaves of the freak were a little the smaller, a fact of no significance, there was no difference whatever. Looking at this great branch, the spectator comes to regard it as a natural graft. This is an utter mistake. It is purely an outcropping of heredity, and is thus an interesting evidence of the identity of species in the curly and the weeping willow. Supposing *S. Babylonica* to be the ancestor, we have here the long-dormant inherited force asserting itself, and proclaiming the ancient and wellnigh lost parentage of *S. crispa.* It is observable, too, that the foliage of the branch, thus representing the true weeper, is much more dense than that on the rest of the tree representing the curly-willow. This is the fact respecting these trees everywhere. The curly-willow has this to its disadvantage, its paucity of foliage, so that, in pointing back to its ancestry, it declares the leaf-wealth of the ancient line. As the tree is a very old one, it is significant that this declaration of heredity should appear so late in life."

**A Wise Public Benefactor.**—In 1868 Sir Joseph Whitworth presented to the British nation an annuity of £3,000 per year, which was vested in the Department of Science and Art, for the purpose of founding scholarships to promote the instruction of young men in the theory and practice of mechanics and the cognate sciences. He has now made over to the public his large landed estates for similar purposes, reserving to himself a life interest. The Department of Science and Art is to hold the estates, subject to the control of Parliament. In commenting upon this munificent action of Sir Joseph Whitworth, the London *Times* commends his wisdom in trusting Parliament to adapt his endowment to the varying circumstances of successive times. "We have had," says the *Times*, "abundant instances of late years of the manner in which what the Lord-Chancellor describes as a 'perpetual trust' has hampered, instead of fostering, the development of the future. It is not merely that so much money has been wasted, but obsolete rules and exploded systems have been a lasting obstacle to the growth of thought and to the intelligent adaptation of new generations to new necessities. The law of mortmain has not been sufficient to avert this danger, and great institutions like our universities and public schools have from time to time come to a dead-lock. Being established with no other dominant object in view than that of perpetuating the systems of the past, a troublesome outcry has always been raised when it has become necessary to adapt them to the present."

**Diffusion of Cholera.**—Pettenkofer's theory of the spread of cholera—namely, that it depends on geological and hydrological conditions — receives confirmation from the researches of Dr. Decaisne, one of the foremost hygienists of France. In a communication to the Académie des Sciences, Dr. Decaisne calls attention to the fact that the cities of Lyons and Versailles have always been in a great measure proof against this disease, though the country round about has again and again been ravaged by it. Paris, on the contrary, has often suffered severely from cholera. In 1832 Lyons entirely escaped the visitation of the epidemic, which ravaged all the rest of the country. Again, in 1835, Lyons was not attacked by the cholera in its advance up the Rhone. In 1849 it made its appearance in one of the barracks, and a few cases occurred in the neighborhood; but three weeks later it had disappeared. In the autumn of 1853 the cholera prevailed in the department of Drôme; there was an outbreak at Lyons, the number of cases being 400, with 196 deaths. In 1865 there were only a few sporadic cases.

According to Pettenkofer's theory, the immunity of Lyons is explained partly by the constitution of the soil, but this explanation applies only to those quarters of the town which overlie the granite rock, either directly, or with a bed of clay interposed. All those portions of the city which rest on the alluvium owe their immunity to peculiar conditions of the underground water. The two instances mentioned above of outbreaks of the cholera in Lyons coincide with periods of exceptional drought, when organic matter, which is usually submerged, underwent decomposition by the action of the air. But those portions of the city which owe their salubrity to the physical constitution of the soil have always enjoyed immunity. As for the city of Versailles, the conditions there are analogous to those found at Lyons. But Paris rests on Eocene Tertiary formations which are permeable and dry—conditions which are favorable to the dissemination of cholera.

**Coal-Deposits in New York State.**—In a recent popular lecture on the subject of coal, given under the auspices of the Buffalo Society of Natural Sciences, Prof. A. R. Grote speaks as follows of the prospects of finding coal within the limits of the State of New York: "Though coal exists in small quantities in the earth below the carboniferous formation, it will not pay to mine it. The Marcellus shale, for instance, is so charged with bitumen that it can be burnt. A great deal of money has been wasted in this State in searching for coal in formations where it could not be found. More money, a thousand times over, has been frittered away than would pay for a new scientific survey of the State, which is so much needed. Instead of consulting scientific men, geologists, people have dug vainly, and wasted time, labor, and money. Within the borders of our State we have no carboniferous formations, except a bare outcropping, in the southwestern part, of conglomerate belonging to the series. No coal exists in this State in any quantity."

**Observations on the Migrations of Birds.**—With a view to ascertain the conditions governing the migrations of birds and certain other periodical phenomena, the natural-history editor of *Forest and Stream* invites the attention of observers throughout the country to the subject, and suggests that each one keep a record of his observations. The points to be specially observed are the following: 1. Whether each species of birds is resident throughout the year, is a summer or winter visitant, or only passes over a locality in spring or fall. 2. With reference to each species in a given locality, whether it is "abundant," "somewhat common," or "rare." 3. What species breed, and whether more than once in a season. 4. Dates of arrival, greatest abundance, nest-building, laying eggs, hatching of young, and beginning of departure of each species, and when it is last seen in the fall. 5. What effects, if any, upon the relative abundance of particular birds, in retarding their arrival or hastening their departure, sudden changes of the weather, storms, and late and early seasons appear to have. 6. Similar notes upon the appearance and movements of the quadrupeds, reptiles, and fishes of the region, and upon the time of flowering of trees and plants. 7. Other occurrences considered noteworthy. It is desirable that records of this kind should be kept. As the writer in *Forest and Stream* observes, it is through such observations as these, continued year after year, that the natural history of England has become so well known, and so many persons there have become interested in it. We may add that children might easily be induced to take an interest in this kind of natural-history observations, and so by degrees acquire the faculty of accurately noting what is going on around them.

**Arctic Research.**—A commission of thirteen eminent naturalists, appointed by the German Government to discuss the question of Arctic discovery, have made a report, in which they adopt the advice of Lieutenant Payer, of the Austrian Expedition. They do not object to Arctic research, but dissuade from voyages of discovery; they believe that the advantages to be derived from the former can be secured by a safer and surer method. They recommend the establishment of permanent stations in those Arctic regions which can be safely approached and abandoned at any time. As a beginning, they recommend several stations to be formed on the eastern shore of Greenland, the western shore of Spitzbergen, and Jan Mayen Island. Houses should be built, furnished with every regard to the inclemency of the climate. In each house the commission would have stationed a detachment of scholars, sailors, and other enterprising men, to remain for a term of years, a ship being sent out for their relief from time to time.

The men at these stations could do good work for meteorology, by observing the periodic recurrence of Arctic phenomena, as well as any deviation from the ordinary rule, and would thus be enabled to discover the reasons for the alternation of storm and calm at the equator. The connection between terrestrial magnetism and atmospheric electricity, cable-currents, and the aurora borealis, can only be investigated in such high latitudes; while the laws of terrestrial magnetism itself will never be thoroughly appreciated unless the variations of magnetism in the far north are studied. Then as to astronomy, the theory of refraction, the atmospheric lines of the spectrum, and the relation between comets and shooting-stars, to be better known, require continued observation near the pole. Geodesy, too, by measurement of degrees and observation of the pendulum, will arrive at more definite conclusions respecting the form of the globe.

Geography, independently of the topographical details to be ascertained on the spot, will derive the most valuable geognostic information from further systematic study. Geology, paleontology, mineralogy, botany, and zoölogy, may expect to make great strides from persistent exploration of the northern and southern poles, while physiology and biology will be enormously advanced by the discovery of the conditions of life in those cold regions. There was a time when man in Central Europe led the life to which Lapps and Eskimos are condemned nowadays. To become familiar with the manners and customs, the religion and morals, the physical and psychical peculiarities of Arctic races, is to dive into the distant past, and may probably explain much that is still unintelligible in our primeval history.

**Force and Work.**—Work without implies work within. No exercise of force can be made except by the generation and use of force of which no part enters into the external result. The use of muscles involves use of nerves. The external force, if exerted by a muscle, is only part of that which it produces. Now, the proportion between these two in their several degrees is a subject of great practical importance, and some interesting facts have recently been published by Helmholtz. From these it is clear that the greater the external force exerted the greater is the proportion of the needful internal force—that is, great exertion is more wasteful than moderate exertion. Then force has to be evolved in proportion to the external work done, and therefore the greater is the wear and tear of the animal machine. The same increased proportion of non-productive work is seen when the external energy is below a moderate amount. It is found, for instance, that in walking, a speed of three miles an hour gives the most economical use of the forces. No doubt in these facts we have an index to much of the ill effects of the present high-pressure rate of work and life. The waste of force is out of proportion to the work done. More is effected in a given time, but the body feels it more, and its working period is proportionately shorter. These facts cannot be too often repeated or too constantly remembered by those who have the regulation of labor.—*Lancet.*

**Contributions to Meteorology.**—The *American Journal of Science*, for January, contains the fourth paper by Prof. Loomis, giving results of recent researches in the science of meteorology, founded on data derived chiefly from the weather-maps of the United States Signal Service.

In a former article attention was called to the fact that low temperatures at the surface of the earth are produced by descent of *cold air from the upper regions of the atmosphere.* It was shown that, in areas of high barometer, the movement of the air is outward from the centre, instead of inward, as in case of low barometer or storm. This implies a supply from downward motion.

The current notion, that extreme cold is brought by wind from colder areas, is met by the fact that, at Yakootsk, in Siberia, which is about the coldest place in the Northern Hemisphere, the temperature is lowest when the air is quite still, and equally when the wind is from north, south, east, or west. These results are obtained from four years' observations at that place, and are similar to those obtained at New Haven, except as to direction of wind. It would be difficult to explain where the extreme cold of Yakootsk came from, except from the upper atmosphere, seeing that it is colder than the country round about.

A diurnal variation in the progress of storms was noticed by Prof. Loomis in a former paper. This fact suggested to him the further one that there is a diurnal inequality in the rainfall. This is now shown by observations made at Philadelphia, not by the Signal Service maps, which do not record hourly observations. It appears that the maximum rainfall occurs at about six o'clock in the afternoon; and the minimum at three o'clock in the morning.

By observations which cover a period of ten years, made at Prague, in Bohemia, it appears that the greatest rainfall during the day occurs in the afternoon, the maximum being from three until six o'clock.

The tracks of storms in America and Europe, already noticed by Prof. Loomis, are further considered in this paper. He determined the precise latitude at which the storm-centres cross certain lines of longitude, and in this way establishes a line which is the track of the storm-centre; a similar method was applied to storms in Europe. It appears that the average track is not regular, but varies. In an article published in July, 1874, it was stated that the average direction of the storms of the United States was, for the year, 8° north of east, and that is correct as a general statement. Connected with the present article is a chart, by which it is seen that the average track of American storm-centres is over Chicago and Detroit, and is deflected to the south east of Newfoundland. From this point it seems to be continuous over the ocean, being deflected northward near the Irish coast, passes over Dublin, and thence across Denmark. These results, however, are obtained from the Paris maps, and the continuity of the line may, in some measure, depend on the extent of the field of observations by which it was determined.

The number of storms traced across the Atlantic Ocean is not large; they undergo changes on the ocean, and frequently are merged in other storms.

The velocity with which storms advance is further considered in this paper. It was previously stated that the rate might vary from a stationary condition for many hours, or several days, to the extreme velocity of 1,200 miles in a day, or even 57.5 miles an hour.

By an examination of European maps it appears that storms over Europe travel at an average rate of 26.7 miles per hour, and it was found from examination of American maps that they move at about the same rate in this country. But over the Atlantic Ocean the movement is only 19.6 miles, showing that the velocity is less over the ocean than over the land.

This proves that the progress of a storm is not merely a drifting of the atmosphere; for, observes the professor, it seems probable that the average progress of the atmosphere in an easterly direction is as rapid over the Atlantic Ocean as it is over North America.

**How Rats and Mice use their Tails.**—To test the correctness of the popular belief that rats and mice use their tails for feeding purposes, when the food to be eaten is contained in vessels too narrow to admit the entire body of the animal, a writer in *Nature* made the following experiments: Into a couple of preserve-bottles with narrow necks he put as much semi-liquid fruit-jelly as filled them within three inches of the top. The bottles were then covered with bladder, and set in a place frequented by rats. Next morning the covering of each bottle had a small hole gnawed in it, and the level of the jelly was lowered to an extent about equal to the length of a rat's tail if inserted in the hole. The next experiment was still more decisive. The bottles were refilled to the extent of half an inch above the level left by the rats, a disk of moist paper laid upon the surface, and the bottles covered as before. The bottles were now laid aside in a place unfrequented by rats, until a good crop of mould had grown upon one of the moistened disks of paper. This bottle was then transferred to the place infested by the rats. Next morning the bladder had again been eaten through at one edge, and upon the mould were numerous and distinct tracings of the rats' tails, evidently caused by the animals sweeping their tails about in the endeavor to find a hole in the paper.

**Experiments in Beet-Culture.**—In the course of their experiments on beet-culture, Dehérain and Fremy planted some beets in absolutely sterile soils, to which were added from time to time such substances as were thought to be essential for the development of the plant. It was found that the beets continued in the rudimentary state when they received in such soils only distilled water; they increased slightly in weight when common water took the place of distilled; their development was greater still when the water contained soluble phosphates, or salts of potash; but yet the roots never attained the weight of 100 grammes. When for these mineral substances were substituted ammoniacal salts or nitrates, the yield was much better. Normal beets, however, cannot be grown unless to these nitrogenous fertilizers are added phosphates and potash salts. It is worthy of note that, when the beet finds in the soil nitrogen, phosphorus, potash, and lime, it develops as well as in a soil containing humus. To establish this point Messrs. Dehérain and Fremy compared the produce of two such soils, and found that the beets grown in sterile soil were heavier than those grown in rich soil.

On examining the beets grown in plots in the experimental garden of the museum, the authors found them to be very poor in sugar, though the soil was very rich. From this it follows that deficiency of sugar in the beet is not due to exhaustion of the soil. In seeking the true cause, it occurred to Messrs. Dehérain and Fremy to ascertain how much nitrogen the beets contained, and found it to be very large. Hence it appeared that a soil rich in nitrogeneous matters is unfavorable to the production of sugar. This conclusion was confirmed by sundry analyses of beets grown at the museum, at the school of Grignon, and in the departments of Aisne, Nord, and Eure. All the results positively confirm the observations made by the authors, and their conclusion is that, if beets are now less rich in sugar than formerly in those departments which have long produced them, that fact is not owing to the exhaustion of the soil and its deprivation of principles necessary for the development of the beet; on the contrary, the reason of the phenomenon is, that the soil is too rich in nitrogenous matters, in consequence of the liberal use of manures.

**Balloons and Carrier-Pigeons.**—It is related by a writer in the London *Quarterly Review* for July, that when Pilâtre de Rozier had descended safely to the earth, after making the first aërial voyage ever undertaken by man, Benjamin Franklin, who at the time (November 21, 1783) was in Paris, on being asked his opinion of the brothers Montgolfier's invention, replied, "A child has just been born." But hitherto its growth has been extremely slow. Nevertheless, the history of aërial navigation is full of interest, and it is well told by the writer in the *Quarterly*. Some of the early objections against ballooning were singular enough. Thus, it was urged that female honor and virtue would be in continual peril, if access could be had by balloons at all hours to the windows of houses! Politicians objected that, if the path of air were to be made free, all limits of property and frontiers of nations would be destroyed. As a matter of course, aërial navigation was denounced as "impious." And, when the brave Pilâtre des Rozier's balloon took fire in the air over the city of Boulogne, and he lost his life, many a one recognized herein the "hand of Providence," just as the peasant-girl, who saw a deal chair fall "from heaven," at once decided that it was a part of the household furniture of the angels. In point of fact, Gay-Lussac, who happened at the time to be overhead, had thrown the chair out of his car, to lighten his aërostat.

During the siege of Paris by the Germans, a balloon post was established in the city. At first there appeared to be innumerable obstacles in the way of this enterprise, the chief one being the difficulty of obtaining a sufficient number of aëronauts. In this strait, the aid of seafaring men resident in the city was invoked, as their training had made them familiar with operations and dangers akin to those of ballooning. From September to January, sixty-four balloons were sent off, and of these fifty-seven fulfilled their mission. The number of letters thus dispatched was 3,000,000. The writer in the *Quarterly Review* mentions one incident connected with these balloon voyages which seems hardly credible: On one occasion, the crew of a balloon found themselves over the sea, out of sight of land. Seeing vessels they made signals for help, but were not answered, *and one vessel fired on them.* The men afterward descended to the earth in Norway.

To carry dispatches and letters *into* Paris, carrier-pigeons were employed. The dispatches, public and private, were first printed on pages of folio size, 16 of which were placed side by side, forming a large sheet about 54 inches long by 32 wide. This was reduced by photography to $\frac{1}{800}$ of its original area, the impression being taken on a small pellicle of collodion, two inches long and $1\frac{1}{4}$ wide, and weighing about $\frac{3}{4}$ of a grain; each contained about 2,000 words, or 32,000 words in all, equal to about 58 pages of this magazine. Every pigeon carried twenty of these leaves, which were carefully rolled up and put in a quill. At the Government office in Paris, the quill was cut open, and the collodion leaves carefully extracted. They were then magnified by an optical apparatus, copied, and sent to their destination.

**Mental Overwork.**—One of the great evils of modern life, in the estimation of many eminent physicians, is mental overwork. It is asserted that affections of the heart are now more numerous than ever before, that asylums for the insane are being overcrowded, and that nervous disorders of every kind are on the increase. What are the signs which indicate impairment by overwork? This question is thus answered in the *Sanitary Record*: "Overwork," says the *Record*, "exists when the sense of energy once possessed is distinctly impaired; when it is found an effort to get through what was once a cheerful task; when what was once found comparatively easy is beginning to be felt a trial; and above all when errors or omissions, the direct outcomes of a flagging and wearied brain, commence to manifest themselves. To spur on an exhausted brain, and by application and longer hours of toil to compel the overtaxed nervous system to complete its round of duty, is one of the most disastrous and erroneous measures that can be adopted. Whenever work, itself unaltered, looks larger than of yore, and is felt to be more trying, then the system is commencing to feel the effects of overwork, which, however, may actually have existed for some time unnoticed. This is especially true of the monotonous labor which is undergone by the clerks and subordinate officials of our commercial houses; if they are free from the anxieties which affect the principals, they are the more subject to the wearing action of monotonous labor. The institution of bank holidays is a step in the right direction, and ere long the absolute necessity for a more decided increase in the number of national holidays will be palpable enough. What man can safely do is not to be measured by his desires, but by his powers; and we are all rapidly becoming convinced that incessant toil is not only undesirable, but that it is uneconomical. The one day's rest in seven is not now sufficient for our needs."

**French Public Libraries.**—In a statistical work, comparing France with other European countries, the following interesting notes on public libraries occur: Paris has six great libraries, the property of the state, and open to the public, viz.: Bibliothèque Nationale (900,000 volumes), Bibliothèque Mazarine, Bibliothèque de l'Arsenal, Bibliothèque Sainte-Geneviève, Bibliothèque de la Sorbonne. Outside of Paris France has 338 libraries which twenty years ago contained 3,689,000 printed volumes. Forty-one of these libraries are open in the evening. Great Britain has (in its public libraries) 1,771,493 volumes, or six volumes per 100 of the population; Italy 11.7 volumes per 100. In France there are 4,389,000 volumes, or 11.7 per 100 persons; in Austria 2,488,000 volumes, or 6.9 per 100; Prussia 2,040,450, or 11 per 100; Russia 852,000, or 1.3 per 100; Belgium 509,100, or 10.4 per 100. Since 1865 school libraries have been founded nearly throughout all France. We have already in the MONTHLY given the statistics of these school libraries, but we copy the figures again from the work to which we are indebted for the foregoing statistics. In 1865 there were 4,833 of these school libraries in France, containing 180,854 volumes; in 1866, 7,789 libraries, 258,724 volumes; 1867, 11,417 libraries, 721,853 volumes; 1868, 12,395 libraries, 988,728 volumes; 1869, 14,395 libraries, 1,239,165 volumes; 1870-'71, 13,638 libraries, 1,158,742 volumes.

**Appearances attending the Passage of a Meteor.**—In stating the results of his observations on the passage of a meteorite seen at Louisville, December 12, 1872, Prof. J. Lawrence Smith says that it first appeared as a large red light in the zenith, which seemed to stand motionless for several seconds, evidently because it was then descending in a line with the eye of the observer. Then starting off with an uncertain, faltering motion, it moved slowly toward the horizon, gradually fading from a lurid red to a dark purplish hue, and leaving a dense stream of blue smoke behind, which remained for several minutes. "These clouds," continues Prof. Smith, "are not unfrequently connected with the passage of these bodies through our atmosphere, and are usually more striking in the daytime, or, as in this instance, just after sunset, when the sun was well situated to light up the cloud and exhibit it to the observer who could no longer see the sun. What are these clouds? Are they composed of impalpable matter abraded from the surface of these bodies in their passage, or are they true vapor-clouds? From a close study of observations in connection with several well-known falls of meteorites, I am more inclined to adopt the former view; but there is reason for believing that the violent disturbance of a portion of the atmosphere (much of it, in the rapid passage of the body, undergoing great condensation), added to an undoubted electric disturbance of the atmosphere, would tend to the deposition of moisture, upon the atmosphere being gradually restored to its former equilibrium."

**Insect-killing Plants.**—During a botanical tour in Atlantic County, New Jersey, Mr. Meehan, of Philadelphia, found growing, near Hammonton, a great number of plants representing three species of *Drosera*, namely, *D. filiformis*, *D. longifolia*, and *D. rotundifolia*. All of these species had insects attached to them, but many of the plants had none. The remains of the insects which have been caught seem to continue attached to the plant for a long time, and thus the observer at once perceives which plant has had the benefit of animal food. No difference in health or vigor could be detected between those which had had insects and those which had not. This, however, does not by any means decide the question whether the plants do or do not digest the insects. As Mr. Meehan remarks, the case of these plants is comparable to that of vegetarians and flesh-eaters among mankind; it is a question which class is the healthier. A plant, he said, might feed on insects, and yet be no healthier than those which lived as other plants did. But the author does not see how this faculty of catching and digesting insects could be developed by natural selection. "It is believed," said he, "that the power to catch insects is a developed one—a power not possessed by their predecessors—and developed according to the law of natural selection. Unless insect-catching can be shown to be an especial advantage, there is nothing to select." Among the many *Droseras* observed by Mr. Meehan on this occasion, only one presented the phenomenon of the leaf bending over on itself, and so enfolding the prey.

**The Soda-Lakes of Wyoming.**—An account of the soda-lakes of Wyoming Territory is given in the report of Mr. Pontez, geologist of the Union Pacific Railroad. He describes two such lakes, the larger one covering about 200 acres. The average depth of water in this lake is three feet, and its specific gravity 1.097. The soda is nearly all carbonate. The second lake is situated near the first, and covers about 3½ acres. During the greater part of the year it is a concrete mass of carbonate-of-soda crystals. Mr. Pontez excavated to the depth of six feet without reaching the bottom of the deposit, which is constantly increasing from the influx from the larger lake. These lakes are situated about 65 miles from Rawlins Station, on the Union Pacific Railroad. The quality of the carbonate is declared to be fully equal to the imported article. Estimating the quantity by the specific gravity of the water, its depth and area, the large lake would yield on evaporation 78,000 tons, which would realize, at $45 per ton, $4,510,000. Besides the cost of freight, the expense of preparing the article for market would be $4 per ton for evaporating. The small lake already crystallized, and estimated only at a depth of six feet and an area of 155,000 feet, contains 30,660 tons, which at $45 per ton would realize $1,379,700.

**Refraction of Sound.**—Refraction of sound by the atmosphere was the subject of a paper read by Prof. Osborne Reynolds, at the last meeting of the British Association, in which were given the results of experiments made by the author. He had confirmed his hypothesis that when sound proceeds in a direction contrary to that of the wind it is not destroyed or stopped by the wind, but that it is lifted; and that at sufficiently high elevations it could be heard at as great distances as in other directions, or as when there is no wind. An upward diminution of temperature had been proved by Glaisher's balloon-ascents, and he showed, by experiments with the sounds of firing of rockets and guns, that the upward variation of temperature had a great effect on the distance at which sounds could be heard. By other observations, he found that when the sky was cloudy and there was no dew, the sound could invariably be heard much farther with than against the wind, but that, when the sky was clear and there was a heavy dew, the sound could be heard as far against a light wind as with it.

**The Opium-Habit.**—The British vice-consul at Kinkiang, China, in a report to his government, states certain facts coming under his own observation, which seem to show that the opium-habit may exist without detriment to health. During a tour on the Upper Yang-tse-kiang, he was thrown into the closest relations with junk-sailors and others, almost every adult of whom smoked opium. Their work was of the hardest, rising at 4 A. M., and working, with hardly any intermission, till dark, having constantly to strip and plunge into the stream in all seasons. The quantity of food eaten by them was prodigious, and from this and their work it may be inferred that their constitution was robust. The two most addicted to the habit were the pilot and the cook. On the incessant watchfulness and steady nerve of the former the safety of the junk and all on board frequently depended; the other worked hard from 3 A. M. to 10 P. M., and often longer. This cook had a conserve of opium and sugar, which he chewed during the day, as he was able to smoke only at night.

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## NOTES.

By a mistake of the printer, the heading to Dr. Jerome Kidder's advertisement in the last number of the Monthly was made to read, "Superior Electro-*Chemical* Apparatus." It should have read, "Superior Electro-Medical Apparatus," as it now stands.

Last summer the French Assembly voted to M. Pasteur a life-pension of 12,000 francs, in consideration of his public services as a scientific investigator. Another pension of 6,000 francs was lately allowed him by a decree of the Marshal-President.

In conjunction with the U. S. Fisheries Commission the Smithsonian Institution will exhibit at Philadelphia the resources of the United States derivable from the waters, including the objects themselves, the products derived from them, the apparatus by which the objects are captured or utilized, and finally the means by which they are multiplied and maintained in a healthy state. The last section is intended to illustrate the present state of pisciculture in this country.

At the annual meeting of the American Microscopical Society of the City of New York, held on January 25th, Dr. John B. Rich was elected President, and Mr. C. F. Cox, 13 William Street, Secretary for the present year.

The Loan Collection of Scientific Instruments, soon to be placed on exhibition in London, will undoubtedly be the most successful enterprise of the kind ever attempted. Nearly every civilized country will be represented. Not only modern instruments, but also those possessing a more strictly historical interest—such as apparatus once used by Galileo, Tycho Brahe, Lavoisier, Priestley, Boyle, Herschel, etc.—will have a place in this collection.

In some parts of Russia the young shoots of the "cat-tail" (*Typha latifolia*) are used as asparagus; they are said to be delicious. The plant grows abundantly in the United States in swampy localities.

Captain Allen Young will sail again next May, from England, to renew the search after the remains of Sir John Franklin's expedition. He will first visit the entrance of Smith Sound, with a view to receive intelligence from the Alert and Discovery.

The death is announced of George Poulett Scrope, the geologist. He was born in 1797, and received his education at Harrow School and Cambridge University. In 1825 he published his first scientific work, "Considerations of Volcanoes." Two years later he published a treatise on "The Geology and Extinct Volcanoes of Central France," a work of signal merit. In 1833 he entered political life as a member of Parliament, and published a number of pamphlets on a variety of governmental topics. His later scientific writings consist of articles contributed to the *Journal of the Geological Society* and the *Geological Magazine.*

A signal for the use of the Coast Survey has been erected on the summit of Mount Shasta, California, at an elevation of 14,402 feet. It is described in the *Scientific American* as being a hollow cylinder of galvanized iron 12 feet high and 2½ feet in diameter, surrounded by a cone of nickel-plated copper, with concave sides, 3 feet high and 3 feet in diameter at the base. The nickel-plated cone is a brilliant reflector and will reflect the sunlight in such a manner that the reflection can be seen for a distance of 100 miles or over.

One of the grandest engineering projects of the time is the union of the Black and Caspian Seas. The plan is to join by a canal the tributaries of the Manytch and the Kouma, two considerable rivers which drain the northern slope of the Caucasus. If these two seas were united, the naval force of Russia would be practically doubled, for then her Caspian fleet could, in case of necessity, be added to that which holds the Black Sea.

An old lioness in the Dublin Zoölogical Gardens was, during her last illness, much worried by rats, against which she could no longer defend herself. A terrier dog having been placed in the cage to protect the sufferer, the lioness at first received him with a surly growl; but, when she saw him kill the first rat, she began to appreciate her visitor. The lioness coaxed the terrier to her, folded her paws round him, and the dog slept each night on her breast enfolded with her paws, and protecting her rest from disturbance.

It is stated in the *Tribune* that Prof. S. S. Haldeman recently found in an excavation in the vicinity of Chickies, Pa., a large number of Indian relics. The collection includes one hundred pieces of pottery, sixty stone arrow-heads, and one of copper; a tomahawk, eight stone chisels, several mallets and pipe-stems; also a few of those instruments commonly called "sinkers," but the proper use of which is unknown.

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