THE POPULAR SCIENCE MONTHLY

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EDITED BY

J. McKEEN CATTELL

VOLUME LXXXIII

JULY TO DECEMBER, 1913

NEW YORK
THE SCIENCE PRESS
1913

PRESS OF
THE NEW ERA PRINTING COMPANY
LANCASTER, PA.

Vol. LXXXIII, No. 1 JULY, 1913

THE

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THE SCIENCE PRESS

LANCASTER, PA. GARRISON, N. Y.

NEW YORK: SUB-STATION 84

SINGLE NUMBER, 30 CENTS YEARLY SUBSCRIPTION, $3.00

THE
POPULAR SCIENCE
MONTHLY.

JULY, 1913

ANCIENT MAN, HIS ENVIRONMENT AND HIS ART

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THE relation of culture to the environment is always a fruitful theme for discussion. To minimize the difficulties in the way of reconstructing the environment of the earliest races of man would be to deny the all-pervasive influence of environment as a factor in human development. We are so accustomed to think in terms of our own surroundings that any other set strikes us at once as strange and unreal. This is particularly true when we attempt at one fell swoop to divest

Fig. 1. A Great Mousterian Rock Shelter, where a female skeleton of the Neanderthal type was recently found. Photographed by G. G. MacCurdy.

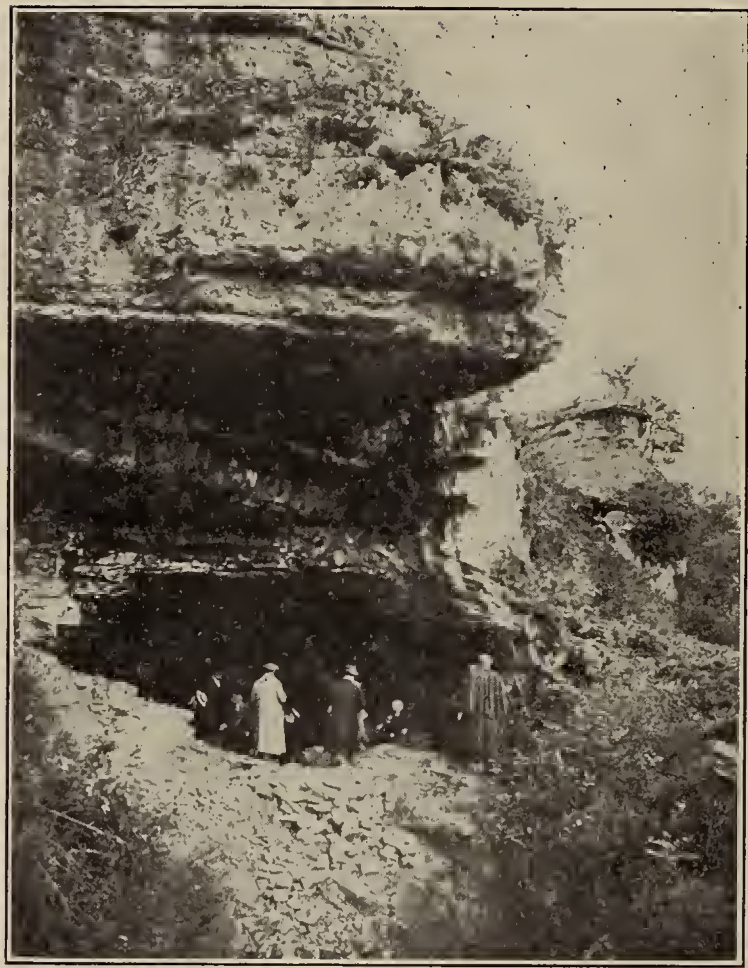


FIG. 2. GREAT CAVE OF PLACARD (CHARENTE), where drinking cups made of the top of the human cranium were found. Photographed by G. G. MacCurdy.

ourselves of the heritage of all the ages and assume the primitive rôle of *Eoanthropus* for example.

Environment presupposes mind, matter, space and time. With these combined in workable proportions it is conceivable how the resultant might be that thing we call human culture. Mind, with its power to register and to profit by its own experiences, is that which has leavened the lump. As long, however, as those accumulated experiences remained individual, there was no real progress. Means had to be devised to translate individual experience into racial experience. The one who discovered this secret, who first deposited that little bank account on which the race has ever since drawn, is entitled to be called the first man.

There were from the beginning as there are to-day individuals with exceptional minds, who contrived to live up to the full measure of the light that was given them, thus contributing little by little to racial experience, which at first could help them very little in return; but which as it grew and as ways were found to make it more generally available became a dominant factor in the racial uplift.

From the start then we must think of man as an inventor. What was his first invention? Aside from air and water, food-getting and defense are the primeval needs. These are met precariously without artificial aids. Something to supplement the teeth, the nails, the fist must be found; and to be found must be at hand and appeal readily to the senses. The most omnipresent and tangible of all raw materials are stone and wood. Both of these are especially abundant along water courses. In fact, man and wood and game, the latter primitive man's chief food supply, are all there for the same purpose—in search of water. The stones are there because the streams carried them or laid them bare. The problem is therefore one of utilization. The most utilizable of all stones is flint because of its hardness and mode of fracture, leaving a sharp, comparatively straight edge. Moreover, flint flakes can be produced by purely natural means. The accidental stepping on one of these would suffice, after repetition at least, to prove their efficiency. Thus the oldest and most primitive implements that have come down to us are utilized flint chips. Once the flint-using habit was formed, it spread; and when the natural supply became scarce it was supplemented by artificially produced chips.

Fig. 3. Mas d'Azil (Ariège), which gave its names to Azilian epoch: transition from paleolithic to neolithic. Photographed by G. G. MacCurdy.

The chief sources of flint are the chalk deposits of Cretaceous age that occur so plentifully in western Europe, as seen, for example, in the white cliffs along the southern coast of England. Approaching one of these cliffs, you will find it studded with parallel beds of flint nodules. Wherever flint occurs stone-age relics are apt to be abundant. The chalk of England, Belgium and northern France is the same age as the flint-bearing calcareous deposits of Spain and southern France; but the latter have not the white chalky appearance and are much harder;

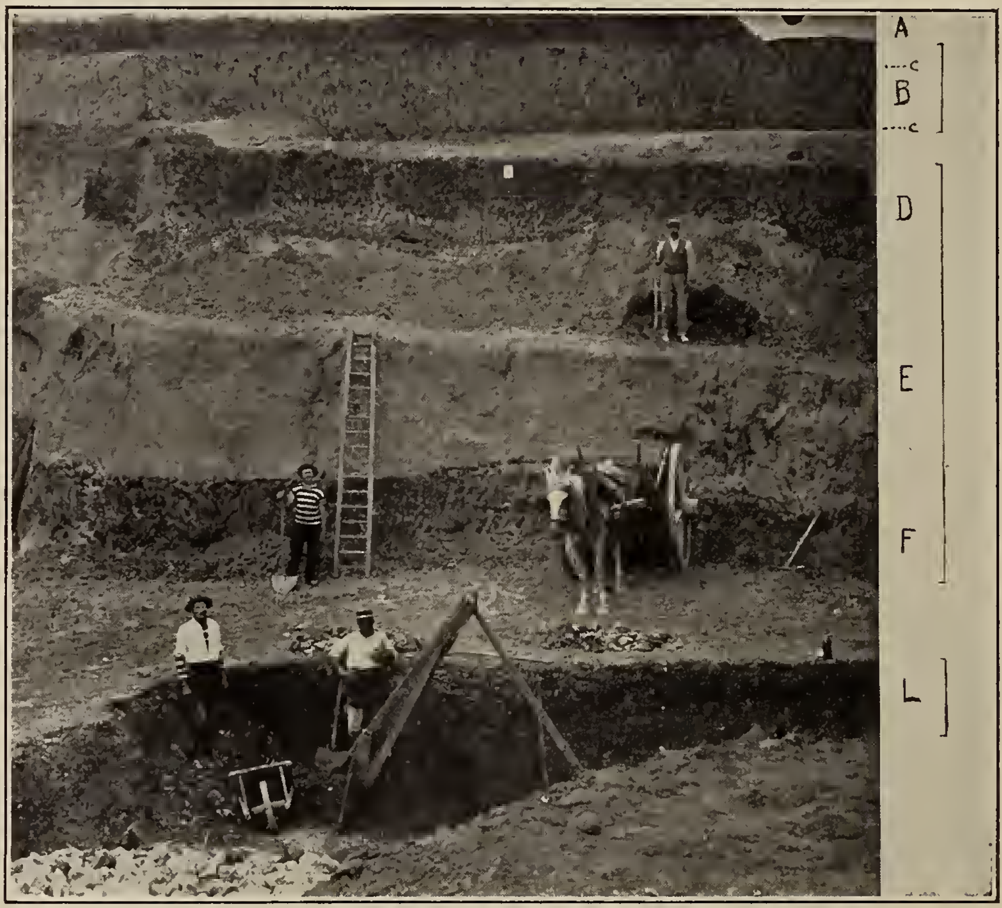


Fig. 4. Tellier Quarry, St. Acheul. Third terrace.

hence are full of caverns and rock shelters about which we shall speak later.

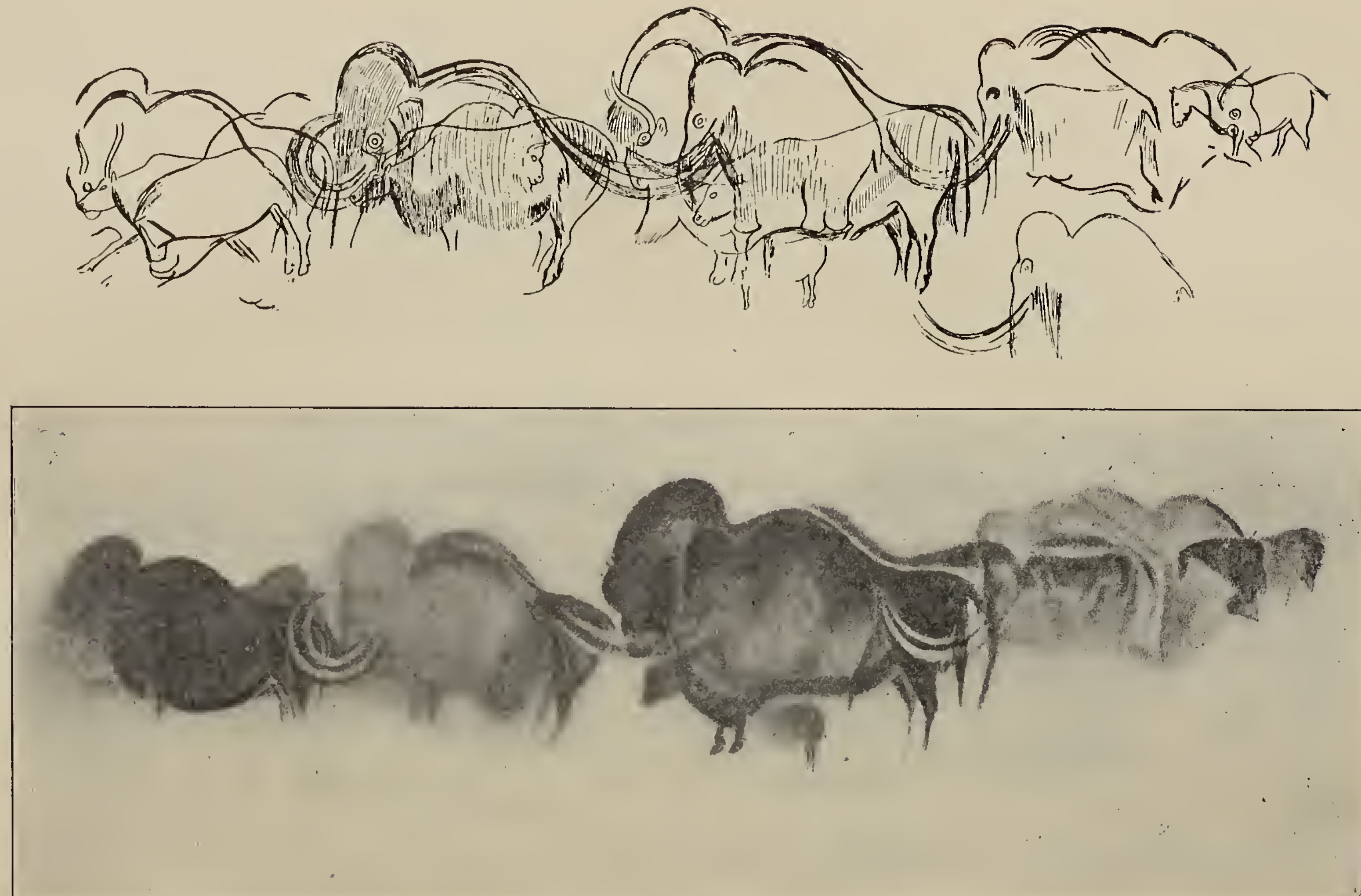
One great difficulty that confronts the student of human origins is the paucity and fragmentary character of the evidence. This evidence is limited to two kinds: skeletal and cultural remains. The first of these is the rarest and at the same time the most incontrovertible. Not one complete skeleton has as yet been found. The less durable parts are missing. The cranial cap, the lower jaw, a few teeth, bones of the extremities, are the somatologist's chief sources of information. Except in rare instances, the face bones and the base of the skull are missing.

Of *Pithecanthropus* we have only the cranial cap, a few teeth, and a femur; of Heidelberg man, only the lower jaw; of the Piltdown skull, the greater part of the brain case, including a portion of the brow ridge, and the right half of the lower jaw. Osseous remains of Neandertal man and the later paleolithic races are more abundant. Of *Homo neandertalensis* alone there are now at least twenty authentic examples.

The mentality of early man is reflected in the size and structure of

Fig. 5. Fourth or Youngest Terrace at Amiens. Photographed by G. G. MacCurdy.

the brain. Casts of the cranial cavity have been studied with great care. The cranial capacity of *Pithecanthropus* is estimated at 850 c.c., placing it in this respect nearer to the minimum in man than to the maximum in anthropoids. The cranial capacity of the Piltdown skull (*Eoanthropus dawsoni*) is given by Dr. A. Smith Woodward as not less than 1,070 c.c. The Piltdown skull apparently belonged to a female, and according to Professor Elliott Smith its brain case, though smaller and more primitive in form, is not unlike those of Gibraltar and La Quina, both paleolithic and supposedly feminine. The most striking feature



Pl. I. Great Band of Frescoes Six Meters Long; the basis of engraving is seen in the upper half of the picture. Cavern of Font-de-Gaume (Dordogne). After Capitan, Breuil and Peyrony. La cavern de Font-de-Gaume aux Eyzies (Dordogne).

is the "pronounced gorilla-like drooping of the temporal region, due to the extreme narrowing of its posterior part, which causes a deep excavation of its under surface." This feeble development of that portion of the brain which is known to control the power of articulate speech is most significant. To Professor Smith the association of a simian jaw with a cranium more distinctly human is not surprising. The evolution of the human brain from the simian type involves a tripling of the superficial area of the cerebral cortex; and "this expansion was not like the mere growth of a muscle with exercise, but the gradual building-up of the most complex mechanism in existence. The growth of the brain preceded the refinement of the features and the somatic characters in general." The Piltdown skull with its primitive brain and simian lower jaw, but with a frontal profile suggesting the modern rather than the Neandertal type, tends to prove that in the lower Quaternary the differentiation among Hominidæ had already progressed much farther than has been generally supposed; and that we shall have to go a long way back in the past to find the parting of the ways between the ancestor of man and that of his nearest of kin among the apes. The capacity of some of the male skulls of the Neandertal type is unusually large, but the brain still lacks the superior organization that characterizes the modern human brain. The Neandertal race seems to have disappeared rather suddenly at the close of the Mousterian epoch. Art-loving Aurignacian man was of a different type both physically and mentally.

Cultural remains, although much more abundant, are confined wholly to durable materials such as stone, bone, horn, and ivory. Pottery and metals are durable, but the fact that they do not occur is very good negative evidence that they were unknown. We are justified in assuming that wood, bark, roots, plant stems, skins, etc., were used, but not one trace of these has been preserved. It is also fairly safe to assume that fire-making was a very early invention of man, for unmistakable traces of it are found as far back as Mousterian times (and have been reported by one author in the Acheulian and Chellean).

The hearth suggests a roof and these the family and possibly the tribe. At Torralba, Province of Soria, Spain, the Marquis of Cerralbo has recently uncovered a large camp site, which has yielded an association of rude eolithic and Chellean industry with the remains of a very old fauna: *Elephas antiquus* (and possibly also the Pliocene elephant), *Rhinoceros etruscus, Equus stenonis,* and a large and small deer. Some sort of tribal organization would naturally develop under such conditions.

Man very early sought shelter under overhanging rocks and in caverns, but these are limited geographically while man's range was practically unlimited. La Quina (Charente) was in Mousterian times a mag-

Pl. II. Bas Relief from the Rock Shelter of Laussel (Dordogne), representing a nude female holding a bison horn; Aurignacian age. After Lalanne. "L'Anthropologie," XXIII., 131, 1912.

nificent rock shelter facing the northwest, but the overhanging rock weathered away long ago, leaving a thick talus slope over the relic-bearing deposits (Fig. 1). Here Dr. Henri Martin found a nearly complete female skull of the Neandertal type and a portion of the skeleton. Placard (Charente), occupied in Mousterian, Solutréan, and Magdalenian times, is a great shallow dry cave, a comfortable and picturesque home for early man (Fig. 2). Equally picturesque is Mas d'Azil (Ariège), a subterranean stream bed with connecting caverns occupied by man in so-called Azilian times, that is to say at the very close of the paleolithic period (Fig. 3). Shelters were evidently produced artificially at an early date, and no doubt varied according to locality just as they do among primitive peoples of to-day. The ancestral hairy coat was not discarded all at once, and before it ceased to be functional, some exceptional mind had set a new fashion in garb. In more favored climes this might well have been nothing more than the proverbial fig leaf. In colder regions recourse would be had to skins of animals.

Much has been written concerning man and the glacial period, or perhaps more correctly the glacial epochs; for there seem to have been about four of these, all (or at least three) of which belong to the Quaternary. The phenomena of fourfold terraces in the valleys of Europe are widespread. To what extent these may be correlated with the four glacial epochs is still an open question.

At Amiens in the valley of the Somme, flint implements have been found in all four terraces. Of the oldest two terraces at a height of 75 and 55 meters, respectively, above the sea, very little remains. A typical pre-Chellean or eolithic industry has been found in the old gravel of the second terrace. The third terrace about 42 meters above the sea is made up of gravel at the bottom and two loess deposits, an old loess and a recent loess (Fig. 4). Chellean industry occurs in the gravel, Acheulian industry in the old loess, and Mousterian and Solutréan industry in the recent loess. That a considerable period elapsed between the deposition of these two loess deposits is proved by the presence of the so-called *limon rouge* at the top of the old loess, representing an old land surface, just as the brick earth at the top of the recent loess represents a decalcified land surface—the present one. The fourth terrace, the one last to be formed, is only 20 to 28 meters above the sea, the 8 meters representing the thickness of the terrace (Fig. 5). Beginning at the bottom, it is composed of coarse gravel with Chellean industry; a whitish layer of sand and gravel containing an ancient Mousterian industry associated with a warm fauna (*Elephas antiquus, Rhinoceros merckii, Hippopotamus*); a sterile layer of fine gravels; and lastly a thick deposit of recent loess with two horizons of later Mousterian industry.

Pl. III. Male Figure in Bas Relief, Aurignacian age; rock shelter of Laussel. (Dordogne). After Lalanne, "L'Anthropologie," XXIII., 147, 1912.

Across the Channel in the Ouse valley, at Piltdown, Fletching (Sussex), there has recently come to light a flint-bearing gravel with a remarkable association of human osseous and cultural remains with those of a Pliocene and Quaternary fauna (Pliocene elephant, *Mastodon, Hippopotamus, Cervus elaphus,* beaver, horse). The gravel bed is 80 feet above and a mile removed from the present bed of the Ouse. The physiographic features of this region have suffered no appreciable change since Roman times, hence the relation of the present Ouse bed to the one that existed when the Piltdown gravels were deposited indicates a great antiquity for the latter. All the relics in it are certainly

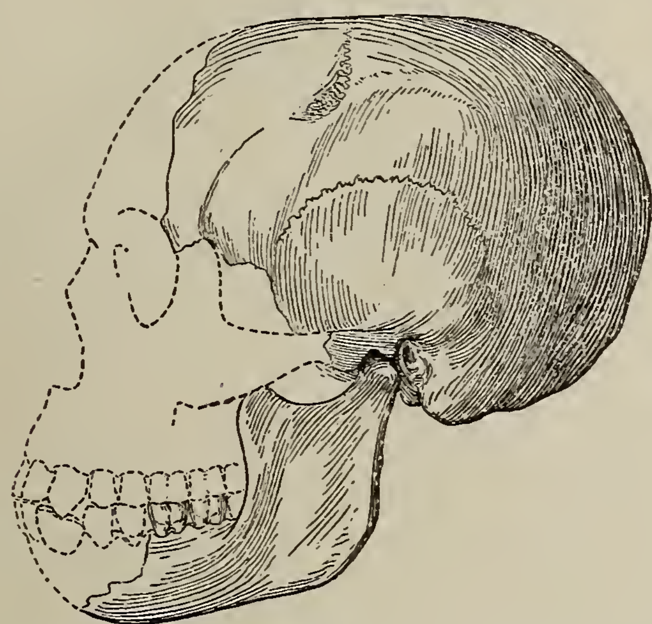
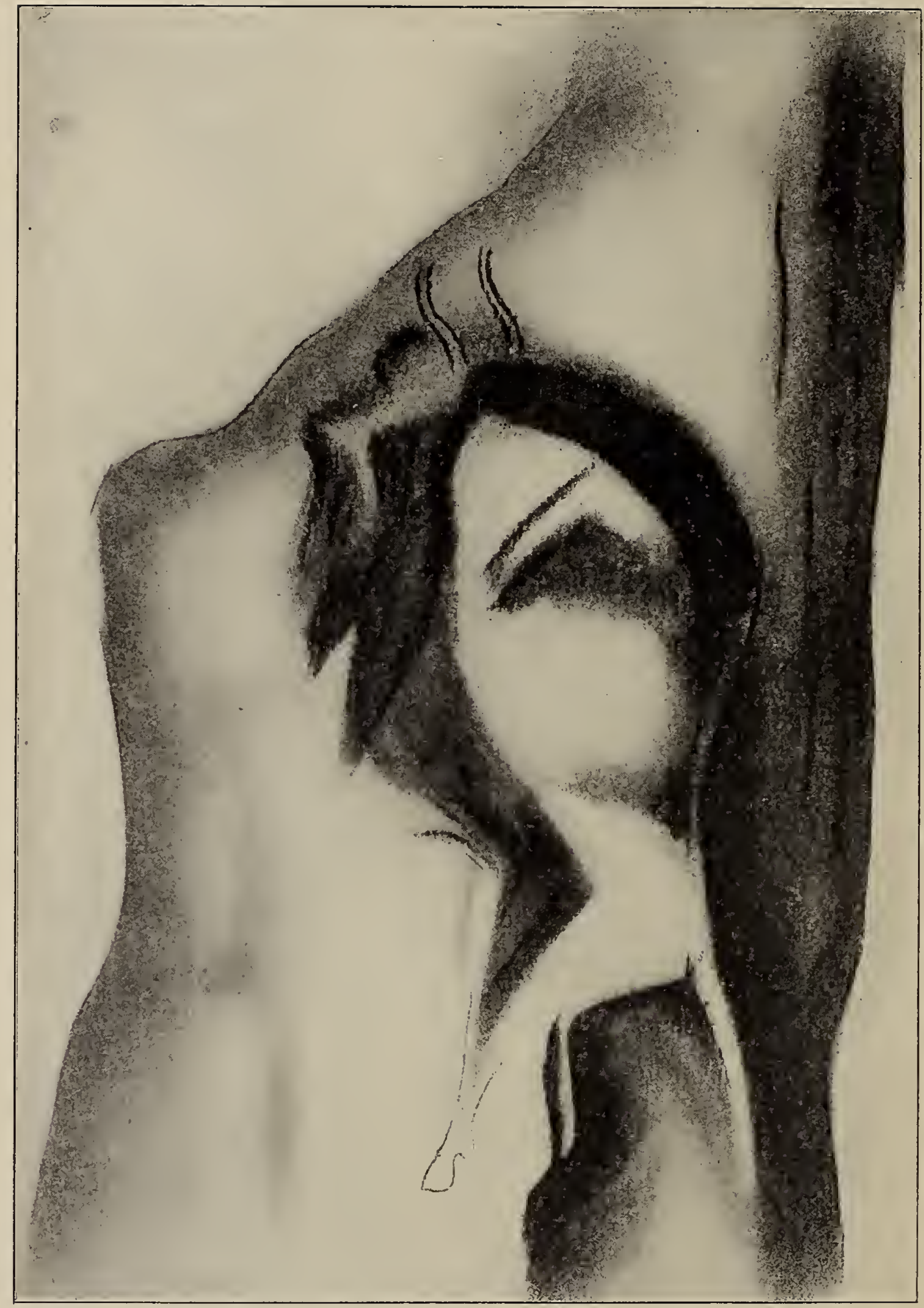


FIG. 6. *Eoanthropus dawsoni.* (½ nat. size.) After Dawson and Woodward. *Q. J. G. S.,* LXIX., 141, 1913.

as old as the deposit. All or some may be older. The somatic characters of the human skull (Fig. 6), especially the lower jaw, postulate great antiquity, as does the nature of the rude flint implements. That the latter were found in association with a very primitive human type would seem to give such implements a standing hitherto denied them by some authorities; unless it can be proved that they were derived from a deposit antedating the one which originally contained the human remains. Their pedigree was needed in order to make industrial genealogy complete, just as the skull itself was needed to fill a gap in man's physical evolution. It remains for the geologists to determine whether in Piltdown the prehistorian's "Rosetta stone" has at last been found. Perhaps they will be able to tell us also whether a channel separated the man of Piltdown from his contemporaries in the near-by valley of the Somme. The present channel dates from the very close of the paleolithic period. That there was a channel in early paleolithic times is



Pl. IV. A Bison on a Column of Stalagmite; the artist completed a figure already blocked out fortuitously by nature. Cavern of Castillo, Puente Viesgo, Spain. After Alcalde del Rio, Breuil and Sierra. Les cavernes de la région Cantibrique (Espagne).

suggested by raised beaches near Calais and on the south coast of England.

All things considered, it looks as if pre-neolithic man had to contend with more than one glacial epoch, which means an environmental disturbance of the first magnitude. Think, for example, of a great continental ice-sheet creeping slowly but inevitably down upon New York City. What an overturning of unearned increments! What a succession of *Titanic* disasters at sea! But unearned increments and floating palaces were happily non-existent in past glacial times. Pre-neolithic man simply abandoned his wind-break or folded his tent of skins and carried it with him. Besides the European continental ice-sheet never reached quite so far south even as London; it never covered the spots where the Piltdown skull and the Heidelberg jaw were found. There was, to be sure, a considerable extension of the Alpine and Pyrenean glaciers, but there was always enough room for safety and the survival of those best adapted to the environment.

The wide distribution in Europe of flint-bearing chalk deposits makes it almost an ideal place for the evolution of a stone-age culture. In many parts of Europe these flint-bearing deposits also afforded man ready-made shelter in the shape of caves and overhanging rocks. They are usually in proximity to water courses, and frequently so bunched as to invite a relatively dense population; these became centers of culture.

Such favored regions as the foothills of the Cantabrian Mountains in Spain, those of the French Pyrenees, the Italian Riviera, and Dordogne go a long way toward explaining the origin and evolution of paleolithic art. The great cave group of the Vézère valley became the Paris of the antique world. Here the arts flourished to a remarkable degree, beginning with the Aurignacian epoch and continuing through to the close of the paleolithic.

It must be remembered that these early artists were limited in their choice of materials. Pebbles, pieces of schist or slate, fallen fragments from the overhanging calcareous rock, bone, reindeer horn, ivory were all utilized; but the most notable works were executed on the walls of caverns and rock shelters. Suitable wall space was at a premium; the result is that one often finds superposed figures two, three and even four deep covering the same wall space. One of the best examples of this is the great band of frescoes, five meters long, which shows interlocking of figures as well as superposition (Pl. I.). Here as in practically all polychrome frescoes there is a basis of engraving which also prepares the field for the color. This foundation of engraving is seen in the upper half of the plate. The band is readily divided into four groups or sections. To the first group belong three figures all headed

FIG. 7. MALE AND FEMALE BISON MODELED IN CLAY, discovered October, 1912; from cavern of Tuc d'Audoubert (Ariège). Votive offering for multiplication of the bison.

in the same direction. The lines of the reindeer cut all others, hence it is the latest of this group. The bison comes next, its head being hidden in part by that of the reindeer. Underneath the bison are the imperfect outlines of a mammoth recognized by the contour of the head and back, and the feet. In section two the mammoth is on top. Beneath come

FIG. 8. FEMALE BISON, front view; cavern of Tuc d'Audoubert (Ariège).

first a reindeer and lastly a bison with the head toward the right. The mammoth is again the latest of the figures in group three. It was incised over the figure of a great bison. Older than the bison is the reindeer; and oldest of all, the small figure of a horse, with the exception of the rump almost obliterated by subsequent drawings. The order for the fourth group beginning with the latest figure is: mammoth, bison, and horse. Below this ensemble is a finely engraved mammoth. That such superposition was in a large measure unconscious, unintentional,

Fig. 9. Engraved Figure of the Horse with Arrows Sticking in his Side. Cavern wall of Tuc d'Audoubert (Ariège). Votive offering for success in the chase.

there can be little question. This superposition sometimes marks a lapse of considerable time and may be of service in the dating of mural art in general.

Quite recently engraved slabs of stone have been found at La Madeleine, some of them from refuse worked over years ago by Lartet and Christy. These and similar specimens from Limeuil (Dordogne) are now the property of the Museum of National Antiquities at St. Germain. Monsieur L. Didon has found engraved slabs of Aurignacian age in the rock shelters at Sergeac (Dordogne), one of which representing a horse and found in 1912, now belongs to the American Museum of Natural History. Still more remarkable are the bas reliefs of upper Aurignacian age from the rock shelter of Laussel (Dordogne) representing the human form. Four of these depict a female type already familiar through discoveries at Brassempouy (Landes), Mentone and

Fig. 10. Head of Reindeer engraved on Cavern Wall at Tuc d'Audoubert (Ariège). A club-shaped figure across the head. Votive offering for success in the chase.

Willendorf (Austria). In all there is an evident exaggeration of certain female characters rather than a serious attempt to copy nature faithfully (Pl. II.). The lines of the male figure, who has apparently just let fly an arrow from his bow, are fairly true to the original (Pl. III.). The bas relief of the female holding the bison horn was painted red; traces of the color still persist not only on the body but also over all the cut portion of the rock. The practise of painting engraved and relief figures was no doubt quite general, examples having been reported lately from La Madeleine and Castillo (Spain).

The paleolithic artist was quick to detect in the configuration of the rock a resemblance to animal forms and to heighten the resemblance by judicious use of engraving or color. To illustrate this point the figure of a bison on a column of stalagmite in the cavern of Castillo near Puente Viesgo, Spain, is chosen (Pl. IV.). It took very little though well-directed effort on the part of the artist to complete a form already blocked out by nature. A few incised lines and the application of color (black) about the head and shoulders sufficed. A bison at Niaux

(Ariège) and a horse at Font-de-Gaume (Dordogne) are also of this class, as is a bovine head in the newly discovered cavern of Tuc d'Audoubert (Ariège). Shortly after his discovery of the cavern Count Bégouen noted two red spots on the wall. The following day it was my good fortune to identify them as a pair of eyes, the animal's head being formed in bold relief by the projecting rock. Such fortuitous objects as these might have been that which originally sensitized the human imagination till it was able to catch and perpetuate a likeness to familiar or cherished forms. With the gradual perfection of the likeness both with and without fortuitous assistance the fine arts were born.

Nothing quite the equal of paleolithic cave art has since appeared among any people in the hunting and fishing stage of culture; for it must be remembered that domestication of animals and the arts of agriculture were neolithic innovations; so was the ceramic art.

It seems almost a pity that this artistically inclined old race was not familiar with the plastic possibilities of clay. What exquisite figures of their favorite game animals they might have left to us, both in the round and in painted forms. Perhaps they did model in clay. If so the objects were not properly tempered and either poorly fired or not fired at all and have since completely crumbled away. Only one

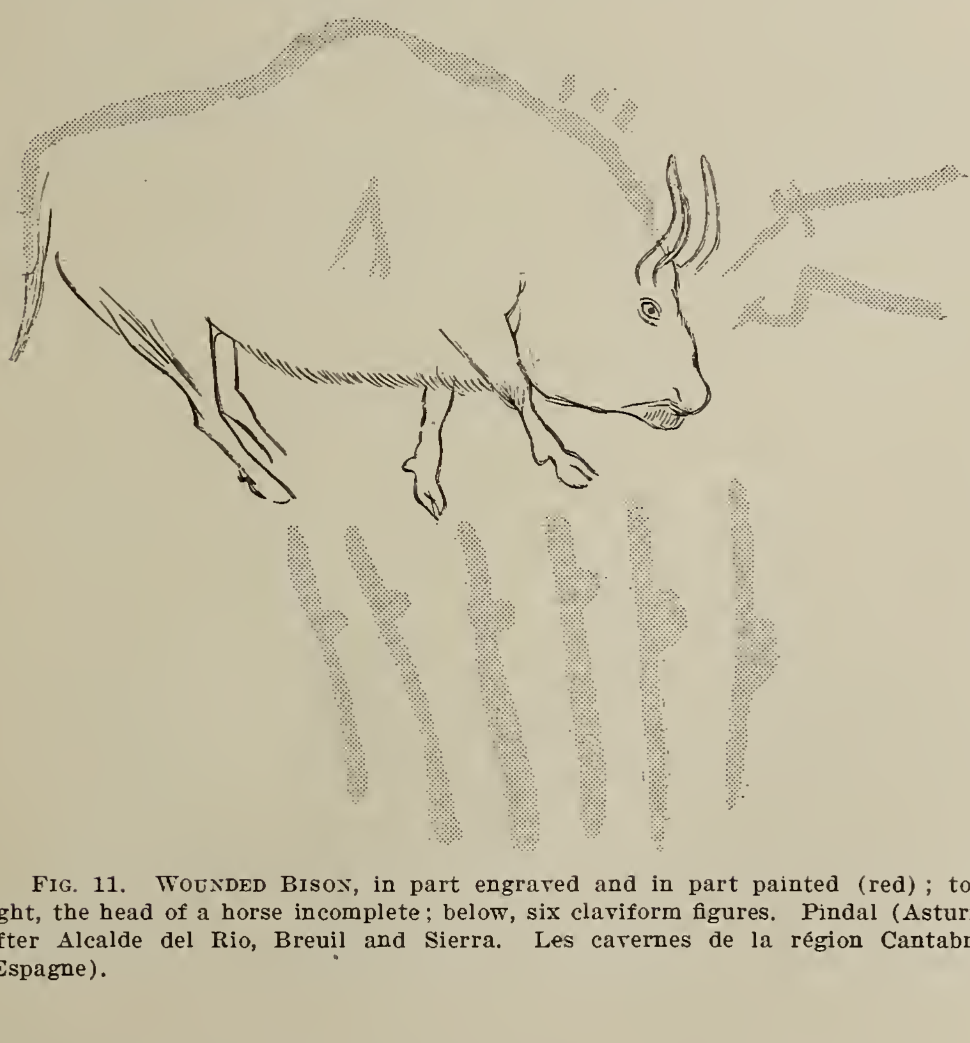


Fig. 11. Wounded Bison, in part engraved and in part painted (red); to the right, the head of a horse incomplete; below, six claviform figures. Pindal (Asturias). After Alcalde del Rio, Breuil and Sierra. Les cavernes de la région Cantabrique (Espagne).

instance of paleolithic modeling in clay has thus far come to light, the discovery being made only last October in the newly found (July 20) cavern of Tuc d'Audoubert. I visited this cavern only five days after its discovery by Count Bégouen and his sons, who in continuing their researches less than three months later came upon two clay figures of the bison, a female 61 centimeters long followed by a male 63 centimeters in length. These figures were never wholly separated from the matrix out of which they were so deftly fashioned. They seem to stand out of the sloping clay talus that flanks a fallen rock (Figs. 7 and 8). They are far removed from any known entrance to the cave and were discovered only after Count Bégouen had broken away huge stalagmite pillars that blocked the narrow corridor leading to that particular gallery, which was evidently a paleolithic shrine since mercifully guarded from unhallowed hands by Nature's own silent white sentinels. On the walls of another gallery of this same cavern are engravings of favorite game animals: a horse, with arrows sticking in his side (Fig. 9); a reindeer with a club-shaped figure across its head (Fig. 10).

In visiting a long series of paleolithic caverns with mural decorations one is struck not only by the number of figures of animals wounded by arrows or associated with claviform representations (Fig. 11), but also by the evident desire of the artist to leave his work in a secluded spot difficult of access. Among the most remarkable art works found in the floor deposits of caves and rock shelters are the spear throwers ornamented with gracefully carved figures in the round or in high relief of the animal to be hunted.

These facts would seem to point to one of the cogent reasons for the phenomenon of cave art. To be sure, many of the figures are so meritorious as to make their execution well worth while for the simple satisfaction they must have given to the artist or the chance beholder. Reading between the lines, one may detect other reasons. The art might well have served another purpose. It was called forth no doubt in a large measure to meet an economic need. As the population increased—and no one familiar with the Vézère valley, for example, can fail to be impressed by the evidences of a relatively dense population—as this increased, the food supply of game and fish decreased in inverse ratio. In order to adjust the supply to the ever-increasing demand, recourse was had to magic, to the aid of the spirit world. The female bison closely followed by the male (Fig. 7), the wounded horse and bison (Figs. 9 and 11), the clubbed reindeer (Fig. 10) are votive offerings for the multiplication of game and for success in the chase. In the end magic was bound to fail as it always will. Then passed away the picturesque paleolithic culture, superseded by the neolithic, capable of meeting the demands of an increased population, based as it was on the domestication of animals and plants as well as on the utilitarian potter's art.

SUSPENDED CHANGES IN NATURE

By JAMES H. WALTON, Jr., Ph.D.

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IN the physical world we are familiar with the fact that changes of all kinds are continually taking place. Prominent among these are changes of state, such as the evaporation of water, the melting of ice and the condensation of steam. These familiar transformations seem to have a common property; as usually observed they take place at very definite temperatures. To be sure, in the laboratory it is possible to heat water to 105–106° without boiling it, and to cool vapors below the temperature at which they ought to condense, but such experiments have usually been regarded as quite exceptional. Within the last few years, however, it has been found that such a reluctance to enter a new state is by no means unusual, that many cases similar to the above actually exist; moreover, that they are not restricted to ultra-refined laboratory experiments, but are a matter of common experience.

If ice is heated it melts, and the temperature at which this process takes place is sharp and definite, as is evidenced by the fact that mixtures of ice and water are used to calibrate and test the accuracy of the most delicate thermometers. No one has ever succeeded in heating ice above the temperature of its melting point, zero degrees, which is a property that ice shares with other solids such as lead, gold, saltpeter and ordinary table salt. But the reverse is not true, for many liquids can be cooled below their freezing points without solidifying. Water, for example, can be cooled below zero without changing to ice. When water freezes in nature, as in ponds and lakes, the transition of water to ice takes place at this temperature and is fairly sharp, but if a clean flask is filled with water the surface of which is protected from dust by means of a layer of oil, it is easily possible to cool the water ten degrees below its freezing point. True, it becomes solid on shaking the flask or upon the introduction of a fragment of ice, but it can be kept for hours in the liquid state, offering a passive resistance to the forces of nature which are operating to change it to ice, the stable form of water at this temperature. Water that has been cooled below its freezing point in this way is said to be in the metastable state; it is also called undercooled water, that is, water that has been cooled under the temperature at which it ought to solidify. The phenomenon of undercooling is not restricted to water, but is shown by aqueous solutions of salts[1] and also to a marked

[1] Solutions may be said to be undercooled when they have been cooled to a temperature at which crystals of the dissolved substance ought to separate from

extent by melted phosphorus, carbolic acid, and many organic substances like thymol and betol that are seldom encountered outside a chemical laboratory.

Although many undercooled liquids are similar to water in that they may be changed to the stable state by agitation, this property is by no means general. An infallible test for undercooling is the addition of a fragment of the stable substance. Thus a bit of ice causes water to

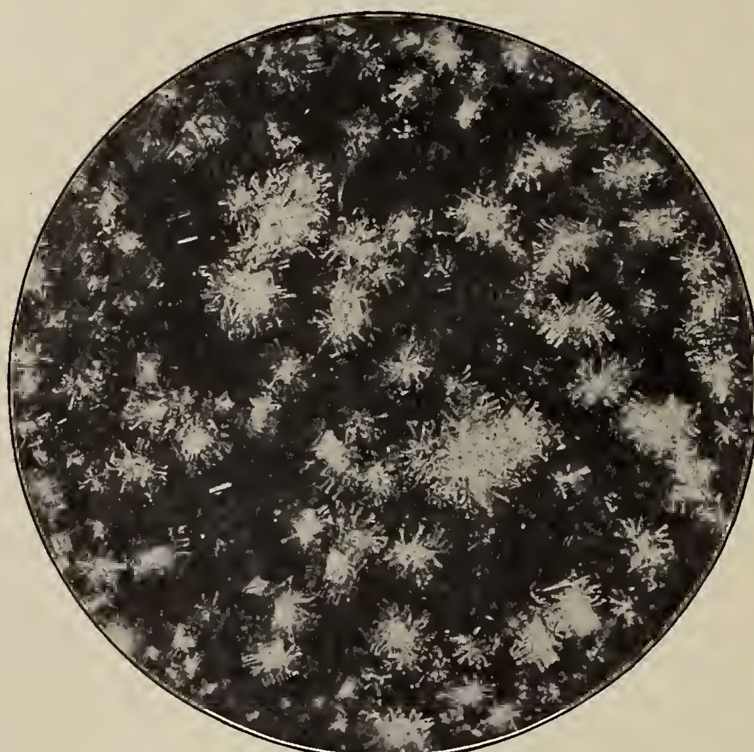

Fig. 1. Crystals Growing in Undercooled Thymol.

solidify, similarly undercooled thymol becomes a crystalline mass upon the addition of a crystal of thymol, while undercooled sodium acetate solutions at once separate needle-like crystals of sodium acetate when a crystal of that substances is added. The addition of a solid fragment for the purpose of causing subsequent crystallization of the liquid is called inoculation or vaccination. The name is particularly fortunate, for the growth and spread of the crystals resembles a bacterial growth.

Undercooled liquids are as sensitive to the presence of a crystal of the solid material as milk is to the presence of certain bacteria, and just as much care must be exercised in their preservation. In working with undercooled sodium acetate under no circumstances may an open flask of this substance be brought into a room in which sodium acetate has been ground in a mortar, for the dust in the air carries enough finely divided sodium acetate to inoculate the solution. Frequently the in-

the solution, without such a separation taking place. Such solutions are usually said to be supersaturated.

vestigator must take his solution into the open air, but here again he must be careful, for his clothes and hair may carry enough powered material to inoculate the solutions.

The amount of material required to inoculate a solution is very, very small, far beyond the sensitiveness of the most delicate balance. Nowhere in science is the importance of the fact that "the very small is as real as the very great" better illustrated than in the case of undercooled liquids; a human hair lightly brushed against a crystal of thymol will collect enough of this material to inoculate a flask of the undercooled liquid thymol. A tube of undercooled sodium acetate may be divided by a piece of parchment paper into two parts (Fig. 3). The inoculation of the solution in *A* causes the separation of crystals which ultimately appear in *B via* the parchment. The pores in the parchment, which are of microscopic size, become filled with the undercooled solution, and as the crystals forming in the pores can not be larger than the pores it is evident that these crystals are of microscopic dimensions only.

Fig. 2. Crystals Growing in a Tube of Undercooled Sodium Acetate Solution.

How far can a liquid be cooled below the temperature at which crystals ought to separate? This depends entirely upon the substance used. With some liquids if the undercooling is greater than a degree or two, crystals at once separate spontaneously from the solution. In the case of water the undercooling has been carried to as low as twenty degrees below zero before crystals of ice separated.

Sodium acetate on being strongly undercooled shows an interesting property, for as the temperature becomes lower and lower the liquid becomes less mobile until at fifty degrees below zero just before spontaneous crystallization the liquid assumes a viscous glassy appearance. Its similarity to glass is more than superficial. When molten glass is cooled it gradually becomes more and more viscous until finally it has all the appearances of a solid. But at no definite temperature does it suddenly harden, as would be the case in cooling mercury or molten lead. The glass differs from the undercooled sodium

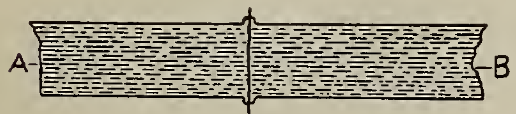

Fig. 3.

acetate in one respect only: its viscosity has reached the solid stage. Glass is an undercooled substance and like other undercooled substances is in the metastable state, consequently it has the power of returning to

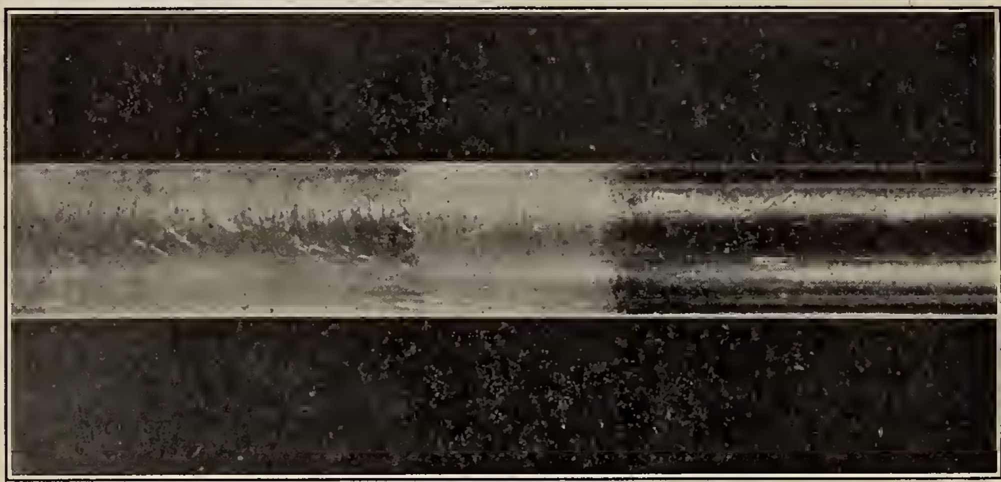

FIG. 4. DEVITRIFIED GLASS.

the stable condition. Old glass, especially glass tubes through which water has been allowed to pass, frequently shows this property when heated for a few minutes. The glass crystallizes, taking on the appear-

FIG. 5. OBSIDIAN FROM WHICH CRYSTALS HAVE BEGUN TO SEPARATE. Magnified about 300 diameters.

ance of ground glass. Its surface becomes rough and the glass is no longer transparent. Pieces of glass apparatus which have partially crystallized can be found in any chemical laboratory. It is called devitrified glass:

Certain glassy appearing minerals like obsidian are really undercooled substances, natural glasses, which have cooled without crystallizing. In the course of time they begin to crystallize. It is not unusual to find in nature numerous samples of these minerals existing in all stages: the metastable, partially crystallized, and the stable or completely crystallized mineral.

FIG. 6. CRYSTALS OF NEEDLE-LIKE OR MONOCLINIC SULPHUR. When first formed they are bright yellow. After standing for a few hours they change to a dull yellow color and become very brittle. A microscopic examination of a fragment shows that it is now made up of minute rhombic crystals (Fig. 7).

The rate of the growth of crystals is a specific property depending on the substance used. Much information has been obtained on this subject by studying the rate at which crystals are deposited from undercooled liquids. By filling a narrow glass tube with the desired liquid, as shown in figure 2, inoculating at one end and measuring the time necessary for the crystal surface to travel the length of the tube, the rate of growth of a crystal can be measured. Undercooled phosphorus crystallizes 200 feet a minute, water at two degrees below zero at the rate of 8 inches a minute, while one thirty-second of an inch a minute is the velocity of crystallization of betol. In nature crystals often grow much more slowly than this.

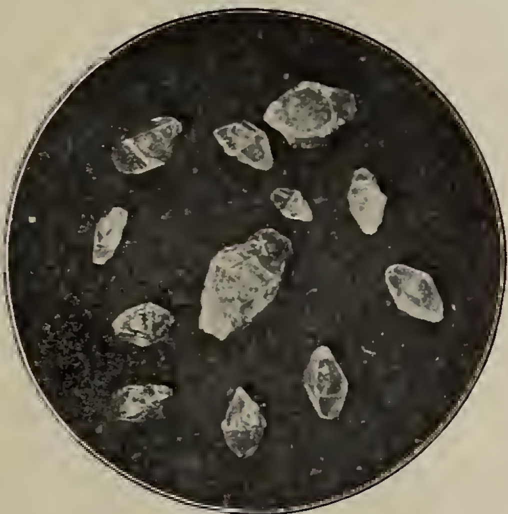

FIG. 7. CRYSTALS OF RHOMBIC SULPHUR.

The examples cited above deal with undercooled liquids, but the phenomenon of undercooling is by no means restricted to this class of substances.

When molten sulphur is allowed to cool slowly, long lustrous needle-shaped (monoclinic) crystals separate from the liquid. On standing for a few days the appearance of the crystals changes; they lose their luster, and examination with the microscope shows that their crystalline form is no longer needle-like, but consists of so-called rhombic figures. The temperature at which the transition from needles to the rhombic form takes place is 96°.

The change by which water is transferred to ice and its reverse may be represented as follows:

$$\text{At } 0° \text{ ice} \rightleftharpoons \text{water.}$$

The arrows pointing in opposite directions indicate that the process is reversible. The significance may be expressed as follows: at 0° ice can be changed to water or water to ice. Similarly in the case of the sulphur,

$$\text{At } 96° \text{ sulphur (monoclinic)} \rightleftharpoons \text{sulphur (rhombic).}$$

Fig. 8. Organ Pipes that have been Attacked by the Tin Disease.

Now just as the water at 0° does not always change to ice, but may be undercooled, so the transformation of monoclinic to rhombic sulphur does not take place immediately, but the needles can exist in a metastable state analogous to the undercooled water. And as the addition of a fragment of ice causes undercooled water to solidify, so the addition of a crystal of rhombic sulphur accelerates the change of monoclinic sulphur to its stable form. The rapidity of the transformation of the metastable solid, however, is by no means as rapid as the change of metastable liquids. This is not surprising when we consider how much more inert solids are than liquids, especially when considered from a chemical standpoint.

A most interesting example of the retarded transformation of metals has been furnished by Professor Cohen of Utrecht. Tin is a white crystalline metal which does not corrode readily and under ordinary conditions appears very permanent. After a particularly cold winter in one of the small towns of northern Germany, it was noticed that in one of the churches the tin pipes of the organ were full of holes and that the tin around the edges of those holes was brittle and would crumble to powder very easily.

A similar occurrence had been reported in St. Petersburg where, after a severe winter, blocks of tin which had been stored in the custom house were found to have crumbled to powder and a number of cases of tin buttons used for military uniforms had undergone a similar change. It was noticed that in the case of the organ pipes, and also on the tin roofs of certain public buildings, the tin had taken on in spots a wartlike appearance; moreover that the warty growth seemed to have the power of spreading. Wherever the tin had changed in this way it had lost its original properties and would easily crumble to gray powder. Because of the appearance of the tin and the spread of the warts over its surface this phenomenon was called the "tin pest" or the "tin disease." That the powder found was still tin and not a product of the corrosion of the metal was easily demonstrated, but the transition of a bright malleable metal to a dull gray powder was for many years a great mystery. But just as there are two kinds of sulphur which can be transformed into each other, so Professor Cohen showed that tin exists in two forms, white tin with a specific gravity of 7.28 and gray tin with a specific gravity of 5.79. These two forms can be transformed into each other, the transition temperature being 18°;

$$\text{At } 18° \text{ tin (white)} \rightleftarrows \text{tin (gray)}.$$

FIG. 9. THE SPREAD OF THE TIN DISEASE ON A PIECE OF SHEET TIN.

But if gray tin is stable below 18° how can we explain the fact that tin pails and tin pans remain bright year after year? The average temperature of the northern part of the United States is far below 18°, consequently why do not our tin utensils crumble into the gray modification of the metal? Fortunately for the housewife, the white tin exhibits to a marked degree the property of metastability. It remains unchanged at temperatures far below 18° and even contact with the gray tin changes it but slowly to the stable form. But once let the transformation of the tin begin, and the spread of the disease is certain. The surface of the tin becomes disfigured with blotches which gradually spread until the whole substance succumbs to the disease. Results of the tin pest are frequently found in museums. A tin vase in the British Museum which was found in Appleshaw, Hampshire County, England, and which dates back to 350 B.C. shows very strikingly the effects of the tin disease. The metal is not corroded, but it is dull in color and is so brittle that it can be broken with the fingers. Some of the fragments on being melted gave white tin with its original toughness and luster.

FIG. 10. A TWO-HUNDRED-YEAR-OLD MEDAL THAT IS SUFFERING FROM THE TIN DISEASE.

Every one who has studied the advance of science during the last few centuries realizes that our modern inventions and processes of manufacture have been in many cases foreshadowed in the ancient world. The use of gunpowder by the Chinese and their extraordinary success with glazes, as well as the perfection obtained by certain of the old civilizations in the use of cements, pigments, dyestuffs and in metallurgical processes, is familiar to every one. What the modern scientist discovers by painstaking investigation was learned in those days either by accident or as the result of centuries of experience. Consequently the fact that the tin disease was known in those days ought not to be surprising. Professor Cohen has pointed to an observation of Aristotle.

They say that Celtic tin melts much more easily than lead. A proof for the fusibility is that it melts even in water. It is apparently very sensitive to exterior influences. *It melts also in the cold, when there is frost.*

The knowledge of the tin disease is no more modern than the knowledge of most other diseases.

In this connection it is interesting to speculate on the antiquity of the use of tin. This metal is one of the easiest to obtain from its ores, and may have been used far earlier in the history of mankind than is generally supposed. Evidence in the form of utensils, etc., would of course have been destroyed by the tin disease.

We are indebted to the investigations of Professor Cohen for a more striking example of a metastable metal, that of the "explosive" antimony. By passing an electric current through a solution of antimony chloride this metal may be deposited on platinum in the form of a thick metallic coating. This electrolytic antimony is in the metastable condition exhibiting the same state of passive resistance towards change as the metastable sulphur, sodium acetate and water. If scratched with a file it changes to the stable form of antimony with explosive violence, heat is given off and dense clouds of whitish vapor are evolved. The metal has changed to the ordinary antimony, used so much in manufacturing as a basis for bearing metals. The method of bringing this change about and the velocity of transformation reminds one forcibly of the transition of undercooled water to the stable form.

That many other metals have the property of existing in the metastable state is highly probable. In this connection the hardening of steel is of especial interest, particularly so since the manufacture of steel has played so important a rôle in the advance of civilization. The method of tempering steel has been the subject of numerous trade secrets. In a book of recipes published in the sixteenth century the reader is told that steel may be hardened by quenching it in rain water in which snails have been boiled; also that

Ye may do the like with the blood of a young man XXX years of age, and of a sanguine complection, being of a merry nature and pleasant . . ., distilled in the middst of May.

Fortunately for this type of young man the modern steel manufacturer uses other methods for hardening steel.

The discovery of hardening steel by the quenching process is of course as much of a mystery as the method of raising bread by fermentation, we only know that it is an ancient process and moreover of great interest from the standpoint of delayed transformations.

If the alloy that we call steel is taken at a high temperature and allowed to cool very slowly it becomes soft and tools made from it will not have a cutting edge. Sudden chilling, however, produces in the metal a decided hardness. The results obtained by different rates of cooling have been explained by the investigations of the last few years. When cooled slowly the steel undergoes a transformation changing to a form very much softer than that which existed at a higher temperature. If chilled suddenly the steel remains in the same form that was stable at high temperatures, consequently the property of hardness is retained. Here again the analogy to the other cases of delayed transformation is evident, for the quenched steel is exhibiting the same state of passive resistance as the white tin that remains unchanged at a temperature below 18°. Now since the tin is not permanent under those conditions the question occurs to us, does steel slowly return to the stable form and thus in time grow softer? That we do not know; we can only say that if such a change does take place hundreds of years are necessary to bring it about. Japanese swords hardened in this way and made as far back as the fifteenth century when carefully preserved are apparently as hard as ever. If, however, this kind of steel is heated to the temperature of boiling water it gradually softens, reverting to the stable form. And if heated to 150° the softening takes place in a very few minutes.

From these examples of retarded transformation an idea of the extent and the importance of this phenomenon in the physical sciences may be obtained. New cases are constantly being discovered, in fact, the reluctance of substances to assume a new state seems to be pretty general. And as it so often happens in science that discoveries which seem at first to be of theoretical importance only, ultimately are shown to be intensely practical, so the study of this phenomenon has cleared up the mystery of the tin pest and promises to be of great importance in the study of metallurgy and many other branches of applied chemistry.

HEREDITY, CULPABILITY, PRAISEWORTHINESS, PUNISHMENT AND REWARD

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MODERN studies in heredity are yielding results whose social bearings can not be overestimated; and of these bearings not the least significant are those that relate to responsibility. To make these bearings clear we have, first of all, to grasp the current views about man.

It is often stated that man is a gregarious species; this illustrates the old point of view. Now we say: "Man is a congeries of elementary species or *biotypes* and hybrids between such; and some or most of these biotypes are gregarious." It is the necessary abandonment of the view that mankind is fundamentally uniform and homogeneous that involves such a change of our fundamental conceptions. There is, indeed, no statement that can be made about man that is universally true; and here is where our social codes, our laws, our works on ethics find their real limitations. We hear it said: "Human nature is pretty much the same the world over"—yes, in its *variety*.

Let us consider some of the evidence for such biotypes in man. Every one is familiar with the ordinary anthropological races; the white-skinned, black-skinned, brown-skinned, yellow-skinned and red-skinned. And inside each of these races no less marked subraces or strains may be distinguished. Take the white race alone. There are the blue-eyed subrace of Scandinavia and the brown-eyed subrace of the Mediterranean coast; the straight-haired western Finns and the curly-haired strains found in spots of Scotland; the tall strain of Ayrshire and Galloway and the short strain of Polish Jews; the dolicocephalic Corsicans and the brachycephalic Dalmatians. Coming to America we find, similarly, in southern California that a subrace that is nonresistant to tuberculosis and bronchitis has been partially segregated; in a valley of the Berkshire Mountains is isolated a nearly pure strain of feeble-mindedness, including much epilepsy and migraine; in eastern Massachusetts is a partially pure strain of deaf-mutism. We have evidence of localities (frequently much inbred) where are being isolated more or less pure-bred strains of albinos, of dwarfs, of syndactyls and polydactyls, of the non-resistant to cancer, of myopics, of hermaphrodites, of melancholics, of eminent scholars (*e. g.*, the Dwight-Edwards-Woolsey complex of the Connecticut Valley), of military men and statesmen (*e. g.*, the "first families" of Virginia), of sea captains and naval officers (*e. g.*, the Hull-Foote family of Connecticut) and so on. Such "families" have just the same biological significance as the blue-eyed or long-headed races; they are properly called biotypes. If some of these biotypes do not persist for more than a few generations it is because of the constant cross-breeding that is going on between biotypes. When a blue-eyed Irish girl marries a south Italian the children are all brown-eyed—the potential blue-eyed biotype is brought to an end by hybridization. So when a great color artist marries a woman who belongs to a non-artistic family the children may not belong to the artistic biotype; but, under appropriate matings, the characteristic of the biotype may reappear in later generations.

The objection is raised to this view that it overlooks the importance of opportunity in determining the vocation in which one finds success. This objection is founded on the fundamental theory that all men have equal capacities for all things and the reason why one person succeeds in one occupation and another in a different occupation is because they have different opportunities. And the objection vanishes when this theory falls. A year in a Berlin conservatory of music would be a great opportunity for some people; but not for me. How often is the dearest wish of a man to have his son take up the profession in which he himself has succeeded frustrated by the son's entire lack of taste or capacity for such a profession. "Opportunity" assumes an innate capacity for taking advantage of it. Hence, those who have had a "superior opportunity" must have had a germ plasm specially adapted thereto. Those who regret a lack of early opportunities really (within limits) regret their inability to respond more adequately to such stimuli—such culture—as came to them. Now, "all men" are born into thousands of distinct biotypes and what is true of those of one biotype is not true of others. A single standard "before the law" is as unbiological as it is cruel.

Consideration of the inequalities of persons "before the law" involves an examination of the foundations of law and society. Again and again, in various parts of the world, men have come together in communal life for physical and moral support, responding to a gregarious instinct. A leader is selected to enforce these communal customs that past experiences have proved to be favorable to the community. Moral law is merely this: behavior that is favorable for the specific community is "good"; behavior that is harmful for the community is "bad." Good and bad thus refer to conduct which is judged in its relation to the experiences, traditions and ideals of the given community.

Now, conduct is reaction to a stimulus; what the reaction shall be depends not only on the stimulus, but also on the nature of the reacting protoplasm; particularly, in man, of the senso-neuro-muscular complex. While in the young the relation of stimulus to reaction is relatively simple, during development there appears, most markedly in gregarious species, an inhibitory mechanism by which the expected reaction may be stopped. The inhibitory mechanism (aside from its usefulness to the individual) is a device for protecting the community from reactions that, however favorable originally to the individual, are antisocial. Children at birth have the inhibitors undeveloped, but they have a marvelous capacity for acquiring them in some or all forms. Many a person, however, unfortunately for himself and society, is incapable of acquiring the full complement of them; he tends constantly or periodically, throughout life and despite the best training, to react directly to the stimulus that falls upon him, antisocial though the reaction may be. Such a person may have perfect "society manners" and be faithful in conjugal relations but on occasion will take from shops articles for which she has no need; or another is regarded as a valuable member of his community, a leading member of the bar and a pillar of the church, but about once a year consumes a nearly lethal quantity of alcoholic drinks; or another is an agreeable, generous, affectionate young fellow who, about once a month, secretly sets fire to buildings in order to feed an irresistible love of the excitement produced by the flames; or a young girl who does well at school starts out from a comfortable home ostensibly to go to Sunday School, but makes it a practise of spending the afternoon in the rooms of some marines; or a lad of refined home, beloved of his parents and loving them, slips out of doors instead of going to bed at night and sleeps in entry ways or wanders out into the country and spends the night in a barn. These are examples, among hundreds that could be cited, of a lack of specific inhibitions. The stimulus can not be shunted off; it must lead to the specific response. Just as the amœba throws out its pseudopods along the path of the incident ray and so moves from the source of light; as the moth flies towards the candle; as the carrion fly is directed in its movements by the scent wafted to it from afar, so such persons perform their unsocial acts as part of their necessary reactions.

In another set of cases every reaction to a stimulus is of a socially desirable sort. All desires for the property of others, all inclinations to avenge insult by violence, all tastes and appetites, including the sex instinct, are readily inhibited—are under perfect control. And why are they under control? Because, first, the person who has the inhibitors came from a fertilized egg that carried the determiners for them; and, secondly, was surrounded by influences that were favorable to their development. In what sense can these people be held to be equal before the law with those considered in the preceding paragraph?

Even in numerous elements of mood and behavior the influence of the hereditary make-up is striking. One person is prevailingly elated, jovial, irrepressible; another quiet, depressed, melancholic; another, still, alternates in these moods and when elated he believes he can do anything, but when depressed a sense of helplessness overpowers him. Again, one person is original and independent while another is always imitative. Here is a famous lecturer who has quelled mobs with his eloquence but who is prevailingly diffident; while there is a woman who has lived always in the backwoods and is as forward as a Canada Jay. Sincerity or insincerity, generosity or stinginess, gregariousness or seclusiveness, truthfulness or untruthfulness, are all qualities whose presence or absence is determined largely by the factor of heredity. The way a person reacts to a given stimulation is, thus, determined by the germinal determinants that have fallen to his lot and the training and experience that have favored or repressed the complete development and fruition of such determiners. The self-control which he realizes he is exercising at any moment is a part of his involuntary reaction. And the individual can no more alter his reaction than he can pull himself up by his boot-straps.

How opposed is the conclusion, to which we seem logically forced, to the theory of organized society as carried out in its laws and in its treatment of persons. Here are two men, one whose reactions are all social; the other whose reactions are prevailingly antisocial. The first we praise, we heap with honors, we supply with the good things of life. The other we condemn, we hold him culpable, we confine him to a cell seven feet by four with little air and less daylight, and we feed him with the poorest food. We are rewarding the one and "punishing" the other. Yet each has turned out the necessary product of his own organism under the conditions in which it has developed. Neither exercised any selection of the elementary constitution of his organism, which was decided at the time the two germ cells united; neither had any control over the conditions of early development of the determiners, over his early education and the development of the germs, if any, of inhibitions. If the reactions of the organism are socially "good," fortunate that person; if he "elects" to study hard and prolong his education he does so because of a liking or ambition for which he is in no way responsible. Society does well to care for the good organism, to preserve it from overwork, from accident, from corroding influences. If, on the other hand, the reactions of the organism are socially "bad," unfortunate that person; if he "selects" bad companions and runs away from school, his reaction is in such case a necessary consequence of his make up. Society does well to restrict the product of the bad organism, protect society from it, or, if it seems best, to send it to the scrap heap. No doubt there are persons who are trainable, but have not had their inhibitions cultivated. It is sometimes possible to develop these dormant germs even relatively late in life. The infliction of pain is occasionally of educative value even in youth at the age of puberty. In other words punishment for crime may have, in some cases, a deterrent effect. But to punish the organism for an anti-social or "bad" reaction just because it is "bad" and in proportion to its badness (as we habitually do in the courts) is just as reasonable as the act of the little child who flogs his broken hobby horse because it no longer goes.

When a crime is committed society's first query is: Who is culpable? Let us find him and he shall be punished. The police officer bribed the gunman to slay the Jew. Who is culpable? The gunman? He reacted to the bribe in a fashion that was predetermined from his make-up and training. In his sordid way the policeman knew whom he could bribe. We can not blame the gunman any more than we blame the tiger. The police officer, then? No, he reacted to the stimulus of greed and fear that was predetermined from his make-up and training; the bear at bay would do the same. The responsibility goes back to society that permits the combinations to be made that react in this fashion and after such combinations are made fails to protect itself against their reactions. But, if these offenders are not culpable may they not be freed? By no means. These organisms are, as their product proves, bad; send them to the scrap heap. In general, if the trespasser has been apprehended, consider both the stimulus and the reaction. If it appears probable that there are undeveloped inhibitors the state should supply the training that may develop them. If not, the person should be permanently segregated from society, while his life should be made as happy and useful as possible; or else he should be entirely cut off. Especially should he not be permitted to reproduce his defects.

A word as to the rewards that society gives to those who are its effective and good members. Wages, salaries, profits, honors are such rewards. Because I am only half as good to society as another I get only half the reward. May I therefore complain? No, society is justified in making distinctions in its rewards. But I have no claim on a reward for attaining which I have done nothing except what I could not help doing; that I am good in any degree is no virtue of *mine*. Yet, from another point of view, the organism that is I has a virtue in so far as it reacts socially, and it may well call society's attention to the importance to society of its output and, in that measure, of the importance to society that it should be adequately supported. The man who invented a machine for making horseshoe nails made a fortune out of it, but he had no claim to that fortune; his germ-plasm had the determiners for inventiveness—his father also made machinery and was even interested in horseshoe nails. Society should certainly see that so good an inventor is properly supported. Indeed, society should see that the prize of special reward is held up before those who need its stimulus; but society may well fix a limit to such special rewards and not permit profits beyond such a limit. The successful lawyer and physician have no absolute claim to their large fees. Society in general recognizes the value of their reactions and wants to see the reacting organism adequately sustained. That boldness, swiftness, certainty of manipulation and that precise knowledge which belong to the great surgeon are not due to himself, but were, in their elements, antecedent to him. He could not help his valuable innate qualities, his knowledge is largely a heritage of the past, his education has been possible because of his educability and because of preexisting knowledge. He can not base his claim for a large fee on any virtue for which he is responsible; but only on the ground that society should adequately sustain his obviously "good" organism. Of the question, in what that adequacy consists, society must be the final arbiter.

Thus the recognition of the part that heredity plays in determining human behavior leads us to see more clearly how secondary the individual is to society, leads us to avoid placing "blame" on the bad and fulsome praise on the good, leads us to recognize the true worth and the real limitations of education, religion and other good influences, and leads us to conclude that the greatest advance that humanity can make is to secure an increasing proportion of fit marriages producing the largest number of effective, socially good offspring to carry on the world's work.

So much I wrote last December and sent to the editor; but shortly after there appeared in *Science* (January 10) the address by Professor Edwin G. Conklin on "Heredity and Responsibility" and the editor suggested that, since Conklin's views and mine were not wholly in accord, that I should discuss our points of difference. Immersion in other work has caused a delay of four or five months.

For the most part Conklin and I are fundamentally in agreement. Certainly no farmer believes that the yield of his crop is predetermined in the seed he plants; nor are reactions controlled solely by one's germinal determiners. The most able artist needs training; but training is vain if there be no capacity whose development is to be cultivated. The importance of training, for the trainable, no one ranks higher than I. Thus I agree heartily with Conklin's statement:

> The factors which determine behavior are not merely the present stimulus and the hereditary constitution, but also the experiences through which the organism has passed and the habits it has formed.

Only I would add: The effect of the experiences and the capacity for forming habits are, to a degree, determined by the hereditary constitution; just as my bantam chicks develop into bantam hens no matter how well I feed them.

But in his discussion of responsibility I am able to detect a difference of opinion between my way of looking at things and Conklin's. When he says it is the duty of society to produce proper environmental stimuli for the child I agree completely but when he states that we have half-used talents that we may greatly improve, I feel like adding "if only the proper stimulus is afforded" (such as Dr. Pepper afforded Dr. Conklin when Dr. Pepper reminded him that he *could* do what he *had* to do).

But in the last two paragraphs of his address Dr. Conklin's views diverge more widely from mine, and I confess I can not follow him. We are agreed that through bad environment or culture potential inhibitions may fail of development; but I can not see how a man is responsible for the consequences of this bad culture of inhibitions any more than he is for not knowing how to read if he has never been taught. And my reaction to his inquiry: "Is it not a fact that belief in our responsibility energizes our lives and gives vigor to our mental and moral fiber" would be a denial. The moral fiber of my dog leaves little to be desired, and there is much in the devotion of many an untaught denizen of Central Africa that can not be matched in the descendant of any Puritan; yet it is fair to doubt if their actions are energized by a "belief in their responsibility." I do not think that "shifting all responsibility from men to their heredity or to that part of their environment which is beyond their control helps to make them irresponsible" or alters to any appreciable degree their behavior; the Puritan will be a Puritan still; the wayward girl will be wayward still. My view is that a person really can not react otherwise than he does under the circumstances in which he finds himself placed; a person, therefore, who accepts the theory that he is not "responsible" can not fail to continue to react in the same old way; except in so far as the idea *may* cause him (if he reacts that way) to put himself in the way of getting his environment improved. If I am not (but others are) responsible for my conduct then I must seek good intellectual and moral influences. And if my neighbor is not responsible for his conduct, but I with others am, why then I must bestir myself to help train him and his children. Man has become in truth his brother's keeper. As the farmer cultivates his crops and rejoices to see them grow, so every man of us lends his service to the culture of his fellow men. But as the corn stalk is powerless in and of itself to add one kernel to its ear, as the spaniel can not train himself to become in any degree a terrier, so I can not find any mechanism in man by virtue of which he can react to a given stimulus in a way opposed to that indicated by his inherent traits and functions, including the culture that they have experienced during their development.

GUSTAV THEODOR FECHNER

By Professor FRANK ANGELL

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SOMEWHERE Huxley says that certain men are counted great because they represent the actuality of their own age and mirror it as it is,

> Such a one was Voltaire, of whom it was said that he expressed everybody's thoughts better than anybody. But there are other men who are great because they embody the potentiality of their own day and magically reflect the future.

In both of these respects Gustav Theodor Fechner was one of the greatest men of his age and perhaps, as not a few psychologists feel, one of the greatest in the history of science.

But in reflecting the tendencies of his age Fechner's influence was less like that of a mirror than of a many-sided prism which bends and reflects light in all directions, sending it out tinged by the action of the medium through which it has passed. There are few divisions of the domain cultivated by natural science in the first half of the nineteenth century over which Fechner did not pass, and there are few on which he did not leave the imprint of his originality. In the second edition of the "Elements of Psychophysics," a work in which Fechner laid the foundations and built somewhat of the superstructure of the present science of psychology, the editor, Wundt of Leipzig, has appended a list of Fechner's published writings. Excluding editions other than the first, and including translations of physical and chemical works which with Fechner usually meant critical revisions, the list comprises 124 titles, and a classification of these under the headings of nonsensical, humorous, literary, chemical, physical, psychological, esthetic, statistical, physiological, encyclopædic, logical and philosophical, would perhaps more than anything else give a representative idea of Fechner's almost unparalleled many-sidedness.

His first published works were an inverted reflection of his university career as a student of medicine. The condition of medical study in the first quarter of the nineteenth century may be inferred from Fechner's objections to entering a profession in which he had taken his degree; although qualified by the examination to practise medicine, he remarks:

> I could neither open a blood vessel, apply a bandage nor perform the simplest obstetrical operation.

Accordingly, the first use he makes of his medical knowledge is to satirize, in the main, with kindly humor, the medical disciplines, especially the materia medica, of his own day. For the medicine of that time was still in the bonds of authority, it still harked back to Galen and Hippocrates, though, as Fechner remarked, it had become what its adherents called so "rational" in its methods, that had Hippocrates himself come up for a medical degree, he would have "fallen through" as not knowing Greek and as being unacquainted with the "Hippocratic method."

These first publications of Fechner appeared under the pseudonym of Dr. Mises—a *nom de plume* which he used for many years in connection with what he perhaps thought were the Fliegende Blätter of his scientific and literary activity. But in whatever he published—literary criticism, riddle books, psychological investigations or philosophical treatises—Dr. Mises is always a co-worker. In his last controversial writing, "On the Principles of Psychological Measurement and Weber's Law," a subject with about as much affinity for the humorous as a table of logarithms, it is Dr. Mises who begins the article with a quotation from Wieland:

> Noch einmal sattelt mir den Hippogryphen Ihr Musen
> Zum Ritt ins alte romantische Land,

and so he goes on to say,

> I once more saddle—and probably with my 86 years, it is for the last time—my war-horse for a ride into the romance land of Psychophysics.

It was indeed his last ride, for that volume of Wundt's "Philosophic Studies," which contains this article, also contains the funeral oration which Wundt delivered over Fechner's bier on the twenty-seventh of November, 1887.

But it is in the philosophical writings especially that it is at times not easy to distinguish between Dr. Mises and Fechner the philosopher, and it is the infusion of something dangerously akin to humor in the unconventional treatment of philosophic questions no less than a curious tendency towards a practical mysticism which made the cut and dried philosophers of Fechner's day shake their heads doubtfully at this philosophy which moreover was attached to no school and sprang from no accredited system.

It is perhaps not to be gainsaid that the fanciful Naturphilosophie of the early part of the nineteenth century for many years tinged faintly Fechner's speculative views, but it was too arbitrary in its methods and too vague in its conclusions to radically affect or infect a mind so incredibly ready as was Fechner's to submit its problems to the test of experiment. At any rate we find that in 1824 Fechner had undertaken the first of those translations of French physical and chemical text-books which busied him not a little in this period of his career.

The work translated was Biot's "Traité de Physique," and the budding scientist sagely questions

> If the Oken-Schelling Philosophy could have shown anything of that fine scientific correlation of optical phenomena which Biot presented with so much clearness.

What were the requirements for a lectureship in physics at Leipzig in the year of grace 1824, the writer can not say, but in that year, aged 23, Fechner began lecturing on that subject, his published work up to that time consisting of two essays by Dr. Mises, a cram-book of physiology and a text-book of logic for school use. But whatever Fechner's qualifications when he took the lectureship, he speedily became a skillful experimentalist and investigator. It was a time when the scattered observations in electricity and magnetism were beginning to be bound up into connected theory. In 1824 Oersted discovered the attraction of the galvanic current for the magnet; it was in this decade that Faraday was making his classical researches on the action of induced electric currents and that Ohm announced the famous law of electric force which bears his name. Into this broad and rapid scientific movement Fechner threw himself with all his tireless zeal, and excluding his translations of French chemical and physical works, published in the period between 1828 and 1848 no less than 21 investigations on electricity and magnetism, devoted mostly to testing the laws and theories of the electric current, especially the fundamental facts underlying the great law of Ohm. The generous equipment of ingenious apparatus, which we are wont to find in German laboratories, was wanting in Fechner's day, so that he had in these investigations to patch out his equipment at his own expense and often with home-made devices, but "despite these drawbacks," says his biographer, Kurd Lassowitz, himself a physicist, "he succeeded," through skillful and careful arrangements of his measurements, together with his tireless industry, in obtaining results of surprising accuracy, and Wundt testifies that, even to-day, Fechner's measurements of the galvanic battery may be safely commended to any one looking for a model of logical method in the domain of natural science.

But beside the electrical investigations, his activity in other kinds of work was unceasing; a bulky Haus Lexikon in 8 volumes, of which he wrote fully a third, a pharmaceutical journal, of which he was at once editor and chief contributor, so-called translations of which he was as much author as translator, text-books in physics and chemistry—his literary and scientific output in this period alone would have insured him no small amount of space in any future Haus or Konversations-Lexikon of his fatherland.

But the load was too heavy for him to carry, and the straw, or rather bale, which finally broke him down was the bulky Hauslexikon. In

1840 after premonitory symptoms of an overstrained nervous system, a three years' illness set in of so depressing, perhaps so desperate a character, that few could have weathered it and retained their reason.

His illness was partly physical, a distaste for food, and partly mental, a distaste for work—the more alarming symptom in a man of Fechner's natural activity—together with an inability to control the course of his ideas or even to distinguish between the real and the imaginary. Added to these evils there developed such a supersensitiveness of the eyes that for almost three years Fechner had to live in darkness. Without means and without earning power, tortured by physical pain, sitting in darkness, anticipating total blindness and perhaps insanity, it is small wonder that his thoughts turned again and again to suicide as the only source of escape from his woes. That Fechner did not put an end to his life is perhaps due to certain traits which were his, by right of inheritance from his father—an almost ideal representative of the high-minded, conscientious German village pastor—to wit, a keen sense of duty and a tough energy of will which set themselves against the unbridled flight of illusionary ideas. He wrote:

> For almost a year I struggled the greater part of each day to banish these ideas from my thoughts, and while this exercise served as a distraction, it was of the most painful nature that it was possible to conceive.

Few could have passed through an ordeal like this and have retained reason, and no one unchanged in his views of what makes life worth living; and so, when Fechner took up academic work again it was not with lectures on molar and molecular forces but with discourses on subjects of ethics, of psychophysics and of esthetics; "from the physicist had come forth the philosopher." But while his lectures were comparatively few in number and given seemingly as a quid pro quo for the 850 Thalers of salary allowed him yearly by the government during his illness, there was no falling off in his pristine zeal in speculation or industry in investigation.

Among Fechner's earliest writings, for which he made Dr. Mises sponsor, was a satire on the methods of reasoning of the natural philosophy of his day, entitled "The Comparative Anatomy of the Angels." Applying, for example, the much-used doctrine of continuity, he finds that the angels, as the highest and most perfect of created beings, can have no legs, for, "beginning with the lowest animals, we see the scolopenders have, God knows how many legs"; next above them come the butterflies and beetles with six; mammals have four; birds, which resemble angels in their free movement through space, together with human beings, who, by their own account are half animal, half angel, have but two. At each step towards angelism two legs disappear, with the step from man upwards all legs must have gone; ergo, angels have no legs. But this also follows *a priori:* for as the most perfect of created beings, angels have the most perfect shape, which is acknowledged to be the sphere with its perfect legless symmetry. Again passing along in ascending order the series of sense organs of human beings, we go from crude mechanical touch and pressure up through taste, smell and sight, to the refinement of vision which is capable of reaction at measureless distances. From this and many other chains of ingenious reasoning Dr. Mises concluded that the eye is the propotype of the angel in form and function, and by other reasoning, equally ingenious, he finds that the planets are conscious beings, to wit, angels. In the "Zend Avesta," published in Fechner's fiftieth year, the jest of Dr. Misses has become a matter of serious earnest. The earth is a higher being, possessed of higher consciousness, the vehicle itself of human consciousness and the connecting link between man and God. Similarly the remaining planets are conscious beings, while, at the other end of the scale of existence, the planets also have consciousness.

Now looking at such utterances, as they stand by themselves, one would naturally suppose physicist had disappeared in the mystic, and that the laboratory had given place to the oracle. But if this was the madness of mysticism, there still remained signs that the old Fechnerian spirit was still alive, for in the succeeding year we find him engaged in counting the steps of men and women passing by his house to serve as material for a statistical study on the ratio of the masculine to the feminine steps, published by the Saxon Academy of Sciences. As a matter of fact the coming of the "Zend Avesta" had been foreshadowed sometime before Fechner's illness in a little work entitled, "Das Büchlein des Lebens nach dem Tode," dedicated to the daughters of a dear friend who had passed away. The little book is rather a message of comfort than a didactic sermon, but in the doctrine that the soul after death becomes diffused into the general consciousness of nature we have the seed that later developed into the remarkable system of Fechner's metaphysics.

But if consciousness is a general attribute of nature it must be shared by plants, and so we find that the first work written by Fechner after his illness was the "Nana or The Conscious Life of Plants," necessary prolegomena to the "Zend Avesta." When the greater part of Thoreau's Week on the "Concord and Merrimac Rivers" had been turned over to him by the publishers as a waste product, Thoreau is reported to have said he had a library of about a thousand volumes, over 900 of which he had written himself. Almost a like fate awaited Fechner's publications of this period and for reasons that are obvious; the physicists could but shake their heads at a colleague who had given up his exact investigations in order to urge the phantastic thesis of plant consciousness and the professional philosophers of that time were unable to reconcile the author of the psychophysics with the seer of the "Zendavesta."

But it was perhaps less the difference in value that he placed on the subjects of metaphysical speculation, than the different way in which he approached them that separates Fechner from the idealist of the early nineteenth century. Believing no less absolutely than Hegel, that the reality of the world must accord with what is reasonable, he saw clearly that this reality could not be deduced by dialectics, but that it must be worked out as one works out final questions in physics, namely, by generalization and by analogy. In other words the metaphysics of Fechner was an inductive metaphysics or "Metaphysik von Unten," as he enjoyed terming it, and as a philosophy of this kind must change with progress in positive science, it becomes a scientific philosophy, so that in this respect Fechner is the precursor of Lotze and Wundt. But it was chiefly with the weapon of analogy that Fechner attacked the problem of the ultimate nature of the cosmic world, and if in the history of philosophy, this logical weapon had ever before been used with such subtlety, such precision and with such bewildering variety of application the writer is unaware of it. The profusion of arguments in behalf of the thesis that plants have mental processes that differ in degree but not in kind from that of animals is overpowering and in many points unassailable, save by a fine old crusted prejudice against the doctrine in general, and whoever takes up the "Zend Avesta" with the expectation of finding there a mystic blend of "confusion, illusion and illation," will be speedily undeceived by the opening chapters which bear a closer resemblance to Newton's "Principia" than to the book of Revelations.

He asks, for example, that the scientific notion of force be extended from inorganic to organic matter, from physics to biology. For force in the scientific sense is not an immanent power residing in bodies by means of which they pull or push one another, but it is a simple phenomenon of motion, and is measured by rate of change of motion. Instead of saying "Here is a force at work" one should rather say "Here is a law of nature." This applies no less to growth of the cell than to atomic attraction and repulsion; to explain organic motion by an innate power of adaptation is logically as wrong as to attribute to the sun an innate gravitative force. In the case of combustion we have only to consider the direct interaction of the particles of the bodies present, but in organic bodies we have an extraordinary close and complicated combination of parts into a unity, so that the necessary change of the separate parts can only be determined with relation to the entire system.

The writer gives this not in any way as the beginning of an explanation of Fechner's metaphysics which would lead one far beyond the scope and limits on this paper, but merely as an illustration of the kind of argument to be met with in the "Zend Avesta," and to indicate how far removed in its methods was the "Philosophie von Unten" from the systematic philosophy of the time, even as its source—the deeply religious turn of Fechner's nature had little place among the conventional philosophizing motives.

Incidentally it may be said that the publication of Fechner of a little volume of riddles in rhythm for children between the appearance of the "Zend Avesta" and the work on the plant soul may throw some light on the failure of the professorial absolute idealist to understand the nature of the versatile founder of the "Philosophie von Unten."

But the year 1848 was a very unfavorable one in Germany for the reception of a new philosophy, particularly for a philosophy to which it was so tempting to attach the tag of mysticism. The German folk, wearied with the pretensions and dialectics of the rationalistic philosophers, aroused by vital questions of constitutional government and interested in the vigorous growth of natural science, had no time to waste on such questions as the mentality of plants and planets; the shallow materialism of Vogt and Büchner seemed to fall in easily with current theories of physical science; as a verbal proposition it seemed much easier to understand the statement that the brain secretes thought as the liver secretes bile, than to work out Fechner's involved, if keen, reason in regard to the seat of the soul. And so the "Zend Avesta" rested quietly with the "Nana" on the book shelves of the publishers. But in no wise discouraged, Fechner once more attacked the question of the parallelism of soul and body as a special problem "von unten auf," and in 1859 published the famous treatise on psychophysics.

The motive for this work was to determine, if possible, exact relations existing between the mental acts, the "psyche," and the accompanying physical process, or, in short, to determine quantitative relations existing between mind and body. Considering the general disbelief in regard to the possibility of such determinations, which had been summed up by Kant in the dictum that psychology could never become a science because it could never be treated mathematically, Fechner's plan might reasonably be termed bold. But when one thinks of the practical difficulties of the undertaking that Fechner had to create new scientific concepts and name them, that he had to create and develop totally new methods of investigation and that he had to invent new apparatus or apply old to totally new uses, it might seem as if Fechner had passed from the region of the improbable to that of the impossible.

The occasion for the psychophysics was a simple investigation on our discriminative sensibility for lines and weights, made by the physiologist E. H. Weber, one of the "seven sages of Göttingen." Weber simply states that we have the power to distinguish between the lengths of two lines which are to each other as 39 to 40 and between weights with a ratio of 20 to 30. Moreover, these ratios are general, holding for centimeters or inches, and for pounds or ounces. Taking up these hints, Fechner ransacked the choir of heaven and the furniture of earth to see if this general relation which, with characteristic modesty, he called Weber's law, did not hold true for all kinds of impressions, for sounds, for colors, lights, temperature, short intervals of time; he even questioned if it did not hold for our feelings; in short, if it was not a fundamental law of human activity. With characteristic thoroughness he launched forth into new seas of experimentation. He tells us:

> For several years I considered it a daily task to experiment about an hour for the purpose of testing Weber's Law and for elaborating new methods of research.

This daily task consisted in "hefting" and comparing pairs of small weights, in analyzing out the multifarious factors involved in judgments of likeness or difference and in noting the results. In so far as Weber's law is concerned it can not be said that the outcome of this vast accumulation of data is decisive, but so far as regards the working out of psychophysical methods of measurement, the experimentation was extraordinarily fertile. For the development of the Fechnerian methods meant that Fechner had founded a new science and reared somewhat of its superstructure in a domain whose only uniformity seemed boundless variability, and that later psychology has failed to find either the universality or the exactness in Weber's law which Fechner hoped to show is assuredly a matter of small importance in comparison with the birth of a quantitative psychology.

In the latter part of the treatise Fechner passes over to discuss what he calls "Inner Psychophysics," and here we strike a mine of acute and subtle psychological observations on sleep and dreams, on hallucination and illusions, on memory and after-images from which most writers of text-books and no small number of investigators up to the present day have "lifted" no small amount of ore. Taken as a whole, from the first remarkable chapter, remarkable at that day, on the conservation of force, through the mathematical treatment of methods of "mental measurement" up to the final discussion of psychophysical motion, the "Psychophysik" is a work which in the library of science one need not fear to place on the same shelf with the "Origin of Species."

If the importance of a work is to be measured by the number and repute of its critics, Fechner had no longer any cause for feeling that his theories were of no significance to the learned world, for among the cloud of witnesses who rose up to testify against the "Psychophysik" we find the names of v. Helmholtz, Hering and Mach, and later Wundt and G. E. Müller of Göttingen. Indeed so acute and penetrating was the criticism of Müller, that Fechner was obliged to defend himself in a new work entitled "Revision of the Main Points of Psychophysics." Later on he wrote a sort of omnibus reply to all his critics and up to the very year of his death he carried on the psychophysical war with unabated vigor. His last extensive article, written in his eighty-sixth year, was on "Weber's Law," and Wundt's judgment on it is that it was the clearest and most perfect presentation of the subject which Fechner had given in the course of his forty years work in psychophysics.

The seeming hopelessness of psychology as an exact science lies in the perplexing multiplicity of the variable factors perturbing every attempt to determine facts and laws—errors of memory, errors of observation, errors of contrast and expectation, the brood of errors hatched by the changing rhythms of attention—and it was to devise ways of sifting out these errors that Fechner for years devoted his tireless ingenuity. But a satisfactory treatment of such conditions means the accumulation of large numbers of observations, which in turn calls for statistical handling of the materials gathered. Here again Fechner's genius found a fresh field to cultivate, for in endeavoring to see if some general principles were not at work in shaping what may be broadly called esthetic proportions, such as those of picture frames, visiting cards, decorative crosses and the like, he found that these classes of objects varied in their dimensions like the variations in the sizes of races of men, species of animals, like variations in temperature and rainfall and countless other objects in art and nature termed by Fechner "Collective Objects," "Collective Gegenstände." Mathematical analysis of the data in this field resulted in the formulation of a branch of statistics or applied mathematics which has become exceedingly useful in working out biological problems. Nor did he rest here; keenly interested in art (he contributed five articles to the *cause célèbre* of the genuineness of the Holbein Madonna, Dresden *vs.* Darmstadt), he followed up his investigation on simple esthetic proportions with a general investigation on esthetic laws carried out in the spirit of the psychophysics "von unten auf" by observation and by experiment. And here be it said that if there is any trait of Fechner which amazes a student of his work more than aught else, it is his incredible ingenuity in applying experimentation to problems where no one dreamed that experiment could be applied. Well! "Kurz und gut." In his seventy-first year he published the "Vorschule der Aesthetik" in two volumes and therewith created the science of experimental esthetics—the third and last distinctive product of his creative genius. His last published work was a clever and witty critique of the Mendel Fountain in Leipzig.

What has so far been set down here got itself delivered substantially as it stands, some eleven years ago, on the occasion of the centennial of Fechner's birth. Since that time the tide of Fechner's fame has swollen until it has overflowed into the German popular magazines. The "Zend Avesta" has passed into the third edition, the soul-question has been born again with no less than Friedric Paulsen as accoucheur. Ebbinghaus has dedicated to Fechner's memory his classical treatise on psychology, and Möbius, the neurologist of Leipzig, has commemorated him in a volume of medical essays. Külpe, the philosopher and psychologist of Bonn, has been unwearied in critical appreciation of Fechner's achievements, and William James, who twenty-five years ago gave his official opinion that the "proper psychological outcome of Fechner's work was "just nothing," has made the *amende honorable* in a generously sympathetic essay in the "Pluralistic Universe." In glancing over the earlier pages of the present paper, the writer had the feeling that it resembled more a card catalogue of Fechner's publications than an appreciation of his work and works. If so, the fault lies somewhat in the faceted many-sidedness of Fechner's activities, as well as in the writer's deficiencies in power of interpretation. Perhaps the perspective of time now reaches far enough for us to view the outline of what he wrought in fairly true proportions. If so, one may say in brief that, able and ingenious physicist as he was it is doubtful if he could ever have risen to the stature of a Faraday; his philosophy will perhaps attract mainly those rare minds who, while working officially by the pale cold light of the intellect, are still prone to follow the promptings of the spirit into regions lying beyond the pale of syllogistic reasoning. His more solid and probably lasting achievements belong to the latter half of his life, to the period of the "Psychophysics" and the "Aesthetics."

As for the daily life itself, it was outwardly singularly uneventful even for a German "Gelehrter." He rarely left Leipzig, but, year in and year out, conscientiously fulfilled within its walls the duties of a public-spirited citizen. And the city responded by awarding him in his middle age an honorary citizenship, and at his death, with rare municipal good taste, erected a modest bust to his memory at the very turn of one of the winding walks in the Rosenthal where he had passed many a sunny afternoon of the long German summer days, discoursing with his friends on things that are little dreamed of by many a school philosopher. In accord with his scanty means was his dwelling in the Dresdener Strasse, fittingly called a nest; his study was furnished with a chair, a table, a stove and some bookshelves; a catalogue of the library resting on the shelves would usually indicate a stack of manuscript and a table of logarithms: sonst Nichts. Here there passed quietly away on the nineteenth day of November, 1887, almost exactly twenty-five years ago, the philosopher, the art critic, the humorist, the mathematician, the friend of children, the creative genius in science, Gustav Theodor Fechner. Verily, as Wundt said, in the funeral oration, "we shall not look upon his like again."

THE INTELLECTUAL AND THE PHYSICAL LIFE

By JAMES FREDERICK ROGERS, M.D.
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THE notion is common and deeply rooted that men of large achievement, especially in letters or art, were physically inferior if not downright sickly and infirm. If one questions this idea, he is informed at once that Stevenson was far from well or vigorous, that Heine lived in a "mattress grave," that Chopin died of consumption at an early age, and that Darwin was hardly better than an invalid for much of his life. Even great military minds have found lodgment in miserable shacks of bodies, and Macaulay tells us that, at the battle of Landen, probably the feeblest persons present were the "hunchback" duke of Luxemburg and "that asthmatic skeleton," the Prince of Orange.

The evidence is very striking and also appealing, for while the sickly mediocre are not especially interesting to any one, the fine qualities of the sickly great are magnified, through our sympathy, by the infirmities which beset their paths. The genius displayed by such is often given more credit on this account than it in cold blood deserves. For example, Stevenson, though a writer of delightful things, does not seem by any means certain of maintaining the high place in literature awarded by the admirers of his personality. Heine, brilliant as he was, does not rank with Goethe; and Chopin, though unique in his way, is master in a comparatively narrow field. We should sadly miss his exquisite tone arabesques, but we never expect from him the sublimities of Beethoven or Brahms.

Of the notables named above, it might be remembered that one, Heine, did not complain of a serious illness until he was thirty-nine and that his paralysis was not confirmed until he was forty-seven; that Darwin also was in good health until he had returned from the voyage of the *Beagle* and was fairly launched in his life work; and that the leaders at the battle of Landen, while frail and sickly, were yet able to knock about on many fields of battle. Even of Stevenson it is said by Mr. Balfour that, "considering his fragility, his muscular strength was considerable and his constitution clearly had great powers of resistance." But for his Bohemian ways and his utter disregard of the laws of bodily well-being, he might have had a much greater degree of health and comfort.

The examples given of great men who were invalids are not always so well chosen, and there is often a tendency to exaggerate the infirmities of those named. For instance, Storrs in his life of St. Bernard informs us that the Hussite warrior Zizka was "half blind from his youth," and achieved his greatest victories after complete blindness came upon him. The truth is, Zizka had the use of but one eye in his earlier life, but as that, so far as we know, was a good one, he was a very long way from being half blind. He did win his greatest battles when totally blind, in his last three years, but he was necessarily surrounded, as every general must be, with faithful and sharp eyes in the heads of his lieutenants. Storr's other infirm hero is Doge Dandola, whom he describes as "blind and bearing the weight of almost a hundred winters when he stormed Constantinople." The Doge was eighty-four, which is some remove from a hundred years, and he was not blind at all. He was really an example of prolonged vigor.

Granting that there are wide deviations from the rule, we would set against the popular notion its antithesis that the intellectual life—that genius, to use that ill-defined but expressive word—is never at war with physical health and strength, but that, on the contrary, as a rule, the greatest men in all fields of endeavor have been lusty persons, and relatively free from serious or prolonged illness, and, where not robust, have usually shown wonderful vitality and powers of endurance. Moreover, they have, we believe, been more careful than the ordinary man to preserve their health, and have often husbanded their energy as the average mortal would not think worth his while.

Genius, of course, is no respecter of bodily tabernacles and takes up its tenancy in all manner of them, from the sickly and deformed to the most heroic and symmetrical, but its light will vary according to its conditions of bodily housing, as the light of a lamp will vary according as its wick is splashed at intervals with fuel of uncertain quality or is constantly bathed in pure oil. The mind of genius has its equally elaborate complement of brain machinery through which it expresses itself, but that brain mechanism depends in turn upon the rest of the body which elaborates, furnishes and keeps pure its supply of energy-material in the blood. It stands to reason that the more well ordered the body, the more active and vigorous will be the organ of the mind, and that anything which depresses the proper functioning of the physiological machinery must impair in so much the product of that organ, both in kind and amount. As there is no line to be drawn between genius and ordinary mental activity, what is true of one physiologically applies as well to the other.

It is quite true that accident or sickness often turns a man to a particular calling. Dickens was always thankful for an early illness which gave him a strong inclination to reading. Had Sir Walter Scott not been in childhood confined to bed with his diseased ankle, he might never have found introduction to the realm of romance which he later revealed with such skill to the work-a-day world. It is not unlikely that he would have entered the army as did his son, and have furnished a mark for Napoleon's cannon.

In a profession where, until recently, its members have preached, even if they have not practised, the neglect and abuse of the body, one would expect to find many examples of the feeble and sickly who have risen to eminence, or who, in the course of an active, strenuous life, from their very attitude toward the body, have brought on ill health and weakness. Yet among the great religious leaders there have been many examples of fine bodily presence and especially of phenomenal energy and endurance. In an age of over-indulgence it is difficult to know just what the asceticism of the medieval monks amounted to, but even where, by their devotion to a mistaken ideal, the bodily machinery was undoubtedly more or less damaged, they often showed that they possessed a wonderful vitality and fund of nervous energy.

Among religionists St. Bernard is described as being, in early life, a man of fine presence; in later years he is pictured as "most delicate," without flesh. Those who knew his labors "felt as if in him a lamb had been harnessed to pull a plow." He was extremely ascetic, suicidally so, it would seem, as his friends had at one time to rescue him from himself and place him in the hands of a shepherd who taught him a few items of common sense. Nevertheless he is reputed to have surpassed robust men in his endurance, a trait readily attributed by his biographers to superior spirituality. Though strong enough for his monastic work, Bernard was undoubtedly physically unfit to lead the crusade which he preached, else he would not have refused the post. On the surface at least he does not appear to lend much support to our present thesis.

According to his half-legendary history, Francis of Assisi was a dashing young man who was turned from a life of frivolity to the religious life by a severe illness. There is no doubt but that St. Francis abused his body and lived the unsanitary life. His conscience must have smote him, for when he came to die at forty-five he begged pardon of "Brother Ass, the body," for having neglected him so shamefully.

The fiery Savanarola did nothing by halves, and we are told that, like Bernard, he was so severe in his mortifications of the flesh that "his superiors were frequently obliged to curb his zeal." There is no record of any sickness and notwithstanding his asceticism he must have been anything but weakly to the day of his martyrdom.

Luther, as a monk, apparently damaged his health by the over-zealous mortification of the flesh. In his post-monkish days he perhaps went to the other extreme. He was apparently a very vigorous, active man until forty, when, doubtless from his too generous living, a troop of ailments settled upon him.

In Erasmus we have another example of the scholar of the cloister.

He was highly sensitive to physical influences. He could not bear the stoves of Germany, but required an open fire-place. He was hypersensitive to odors and delicate in his diet. He lived to be seventy despite attacks of gout and, as his days were crowded with work, he must have had a strong, though sensitive, constitution.

Of modern preachers, Robert Hall was a sufferer for years from renal colic, though he possessed great vitality. Jonathan Edwards was frail and Channing was not robust, but there is a numerous company who loom large in bodily impressiveness and health, and who show us the possibilities of the religious genius lodged in a fitting temple.

John Wesley "loved riding and walking, was an expert swimmer and enjoyed a game of tennis." His journal has been called "the most amazing record of human exertion ever penned by man." "On horseback he traveled more miles, spoke oftener and to more people than any man who ever lived." "Eight thousand miles was his annual record for many a long year, during each of which he seldom preached less frequently than five thousand times." At eighty he writes, "I find no more pain or bodily infirmities than at five and twenty," and he imputed this in part "to my still traveling four or five thousand miles a year and to my constant preaching."

Chalmers had a "great look" with his "large head, large chest, his amplitude in every way" and his "erect, royal air." He "had a frame of adamant, that bade defiance to the weather, and that actually exulted in the wildness of the blast" as he hurried over the moors. Spurgeon's body cast a shadow of no mean dimensions and he was in such vigor as to do an immense amount of work. Brooks was a man of great physique, who was so well that when taken with the grippe at fifty-five, he exhibited the impatience with sickness characteristic of one who has always been well by exclaiming, "How strange it all is, this being sick!" Beecher is another example of health and bodily vigor and it is interesting to note that it was his great maxim to keep his body "in first-rate working order, for he considers health to be a Christian duty, and rightly deems it impossible for any man to do justice to his mental faculties without at the same time attending to his physical powers." From Bernard to Beecher is a long interval of time, but a greater gap in ideas of the Christian life, and the last few examples prove that bodily abuse is not essential to spiritual power.

Among artists Leonardo, Raphael and Michelangelo would hardly be denied first place, and a second, later trio, Titian, Rubens and Turner, would rank very high. Raphael died at thirty-seven. He was beautiful, with an almost delicate face, but there is no history of sickness or any bodily weakness. Just prior to his sudden death from plague he had entered into a contract for an arduous piece of work. Leonardo, "painter, sculptor, architect, musician, mechanical engineer and natural philosopher," was a person of splendid physique "who outstripped all the youth of the city in feats of strength and horsemanship," and who was "zealous in labor above all men, with a strength more than human."

Michelangelo was almost as ascetic in his habits as a monk and he labored with "furious" intensity, with chisel and brush, up to his seventieth year, when he still had energy left to plan and carry forward such great architectural works as St. Peter's. Even in his last year he is described as "healthy above all things," notwithstanding the storm and stress of adverse circumstances against which he had to contend throughout life.

It was said of Titian that his death from plague came (at the age of ninety-nine) as a surprise to his friends, since he lived "a life so strong and resisting that it seemed able to withstand all the assaults of time."

Rubens lived sparingly and was devoted to horseback riding. Despite bodily care he suffered from attacks of gout, so common in that age. It was not, however, until in his fifty-seventh year, when his attacks became more severe, that he had to adopt the use of the mahl stick in painting, a utensil which few painters have sufficient nerve control to do without at any time. The fact that "not the remotest trace of approaching old age, not the slightest failing of mind or skill, can be detected even in his latest works" testifies that he had not declined up to his sixty-third year.

Of Turner, the last of this sextette of artists, we know that his health was perfectly sound, that he walked his twenty miles or more a day with ease, often sketching as he walked. He could work fifteen hours at a stretch without weariness, and his digestion was so vigorous that all extremes of living were alike to him. He "worked harder and produced more than any artist of whom we have any record." As Hamerton said, "Man is an intelligence served by organs and few intelligences have been better or more regularly served than Turner. His nervous system was so sound that he could work anywhere and everywhere." At the age of sixty-seven he had an illness, but it was not until seventy that we "are sure that he declined as an artist, . . . when his health and with it, in a degree, his mind, failed suddenly."

Among musicians we have no trouble in selecting the greatest. All others stand on a lower plane than Bach, Beethoven and Brahms. Those who mark the physical imperfections of men of genius will at once say that Bach was blind and Beethoven deaf. Bach did become blind at sixty-eight, after such severe use as perhaps no other eyes ever received, and Beethoven (strange fate) did become deaf, his affliction beginning at twenty-eight years. This terrible defect undoubtedly affected his general health materially, though his vigor seemed little impaired.

Up to the time of his failing sight, in 1747, we have no record of any sickness of Bach, while his untiring energy, as shown in his vast amount of work, bears sufficient testimony to his great vitality. He was able to be, besides a marvelous maker of music, " a particularly excellent father (he had nineteen children), friend and citizen."

Of Beethoven it is sufficient to know that he was spoken of as the " image of strength," as power personified—that there was concentrated in him " the pluck of twenty battalions." He was a great walker, and no day in Vienna, however busy or stormy, passed without its constitutional, " a walk, or rather run, twice round the ramparts . . . or further into the environs." Notwithstanding the constant effect of his deafness and the fact that digestive disturbances early began to keep him company, " his splendid constitution and extreme fondness for the open air counteracted his physical defects and even in his last illness " " his constitution, powerful as that of a giant, blocked the gates against death for nearly three months " and during the struggle his fancy seemed to soar more vigorously than ever.

Of the third of the great B's, Brahms, burly, well-knit, muscular, the " very image of strength and vigor," there is little to say beyond the fact that he was never sick. Widmann says " he displayed an absence of physical sensitiveness of which few could boast." " His constitution was thoroughly sound, the most strenuous mental exertion scarcely fatiguing him," and he could " go soundly to sleep at any hour of the day he pleased." Like Beethoven, Brahms was a lover of nature and a tireless walker.

If we step down from the company of the greater to that of the lesser gods of music, Mozart, Weber and Chopin are presented by the advocates of the feebler life for genius. Chopin we have already mentioned. Weber was weakly and tuberculous. With health and strength he might have equaled Beethoven. Mozart, though of inferior bodily presence, did a lifetime's work before his early death from typhus fever. He was trained by his father to take care of himself and would probably have lived the allotted time but for the stress of want, and overwork for thankless and unremunerative patrons.

Over against these few exceptions we could set quite a company of master musicians full of health and vigor. Handel and Haydn with their " continuous, sunny healthfulness." Spohr, " of sound health and herculean frame," his life filled with uninterrupted success and honors up to seventy years.

Then there was Wagner, " the best tumbler and somersault-turner of the large Dresden school," an adept at every form of bodily exercise, who " still performed boyish tricks (such as standing on his head) when nearing three score and ten." Despite dyspepsia and a susceptibility to erysipelas he always possessed "an unusual amount of physical energy." Verdi is another example—the old-man-progressive produced his greatest works after he was seventy, his "Otello" being first performed when he was eighty.

The executive musician especially needs a good physical balance, for the strain upon his nervous system is very great. We find no invalids in the list of great singers. Liszt, Rubinstein and Paderewski were physically strong and robust, while Joachim and Ole Bull were men of long, healthful and vigorous life. A partial exception to the rule is met with in that strange personage Paganini, the severity of whose early training damaged an already frail constitution. He was extremely temperate and had a marvelous use of muscle and nerve in the weaving of his musical magic. He died at fifty-six.

When it comes to the philosophers, among the ancients we must include Socrates, Plato and Aristotle. From what has come down to us we know that Socrates served as a hoplite, or heavy foot soldier, and that in more than one campaign he was conspicuous for both bravery and endurance. He was short, thick-necked and corpulent, although thoroughly schooled to temperance. He was evidently as finely robust physically as morally, until his untimely death at the age of sixty-six.

Of Plato we are positive only that he lived to be seventy years of age. From his writings we know how greatly he appreciated bodily development and well-working.

Of the details of Aristotle's life we know little, but there is no evidence to signify that he was not always in at least fair health, and it would seem from the amount of his work that he must have been a man of great vitality.

Philosophy does not seem to have agreed so well with the moderns, and it seems to have fitted better into inferior somatic conditions than a combination of brain and handiwork as in the artists and musicians. Hobbes was an enthusiastic tennis player until beyond seventy and wielded his pen vigorously after he was ninety. J. S. Mill was "healthy and high spirited." Comte, Leibnitz, and, after his youth, Descartes, were all in fair health and strength, but Locke, Spinoza and Kant could not boast such physique. Of the three, Spinoza alone was short lived, Locke living to the age of seventy-two and Kant to that of eighty.

Spinoza, always of delicate constitution, was early afflicted with pulmonary disease and suffered also from ague. He was extremely abstemious, which did not tend to improve his condition, but it was not until he was forty that he became a confirmed invalid. In Locke's case prudent habits seem to have kept a delicate constitution in even balance of health up to the age of thirty-five, but from this time on, with all his care of himself, he was seriously handicapped by complicated and increasing infirmities, chief of which were "chronic consumption and asthma." All this "painfully impeded his schemes of work and occasionally induced states of mind altogether at variance with its otherwise robust character." He was twenty years in writing his famous "Essay on the Human Understanding" and it was done "by incoherent parcels and after long intervals of neglect." No man was ever more impressed with the value of health and vigor and his "Thoughts on Education" begin with the bitter words, "Our clay cottage is not to be neglected"—for "he whose body is crazy and feeble will never be able to advance in it."

Immanuel Kant is a shining example of what can be done in economizing the bodily forces, and of how much may be accomplished in the way of mental work by a frail body which is kept in a fair state of health. "Possibly a more meager, arid, parched anatomy of a man has not appeared upon this earth." "His organization was so delicate that he was extremely sensitive to impressions from external objects, and Jachmann relates that a newspaper fresh from the press and still damp would give him a cold." "His digestive organs were early deranged and gave him perpetual trouble." Yet he said of himself that he was healthy, "that is in my usual weak way." If we can trust DeQuincy, "Kant's health was even exquisite." That "weak way" interfered with his work and he exclaimed: "Think of it, friends! Sixty years old, constantly disturbed by indisposition in plans only half completed." "He spoke of himself often under the figure of a gymnastic artist, who had continued for nearly fourscore years to support himself upon the slack rope of life without once swerving to the right or to the left." We owe to Kant's clock-work regularity and temperance of living the product which his fine brain produced, and his vast influence upon the world.

Herbert Spencer is another example of a philosopher who is put down as an invalid, and invalid he was for the greater part of his life after thirty-five. At thirteen he became homesick at school and started one morning at six for home; walked forty-eight miles the first day, forty-seven the second and twenty miles the third day, and in the whole time had very little to eat. It would seem that only a child of very remarkable vitality could have carried out such a program and survived. As he himself says, "It can scarcely be doubted that my system received a detrimental shock . . . although there was no manifest sign of mischief." As a boy he excelled in running and was a good skater.

At sixteen he speaks of himself as "strong, in good health, and of good stature," but easily excited and kept awake.

At twenty-one as a draughtsman he worked from eight in the morning to twelve at night and one day a week to three A.M. Keeping these hours, either with his routine or literary work, he found himself at twenty-eight becoming sleepless. At thirty-five "the mischief had been done." "His nervous system finally gave way." A night of sound sleep became unknown to him, while distress in the head and dyspepsia kept him company the remaining days of his life. Still, it must be kept in mind that even at sixty he writes, "My vigour is pretty well shown by the fact that I found myself running up stairs two steps at a time" and "it seems remarkable, considering my frequent bouts of dyspepsia and perpetual bad nights, I should have retained so much vitality." It was only between sixty-two and sixty-nine that he could truly be called an invalid with a capacity of only a few lines of work per day.

The work of science has often been carried on by men in not the best of health, nor of especial vigor. It has also so fascinated many of its disciples as to lead to bodily unbalancing from over-application to a sedentary calling. Galileo did an enormous amount of work, but his health was sometimes indifferent and he suffered from a number of illnesses. Darwin inherited a strong constitution and up to his voyage on the *Beagle* was "well, and vigorous and passionately fond of outdoor sport." His chronic nervous weakness seems to have been brought on by the privations and over-exertions of the five years' journey of exploration. By careful limitation of work and removal of unnecessary distractions, he lived to a good age, and accomplished a large amount of work.

Sir Isaac Newton was in fair health most of his days, though, from excessive mental work and absent-mindedness about eating, he had a nervous breakdown at fifty-four from which he was some months in recovering.

Franklin was proud of his physical attainments. "He was as temperate as it was possible to be in that age." He was an expert swimmer and at eighty he was fond of displaying his strength. He nearly died from attacks of pleurisy, and late in life he fell a victim to the diseases of the age—gout and stone. On the whole, Franklin throughout a long life may be considered an unusually vigorous and healthy person.

Huxley, strong and vigorous, worked at a terrible pressure and wore out before his time, but there have been many other scientists of note whose health was more constant, as Faraday, Tyndall, Agassiz and Lord Kelvin.

When it comes to men of letters, it would seem that health and vigor might be less frequent. The conventional poet, like his verses, seems a part of the world immaterial, until we become intimately acquainted with him and find that he too lives on bread and butter, beefsteak and onions.

Of the dramatists, Shakespeare, for aught we know, was reasonably healthy and vigorous. Molière led a busy, combative existence. Play-houses were even worse in hygienic conditions then than now, and cold and fatigue seem to have injured his health. He continued his acting and writing with scarce abated vigor until his fifty-fourth year, when, just after playing the part of the invalid in the "Imaginary Invalid," he burst a blood vessel in a fit of coughing and did not survive more than half an hour. Molière was described as "neither too stout nor too thin, tall rather than short; he had a noble carriage, a good leg and his complexion was brown." This eye-witness saw nothing especially sickly or feeble about the great player and playwright. Goethe, great as scientist and novelist as well as poet—a universal genius—was likened in his youth to an Apollo. His frame was strong and muscular. In his mature years, Hufeland, one of the great physicians of the time said that "never did he meet with a man in whom bodily and mental organization were so perfect. Not only was the prodigious strength of vitality remarkable in him, but equally so the perfect balance of functions."

Goethe knew what sickness meant. From self-confessed youthful excesses ("However sound and strong one may be, in that accursed Leipzig one burns out as fast as a bad torch") he suffered some severe chest affection and he was for a time "uncertain whether he was not yet consumptive." In mature life he more than once suffered from renal colic and from rheumatism. Such attacks had but a transient effect, however, upon his wonderful physical make-up. He was a big eater, as have been so many great men (energy for work must be supplied by bread and butter) and he was a profound sleeper. Even when beyond the age of eighty he was still so vigorous as to produce truly remarkable works.

Of the personal history of Dante we know little, but he was evidently made of elastic stuff and we read of no sickness which came to him in his wanderings. He took part in the civil wars of his city. He died at fifty-six of a fever contracted in the lagoons of Venice.

Milton possessed a "peculiar grace of personal appearance." He seems to have been in good health up to about forty years, when he lost ground somewhat, and in later life, especially during his blindness, his health declined. Speaking for himself at forty-seven, he says: "Though thin, I was never deficient in courage or in strength." He exercised regularly with the broadsword and says he "was a match for any one." His blindness seemed to accompany the onset of gout, a disease hardly due in his case to intemperate living.

Of the great modern English poets, Tennyson was a man of splendid physique—"one of the finest-looking men in the world." In regard to his health he said of himself: "What my infirmities were I know not unless short sight and occasional hypochondria be infirmities."

Wordsworth, according to Hayden the artist, was of very fine heroic proportions. He led a simple life and was healthy and vigorous. He was "as robust as one of the peasants of his native Cumberland." At sixty he walked fifteen to twenty miles a day; he was "still the crack skater on Rydal Lake, and, as to climbing mountains, the hardiest and youngest are yet hardly a match for him." Even at seventy-three he was "wonderfully well and full of vigor."

Browning had some headache, sore throat and colds, but his son wrote, "He was the healthiest man I ever knew," and another biographer called him "brilliantly healthy." Until past seventy he could take long walks without fatigue, and endure an amount of social and general physical strain which would have tried many younger men.

If we turn to the writers of what Dr. Johnson called "irregular and undigested pieces"—of essays—in the expectation of having only invalids for wielders of the pen, we find the inventor of this beautiful form of literature, Montaigne, speaks of his body as "strong and well knit." "My health is vigorous and sprightly, even to a well-advanced age, and I am rarely troubled with sickness." He considered health "the fairest and richest present that nature can make us." It was not a time of long living and Montaigne considered that he had reached a "well advanced age" when he had passed forty. At forty-five he became afflicted with stone in the bladder, which doubtless shortened the days of what was for him old age.

Bacon's health was always delicate. He speaks of himself as "a man of no great share of health, who must therefore lose much time." His nervous system seems to have been exceedingly sensitive and he swooned upon slight cause. By careful management of his health by the admirable rules he has laid down for others, he survived the storms of his political career and his friends expected for him a good old age. In his sixty-sixth year, when driving in London, he suddenly hit upon the notion of using snow as a preservative. He stopped his carriage, purchased a fowl and with his own hands stuffed it with snow. He was seized with a sudden chill, the cold and chill were succeeded by bronchitis, and he died within a few days. Bacon, like Kant, deserves to be remembered as one who lived his philosophy and who with small resource of vital energy kept that at its best and so made the most of the marvelously fine thinking machinery with which he was endowed.

The more modern essayists, Lamb and DeQuincy, did not present a very vigorous aspect. DeQuincy was, according to Carlyle, "one of the smallest man figures I ever saw . . . you would have taken him for the beautifullest little child." Yet he was not so frail even though small, and while hypersensitive to pain "he was wiry, and able to undergo a good deal of fatigue. Indeed he was a first-rate pedestrian, and kept himself well in exercise. He considered that fourteen miles a day was necessary for health. He never took cold, and even at seventy he was active and vigorous." He easily outwalked James Hogg, who was much younger and who has been described as "hale and hearty as a mountain breeze." So much for this "invalid."

Lamb, who had "the appearance of an air-fed man and whose light frame" with its "almost immaterial legs" "seemed as if a breath would overthrow it," was spoken of as being "as wiry as an Arab," and Proctor said he "could walk during all the day."

In this list of worthies Carlyle and Doctor Johnson should have a place. The great lexicographer "in his bodily strength and stature has been compared to Polyphemus." Boswell speaks of his "herculean strength" and of his "robust health," which was not in the least affected by cold. His great appetite and his intemperance in tea have gone into history, but he could fast for two days without difficulty, and his frequent prayer was "that I may practice such temperance in Meat, Drink, and Sleep, and all bodily enjoyments as may fit me for the duties to which thou shalt call me." Notwithstanding his tendency to melancholia and some attacks of gout he was anything but an invalid.

The Seer of Chelsea was the descendant of a long line of "hardy and healthy Scottish dalesmen." He grew to manhood, he tells us, "healthy and hardy." It was not till after his twentieth year that "he became aware that he was the miserable owner of a diabolical arrangement called a stomach." From this time on he suffered from dyspepsia, headache and sleeplessness. He gave vent to his irritability by lamentations so grotesquely exaggerated as to make it difficult to estimate the real extent of the evil. According to Froude he had a Titanesque power of making mountains out of molehills. Notwithstanding his complaints he lived a vigorous, combative life to a good old age and even at eighty-two was able to walk over five miles a day.

Among novelists, Sir Walter accuses himself of perhaps "setting an undue value" on health and strength. For him "bodily health is the mainspring of the microcosm. . . . What poor things does a fever fit or an overflowing of bile make of the masters of creation?" He writes in his journal, "My early lameness considered, it was impossible for a man to have been stronger or more active than I have been, and that for twenty or thirty years. Seams will slit and elbows will out, quoth the tailor; and as I was fifty-four in August last, my mortal vestments are none of the newest." As a young man he was a desperate climber, a bold rider and a stout player at single-stick "and he walked twenty or thirty miles without fatigue, notwithstanding his limp." Attacks of rheumatism, renal colic and the awful burden of debt under which he toiled so heroically, finally overcame a constitution which, as he said, was "as strong as a team of horses."

Victor Hugo "was born with a thoroughly sound constitution" and he was "in full vigor when many great intellects have passed into their decline."

Balzac "was eminently sound and healthy," "his whole person breathed intense vitality," yet those who were in the secret of his life asked with pitiful wonder how any man could find the time and physical endurance sufficient to support the enormous work of his "La Comédie Humaine."

Dumas's "health was well known and stood firm against the almost wanton test he imposed upon it." Such abuse plus the writing of "1,200 volumes" did not seem to impair his physical vigor until after his sixtieth year.

Thackeray was described in 1813 as "a stout, healthful, broad-shouldered specimen of a man." He knew no such thing as taking care of himself and suffered the consequences, though it took time to undo him. Edward Fitzgerald tells us how he wrote "reviews and newspapers all the morning; dining, drinking and talking of a night, managing to preserve a fresh color and perpetual flow of spirits under a wear and tear of thinking and feeding that would have knocked up all the other men I know two years ago at the least." Thackeray had the best medical advice, but, as he said, "What is the use of advice if you don't follow it? They tell me not to drink and I do drink. They tell me not to eat and I do eat. In short, I do everything I am not to do, and, therefore, what is to be expected?" Thackeray has the unenviable distinction of being one of the comparatively few men of genius who have undervalued health. He preferred, as he acknowledged in his exaggerated style, to "reel from dinner party to dinner party, to wallow in turtle, and to swim in claret and champagne." It is little wonder that the time came and came early (at fifty-one) when "he could not work at will"; when upon taking up his pen "his number of the magazine would not come."

In Dickens we have a man of superlative energy. After writing until twelve "he came out ready for a long walk . . . twelve, fifteen, even twenty miles a day were none too much for Dickens . . . swinging his blackthorn stick, his little figure sprang forward over the ground, and it took a practiced pair of legs to keep alongside of his voice." Dickens himself relates "a special feat of turning out of bed at two, after a hard day, pedestrian and otherwise, and walking thirty miles into the country for breakfast."

He was temperate in meats and drinks. James Fields said he had "rarely seen a man eat and drink less," but he was not temperate in his outlay of energy. As his self-chosen biographer said, "He never thought of husbanding his strength except to make fresh demands upon it," and besides, "his notion of finding rest from mental exertion in as much bodily exertion of equal severity, continued with him to the last." All this was more than even Dickens could stand, and, as in the case of Thackeray, the machinery began early to show wear, though it was not until he was fifty-six that there was any manifest abatement of his wonderful forces.

Among statesmen and warriors the strong and healthy predominate, though there are exceptions. As already noted, Bacon was not robust, nor were the Duke of Luxemberg and the Prince of Orange, mentioned previously. The greater Prince of Orange, William the Silent, was of a very different type, as were Marlborough, Gustavus Adolphus, Cromwell, Frederick and our own model of physical manhood, Washington. Among statesmen we may compare with Bacon such men as Gladstone, Bismarck and Lincoln, all of them giants in physical powers.

It goes without saying that the superb will of Napoleon "had its roots in an abnormally firm vitality." His bodily machinery, of which he in some ways took fastidious care, furnished him with a supply of nervous energy at Napoleonic pressure which sufficed for a working day of from fifteen to eighteen hours. He said of himself that he "was conscious of no limit to the amount of work he could get through." It is interesting to note that his critics have made careful study of his physical condition as affecting the outcome of his last compaign. Most of them are of the opinion that there was a visible physical decline, one dating this from the cold of the Moscow campaign; others from his confinement at Elba, while one who knew him well attributed the lassitude which now and then came over him to the feeling of perplexity in the new conditions under which he worked. Whatever may have brought it about, the Napoleon of Waterloo "was no longer the Napoleon of Marengo or Austerlitz, and, though he was not broken down, his physical strength was certainly impaired."

In selecting the representatives of various kinds of brain work, the author has tried to be unbiased by his thesis, and for good-measure allowance to the common notion, has admitted a few names to the list, such as those of the Duke of Luxemberg, which would hardly nowadays find place among the immortals. Of those mentioned, some seventeen may be said to have been more or less delicate from childhood, though most of these were by no means sickly much of the time. Some eight or ten more, like Darwin and Spencer broke down after a healthy, vigorous youth and early manhood. At least fifty were robust and many of these remarkable for physical powers. The remainder were probably above the average in physical endurance, even if their physique and health was not so impressive.

Genius, superior mental power, or whatever we may choose to call that quality which lifts one man above his fellows in any line of work, does not prefer to have lodgment in inferior bodies, and when this so happens, it finds itself sadly handicapped. Though the soul tides may at times rise very high in those of frail physical nature, the ebb is always lower and more prolonged than in those possessed of greater vitality. The handicap of weakness and ill health has been most recognized by greatness itself, and we have eloquent comment upon the value of health and strength from such men as Plato, Bacon, Locke, Montaigne, Addison, Wesley, Spencer, Molière, Franklin, Carlyle, Beecher and others.

The handiwork of an artist or executant musician is, in a way, a record of his physical condition, and for him to do consistently good work health must be equally constant. Even Michelangelo failed as a sculptor in his later years, though he flourished as an architect. The combination of brain and hand work is in itself conducive to better health than brain work alone, which may also help account for what, in our brief preceding list, would seem to indicate the superior health of such men.

The pursuit of religion, philosophy and science may be more spasmodic, but even here health and strength add greatly to the product, in both quality and quantity. Had the more vigorous men of the middle ages devoted their talents to spiritual affairs, the reformation might have come earlier or might not have been necessary. To-day the church recognizes that the adequate unfolding of the bodily forces is necessary to the full use of the mental powers with which one may be endowed. Asceticism has given place to temperance. Crusades for the sake of a sepulcher are succeeded by crusades against conditions which war upon physical sanity.

It is inspiring to know what has been accomplished under heavy handicap, but it is sad to contemplate what the same mental powers might have accomplished had the handicap never existed. There are quite enough other agencies for tempering and annealing the soul without preventable sickness and infirmity, and an untimely end rings down the curtain before the possibilities of the player are fairly exhibited.

One can not distinguish a fool from a philosopher by either his appearance, physique or vegetative capacity, but, given the finer mental endowment, he in whom that equipment is backed by superior physical balance and endurance is sure to prove the man of larger accomplishment in every sphere of endeavor.

WOMEN TEACHERS AND EQUAL PAY

By Mrs. ELFRIEDA HOCHBAUM POPE

ITHACA, N. Y.

ARGUMENTS opposing the progress of women are apt to begin with a praise of "typical, sweet" femininity, continue with a retailing of the fixed and inherent failings of women, add instances of selfish action on the part of individual women, such as taking away a man's seat, obstructing a man's view, getting in front of him in a ticket or bank line (forgetting that women have been carefully educated to consider themselves as creatures of privilege), and end with visions of race-extermination.

Arguments opposing the equal remuneration of women with men, where the services rendered are of equal value, have not escaped contamination from this kind of logic, in witness whereof we can point to two articles published in the *Educational Review,* in the past year, entitled "The Monopolizing Woman Teacher," by C. W. Bardeen, and "Women and 'Equal Pay,'" by Arthur C. Perry, Jr.

It was in 1869, forty-four years ago, that J. S. Mill wrote:

> The general opinion of men is supposed to be, that the natural vocation of a woman is that of a wife and mother. I say, is supposed to be, because, judging from acts—from the whole of the present constitution of society—one might infer the direct contrary. They might be supposed to think that the alleged natural vocation of women was of all things the most repugnant to their nature; insomuch that if they are free to do anything else—if any other means of living, or occupation of their time and faculties, is open, which has any chance of appearing desirable to them—there will not be enough of them who will be willing to accept the condition said to be natural to them. If this is the real opinion of men in general, it would be well that it should be spoken out.

After nearly half a century's progress of civilization and thought, it remains for an educator to speak out this very sentiment in the following words, apropos of the granting of equal salaries to men and women in the schools of New York City:

> Suppose society were to embark upon a world-wide attempt thus to abrogate natural and economic law by legislative fiat. A severe temptation would be placed upon all women wilfully to disown their natural mission in the scheme of nature. With the material reward before them double that which the normal life would yield, they would become unwilling to renounce the larger for the smaller. There would follow a gradual but sure lowering of the wage standard set for both men and women until both sexes were on a basis of self-support only. Under this condition neither sex could be expected to undertake the support of a family and the family would disappear.

This strain immediately gives us our clue, for we have heard it often before, as when we laid claim to souls and to minds, and though the gods of nature and of economics are appealed to, we know that we are dealing with the ancient sex prejudice, conscious or unconscious, which the present day is gradually overcoming with the increasing realization of the sanctity of human personality irrespective of sex.

It was still longer ago that Wendell Phillips said, in 1851:

> When Infinite Wisdom established the rules of right and honesty, he saw to it that justice should be always the highest expediency.

What is the clear and natural justice of paying women teachers equally with men? Two persons are expending an equal amount of energy in rendering services of equal value. In exchange a return energy is given in the form of financial reward. There is no reason why the return energy should diminish in quantity, the moment the recipient is a woman, but retain its normal volume if the recipient happens to be a man. Is it not an ancient principle of justice that the laborer is worthy of his hire?

The immediate reply to this will be: It is just that a man receive more, because he has to support a family. And Mr. Perry, whose argument rests on the ethics of not violating the principle of the "market-value" of teachers, unmindful of the principles of the bargain counter, says:

> The fact that the great majority of men have families to support has led to an economic balance whereby men's wages expressed in terms of money are such as enable a man to support his family.

This is plainly an economic fallacy, since wages and salaries are not a result of a nice adjustment to personal and family needs. A man supports his family in accordance with his wages; he does not receive wages in accordance with his family. And does the man who has no family receive less and the woman who has a family receive more? Is it the custom to arrange salaries on a sliding scale in accordance with celibacy or marriage among men? Why is it that late marriages are so common? Is it not because the incomes earned are thought not to be sufficient for the support of a family? Does any one know of a scheme like the following? An instructor in a university receives a salary of $1,000 a year, and manages to be fairly comfortable on it. He marries, and the trustees grant him an additional $100. He has a child, and his income is increased again by $100, and again for every succeeding child. We leave it to the trustees to estimate the proper value of a child on the basis of a full professor's salary. Now the wife dies, and $100 are subtracted from his salary, and as his children become self-supporting the salary is reduced in proper measure, leaving him, when all his children have departed in the *status quo* with his original salary, for as a single person he requires no more. No doubt such a sliding scale would be most acceptable to college instructors so long as it went up and would encourage early marriage. The only bitter pill would be to have the scale slide down. In the actual world, however, the bachelor does not receive less because he has no family and the married man does not receive more because he has. The woman teacher still generally receives even as high as fifty per cent. less than a man, whether she has a family to support or not.

But, it is replied, the single man expects to have a family in the future for which he must lay a financial foundation now. Is then the young woman not expected to have a family? Will her savings be less of a help to the future family because they are feminine? Or will they go farther for the same reason and do they therefore not need to be so great? Is not the family the ultimate loser by this principle of stinting women, since the family funds are derived from one source alone? After marriage, if both father and mother are capable of earning, is the family not the gainer if the earnings of the mother are at the same rate as those of the father? If the father dies, is the family not the gainer by having full support instead of two thirds or thereabout?

The highest expediency that attaches to natural justice is brought out by an economic principle that few will dispute. Women who are discriminated against in the matter of pay immediately become a cheap labor class, and cheap labor is bound to injure the cause of well-paid labor. This injustice bears within itself the germ of that economic vengeance that has wrought such harm in the profession of teaching, and has been so conducive a factor in driving men out of the ranks. This principle has been brought home to the laborers in industry, and in the ranks of labor the feeling is becoming wide-spread that men and women have a common cause, and all movements that make for economic improvement for women are apt to find there much greater support than in the so-called higher ranks of society. The world of trade could easily appreciate the principle also. If a woman set up a successful business with a margin of profit 25 per cent. or 50 per cent. less than that of her masculine competitors in the same business, would the men not immediately protest and combine to force her to sell at their terms or to wreck her trade?

It has been stated that where men and women teachers receive equal wages the men will vanish. This assertion, however, seems to rest on the implication that the wages are low, for when it has been suggested that women receive the high wages of men, opening the way for a natural competition irrespective of sex, the answer has frequently been that the natural result of this competition would be that the men would be chosen and the women would be left. Now certain qualities excellent in a teacher have been conceded to women. For instance:

Taking it altogether the fine women who as a whole make up our teaching force exert a healthful influence over their boys and are successful disciplinarians.

The woman is quite as apt as the man to establish that connection between her mind and the child's which is the foundation of instruction.

Even a woman's knowledge is apt to be sufficient, at least for the high school. But it is possible that these virtues exist only at a low rate of wages and take wings at an equal high rate. It is one of the characteristics of arguments springing from the traditional view of women that quite opposite assertions are made to fit the same theory. Thus women are better than men and they haven't so pronounced a moral sense; they have no time for professions, and they waste time in frivolity; they are thrifty, and they are extravagant; they are physically weak, and do the physical work of the household; in the case of women teachers, they drive men out of the profession of teaching, and they can not compete with men; and again: they are not worth so much because they leave teaching to marry, and they are not worth so much because they do not marry. Perhaps it would be safest to adopt the high and equal rate of salaries even if it leaves man, as the superior teacher, victor in the field, since in education we are concerned with the best results obtainable. We sincerely trust and believe, however, that even at an equal high rate of pay it will be realized that men and women are needed in the schools as in the home. Woman is as much a factor in human life as man, and her interpretation of life and knowledge is just as necessary for a complete view. If there is no difference between the masculine and the feminine viewpoint surely there is no reason for discrimination. But the very possibility of a difference of conception is of immense potential value educationally, and forbids a lessening in value because of sex. Surely if we need the feeling for and interpretation of the "Arma virumque cano," the destructive ele- the feeling for and interpretation of the

Prima Ceres unco glaebam dimovit aratro,
Prima dedit fruges alimentaque mitia terris,
Prime dedit leges: Cereiis sunt omnia munus.
Illa canenda mihi est

of the constructive element of civilization by representation through fostering womankind, especially as arms are beginning to lose some of their prestige. But as long as we regard education as a thing to be provided, in large measure to be sure, but at as low an expense as possible, we shall encourage the cheap labor of women teachers and the proportion of men and women will not be normal. As soon as we realize that education is an investment whose returns are to be measured in quality and diversity of knowledge and of character, we shall be glad to invest capital in that enterprise, though for intangible and indirect returns, and we shall recognize that woman's share in the product is as important as man's.

As far as the theory goes, held by Mr. Perry, that a budget permitting the expenditure of only a certain fixed amount for teachers' salaries forces a reduction of the men's salaries because of the necessary averaging, it is a matter of fact that a budget can always be increased where the need is felt to be actual. Even the "practical administration difficulties" of a huge system like that of New York City should not prevent meeting actual needs. In smaller systems, the budget can always bear an increase when a man teacher is needed who will not come at the salary allotted to women. In women's colleges the principle of exclusive femininity is inevitably disregarded through the crying need of some masculinity, possible naturally only on the teaching staff. A certain proportion of men is felt to be absolutely necessary either for the sanity of the educational process or for the protection of the masculine teachers themselves from the danger of feminization. When that proportion is threatened the budget does not stand in the way. And thus it is possible for a new-fledged doctor of philosophy, untried and without teaching experience, simply because he is a man, to obtain a salary 25 to 50 per cent. higher than that of a woman professor who may have greater knowledge, greater experience and every requisite for a successful teacher. Is it a wonder under such conditions that we do not find women stimulated to do more productive work? It is quite possible, too, that the youth has no obligations whatever, and that the woman has financial and family obligations. It is possible that the case of obligations may be *vice versa.* It is certainly wrong for us to assume that the man has always the financial burdens to bear, the woman never. Can we, who have taught in college and high school, not name numerous cases of that kind? Do we not also know of men teaching in the high schools who were merely taking advantage of the relatively good salaries they could obtain as teachers until they could get a foothold in another profession, thereupon to leave the teacher's calling forever? And have we not seen in the same schools women teaching at lower salaries, some of whom were supporting relatives, sending brother or sister to college, and some even husbands?

As far as the theory of the market value of the teacher goes, we need only point to Germany to be covered with shame for our mercenary attitude towards education. In that land swarming with Ph.D.'s, despite the enormous supply, the teacher, masculine, to be sure, receives a very fair salary and generous pension provision, without regard to a market value determined by the laws of supply and demand.

The same principle and view of life that reduces the pay of the woman teacher reduces the pay of women in whatever field. It forces girls in factories and department stores into lives of shame, and gives the washerwoman who supports a family (and who ever hears of a washerwoman who has not a family and sometimes a husband, too, to support?) for labor that is by no means unskilled $1.25 a day, while the unmarried Italian who digs ditches gets $1.75 or $2.00.

There are other causes, to be sure, besides sex discrimination, which have encouraged unequal wages. Foremost among these is that women have not realized their own worth, have not demanded equal wages, have not been able to do so, in fact, through lack of organization. Moreover, in the past, women were crowded into a very few callings, among which teaching was a very prominent one, and thus they competed with each other. In the past, too, when women left the home to work, it was because they were forced to. Any addition, however meager, to the family income was welcomed. In the higher walks of life, again, women were content to earn the luxuries, depending on their families for the home and necessities. The parents, meanwhile, took pride in the fact that their daughters did not "have to" work. The effect on the worker, on the profession and on the family was bad. You got cheap labor, poor and half-hearted labor, and the family was out something, too. With modern times has come the realization that labor and self-support are necessary for the dignity, the character and the development of women, and that the welfare of society and of the family demands that she become a contributor of wealth rather than a mere consumer. But we shall not have the best efforts from women in professions until professional rewards are open to them. That increase of salary, with advance in position, based on merit alone is a necessary stimulus no one can deny. It will be well when all women realize the harm that is done, not only to their sisters, but to their profession, when they permit themselves to be stamped as cheap labor.

And as for the man, we fear that it is not chivalry that fails to recognize the equal value of woman's labor with his own. We fear that it is not chivalry that frowns upon the married woman teacher. And so we hope that he will be moved to a more generous spirit when he realizes that woman's loss is his own. The modern marriage is a halving of resources, whereas the colonial family was a doubling of resources. What the wife formerly actually produced by the labor of her hands in the way of food, clothing and household supplies, in a personal field of industry, quite free from competition either with her own sex or with the other, she must now produce in the form of the wherewithal to buy the food, clothing and household supplies. Her field has become wider, she must compete with others, but her capabilities have also grown wider, and must increasingly grow as she, with her husband, progresses farther and farther from that rude and simple life that was enclosed by four walls and called forth only a few of the manifold potential powers of hand and mind. Men must come to an insight of the economic waste of an unproductive life for their women, or of production without fair returns. But perhaps they will also begin to realize forms of waste that are not so material. When women, through motherhood, have that insight into the growing mind that no one else can possess, we prefer to have them withdraw from the profession of teaching. Is there no sense of a tremendous pedagogical loss? Because women alone can be mothers is that a reason that they should be nothing else? Shall their souls and their minds be refused their proper occupations even after motherhood is past, and shall they be condemned to atrophy because of a great though not exclusive function? Is there no insight into this spiritual waste? Does not society suffer from all these forms of waste? When we demand that a woman sacrifice her talents and ambitions, in other words, her natural powers, in order to become a wife and mother, we must not close our eyes to the fact that it is a sacrifice, and that sacrifice means waste. Our marriages rest upon a wasteful basis, and must become increasingly wasteful as civilization takes away more and more woman's former productivity in the home, unless she is granted a free field for her energies outside of the home. The young woman teacher must look forward, then, to contributing her share to the establishment of the home by her earning powers before she is married and afterwards when she can. The more she earns, the better. With this earnest view of the necessity of contributing to the family support, her profession will become something more than a means of occupying durance vile. It follows as the night the day that early marriage will be encouraged where two are contributing, and when marriage does not mean sacrifice and dependence on one side, and sacrifice and a heavy burden on the other side. Men, while necessarily bearing the financial burden alone for some of the time of married life will yet not be sacrificing more of their individual energy to the family than the mother who is giving of her life substance. For the woman a life of development and service will be added to motherhood, as a life of development and service are added to the fatherhood of the man. For we conceive of fatherhood as something more and nobler than the occupying of all one's time and energies with earning money for the children. Will there not be more time for fatherhood when the pressure of financial responsibility is lessened? And who knows what rich rewards of womanly forces future society will reap from allowing women to develop according to the divine promptings from within rather than by rule of man. For the full honors and rewards of effort, whether in the household or in scientific academies, have never yet been granted to women. They have never yet been permitted to drink freely of the cup of life. Let the men who openly or covertly regard women as their inferiors consider this, and for the sake of the future give her an equal chance. It was Schopenhauer who said, in quite a different connection, we may be sure, "First they bind our arms, and then they sneer at us because we are impotent." And it was Wilhelm von Humboldt who wrote of "the absolute and essential importance of human development in its richest diversity." If women are to develop humanly, they must not be arbitrarily cut off from the inspirations and the rewards that stimulate the growth of human mind and character.

A discussion of this general nature seemed necessary, because it was felt that prejudice against remunerating women teachers equally with men was mere prejudice based on a failure to grasp the wide bearing of the forces at work in the natural and historic evolution of women. We have still to consider the fact that there will always be some women in the profession of teaching who no longer look forward to marriage, though the *terminus ad quem* of this hope is nowadays very problematical, and who have no dependents whatever. This will be true, even after women have become large factors in all the professions, in most of which they already are represented, and after they have invented some new ones. But their number will not be very much greater than that of the single men in like circumstances unless women preponderate immeasurably in the population. If there were an injustice in giving them the full return for their labor, it would yet be less than the sum total of injustice of the old system. Moreover, dare we not hope, with the special penchant of women for charity and philanthropy, with the noble roll of "old maids" who are milestones in the progress of civilization, Frances Willard, Florence Nightingale, Clara Barton, Jane Addams, that the surplus energy earned will go for the improvement of society? Society needs the development of all its latent energies for its own purification and advance. Who dares, unless he was present when the foundations of the earth were laid, brand woman's energies as inferior because proceeding from a woman, and say to her, "Hitherto shalt thou come, but no further"?

THE BUSINESS MAN AND THE HIGH-SCHOOL GRADUATE

By JAMES P. MUNROE

BOSTON, MASS.

NOT so very long ago the merchant, the manufacturer, the teacher, the young man, and the public in general were under the spell of the boys' magazine, wherein the first prize—the prize of partnership in the business and marriage with the "old man's" daughter—is awarded to the boy who keeps his hands clean, brushes his shoes, picks up stray pins on the office floor and carefully saves the twine from his employer's parcels. To do these things is indispensable; but besides this, the aspirant for partnership (and the daughter) must also—according to the story-books—write a perfect hand, never make a mistake in addition, never forget a message, never have a deceased grandmother on the afternoon of the ball-game, never think of aught except mastering every detail of the business, never be anything, in short, but the kind of prig that real, red-blooded boys are not.

The so-called Manchester school of political economy was built around a supposed economic man wholly unlike any human being ever born. Consequently there were promulgated for nearly a century a host of solemn fallacies which have given, and are still giving, endless trouble to civilized society. In much the same way the supposed demands of business upon boys have crystallized around these story-book heroes and have led the business man, the boy and the boy's teacher into all sorts of difficulties, misunderstandings and wild-goose-chases after educational impossibilities.

It may be that the story-book boy and the story-book employer—and even the daughter—did exist at some period anterior to the middle of the nineteenth century; but since that time all three have been as extinct as the dodo. Yet much of the thinking and much of the talk about the demands of business are based, even now, upon these ancient and mendacious yarns.

To reach any sound conclusions, to-day, however, one must rid himself of the obsession of these romantic fallacies and must face the actual facts. The clean-hands, blacked-shoes fallacy has ruined thousands of boys who, if they had pitched in and got their hands dirty, would have turned out first-rate mechanics and mill-men, instead of sixth-rate clerks. The pin-picking and twine-saving fairy-tales have started many a boy on the downward path of petty, two-cent economies instead of on the upward way of large-minded, far-seeing business policies. While as for the other things demanded by the story-books—they are about as obsolete as sand boxes and quill pens.

Who seriously cares about long-hand writing, when actual business to-day is done by the aid of shorthand and the typewriter? What is the use of drilling a boy who has cost the community at least $4,000 into becoming a fairly accurate adding machine when one can buy an absolutely accurate metal one for a hundred dollars? Why lay so much stress upon errand running when the telephone is a far more efficient messenger? Why talk about learning all the ramifications of an industry, when the main hope of business success is in being a first-rate specialist? Why even specify that the boy shall know how to wield a broom, when the incorporated cleaning company will sweep the offices, and sweep them well, for far less money than the wages of the veriest greenhorn?

Should the present agitation over vocational education come to nothing—which is almost inconceivable—it will have been worth while if it forces teachers, boys and, eventually, employers to ask themselves straight questions and to face actual conditions. What does modern business really require of the average boy? How fully can the boy meet—or can he be trained to meet—those requirements? And, finally, what can the school do and how far can it go in bringing the boy into line with the reasonable demands of a rational, up-to-date mercantile or manufacturing concern?

Just now everybody is in a turmoil over all three of these problems; for all of us—business men, boys and schools—are in a transition state. Business itself is in the travail of readjustment—as witness the attempted regulation of it by the Congress and the states; and as witness, also, the vogue of anything that labels itself scientific management. The young man—still reading the old story-books about business—is finding out that those tales and the real conditions are not even fourth cousins to one another. While the schools, tired of putting boys through the treadmill work demanded by formal college entrance examinations, and looking for some better incentive to hold before the pupil, are turning (generally with more eagerness than knowledge) towards preparation for business as something at once tangible to them and interesting to the youth.

It is a tremendous point gained, however, that all three of them—business man, boy and pedagogue—are working at the same problem, each from his own angle of vision, but all seriously; the business man being desperately in earnest as he finds that profits are dependent upon securing really trained men; the boy being more and more driven, by modern competition, to weigh the problems of his after-school vocation; and the schools, as the educational tax gets heavier and heavier, feeling ever more keenly the need of showing tangible returns for the millions given every year to education.

No business man can presume to say, however, that those millions are thrown away so long as he is every day wasting much good material (both human and inanimate) through haphazard, antiquated and unscientific ways. Since he is manfully buckling down, however, to the problems of real conservation in manufacturing, transporting and selling goods, so must the teacher, also, get down to actualities. For in all industries the chief element to be conserved is the human element; and the teacher is paid by the state to understand, guide and give a right start to his quota of those boys and girls who are to be the producers, distributors and consumers of the coming time. For years and years everybody has been saying that the real work of the schools is to produce good citizens; but no one—broadly speaking—can be a good citizen unless he is an able producer and an intelligent consumer. Education that does not have these ends in view results in dreamers, parasites and social anarchists. Education that does recognize these aims is in line to produce self-reliance, self-respect and social responsibility—the three main bases of sound citizenship.

However high the ideals of all teachers should be, however strongly they should insist upon breadth, culture and "uplift" for their pupils, every one of those noble things of education should be soundly bottomed upon the no less noble demands of self-respecting, intelligent, purposeful winning of the daily bread. What higher and finer goal for all school life than the founding of a family and the rearing and training of the next generation? Yet how absolutely bound up with that true ideal of a civilized state is the ability to earn a living, in ways congenial to the earner and in such an amount that ease of mind, comfort of body and education for the brain and soul shall follow for the worker himself and for those depending on him?

Using the word "business" to cover all the fields of human activity along material lines—the fields of production, distribution and consumption—every boy and girl in every school is going to find his or her chief interests and his or her chief medium for development in the business world. Therefore, every teacher should understand—at least in a broad way—what business is, what it demands, and how those demands are to be met—so far as they can be met—by the school.

Obviously, however, the most zealous of teachers could not acquaint himself intimately with more than one general line of business activity; and it is a serious question whether or not, if he had so trained himself, he wouldn't then be doing the teaching profession a service by leaving it. The teacher must never forsake the teaching point of view—the view that his duty is not to train the boy for business, but to use business as a powerful instrument in training the boy. To do this, however, the teacher must understand not only boys in general, but also business in general. And, however great may be the differences between manufacturing and merchandizing, between banking and baking, there are certain fundamentals characteristic of substantially every branch of that production, distribution and consumption of commodities—noting that consumption, and therefore household management, is put on a par with production and distribution—which is gathered under the one comprehensive term: modern business.

The most striking characteristic of modern business is the rapidity with which it is moving from a competitive to a cooperative basis. This is resulting, on one hand, in the "trusts" and other combinations, which furnish so much good copy for the newspaper and the congressman; on another hand, in the public service corporations, wherein quasi-public needs are supplied by quasi-private bodies; on another hand, in that genuine cooperative production and distribution with which we are less familiar than are the Europeans; and, finally, in that public ownership, pure and simple, which the modern politicians are falling over one another in their haste to promise to the people in exchange for the people's votes.

In whatever form it may appear, however, cooperation results in two things: bigness and complexity. When two men form a partnership the profits may be out of all proportion to the business paraphernalia. But when oil producers get together, and then (at the behest of Congress) unmix themselves again; when the subways, elevated roads and surface lines knit themselves into a single great transportation cobweb; when the workingmen of a whole county decide to buy their flour at a single purchase; and when forty cities and towns combine to supply themselves with water; then there result not only a bigness that has taught us to talk in billions as easily as our fathers talked in hundreds of dollars, but also a complexity which staggers us poor outsiders and, there is reason to believe, staggers the insiders as well.

The third feature of modern business, growing naturally out of the characteristics of bigness and complexity, is that profits to-day are made by the geometrical progression of innumerable small gains instead of through the adding together of a few large gains. Selling a few hundred things at a good profit in a country store in New York state brought in to Mr. Woolworth's employer a few thousand dollars a year. Selling millions of things for not exceeding ten cents each has enabled Mr. Woolworth himself to capitalize at $75,000,000, and to erect the highest building in the world. The mining fortunes of yesterday were made by working the richest veins and pockets, leaving the rest to waste. The mining fortunes of to-morrow will be made from the dump-heaps of abandoned plants. The day of the telescope in business, the day of seeking new worlds in order rudely to exploit their natural resources, has gone by; and the day of the microscope in business, of getting infinitesimal profits infinitely multiplied, has come. Thus far we have been a world of wasters; henceforth we are to be a world of savers, and are thus to outwit Malthus and to make the world's resources not less, but greater, by every added baby born.

A marked characteristic of modern business, consequently, is (in merchandizing) frequent "turn-overs," and (in manufacturing) the utilization of what used to be called waste. The stream of trade flows so fast through a modern department store that the one cent profit here and the two cents profit there aggregate in the course of the year a huge amount of money. According to a recent article in the "World's Work," the beef barons actually lose on sirloin steaks and choice cuts of pork; where their profits are made is in converting every scrap of the animal's carcase into something that can be sold.

To keep the stream of business flowing through a great store, and to make it profitable to save every hair of every beast in the Chicago stockyards, however, there must be highly-developed organization, highly complicated machinery, and just as little as possible of that most expensive form of power, the human hand. Human hands are still wanted, and in proportionately greater numbers than ever before in history; but merely as servants to machines that multiply hundreds and thousands of times the initial force given by those hands. It is nonsense, however, to talk of this as slavery to machinery. On the contrary, it is mastery of the forces of nature, an ever-increasing mastery, which is—so to speak—kicking the brute laborer, the pick and shovel man, up into the ranks of the machine-user, and is kicking the machine-user up into the ranks of the organizer, those ranks where brains are every day setting hundreds and thousands at new work, and every day bringing what used to be luxuries down to the horizon of the commonest man. The cost of living is high, not because of the scandalous luxury of the rich, but because of the commendable luxury of the poor. It is true that the desire for the good things of life is growing somewhat faster than the devices and economies of modern industry can bring those good things within reach; but this is simply a question of gradual adjustment. And the fact that more men are every day wanting and demanding more things is one of the surest guarantees of a continued and genuine prosperity.

An inseparable accompaniment of machinery, however, is speed. Therefore the next notable characteristic of modern business is whirlwind pace. Thirty years ago, even New York, Paris and London were horse-car towns, with clerks nodding over pigskin ledgers, errand boys playing marbles in the roadway, with no telephone, no rapid transit in the modern sense, with scarcely any devices for making speed or saving time. To-day, even London, the archetype of conservatism, is a whirlpool of motor-buses, speeding men and clamoring advertisements.

Consequently, not merely what the business man, but what modern business itself, demands of the high-school graduate is rational and orderly speed. In the high school, in the schools below, in that larger school, the community, and above all, in the boy's home, he must have been trained to "go the pace," not of dissipation, but of modern industry.

Since, however, no one can get speed, without a breakdown, out of a weak or badly-built engine, so one can not get efficiency from a half-sick or ill-developed youth. Consequently, now as never before, the business world must have boys who are sound in body and in nerves and who know the value of good health, clean living, exercise, right eating and fresh air. As already intimated, the average boy of eighteen has cost the community at least $4,000 to "raise";—most high-school boys have cost a good deal more. Furthermore, to train that $4,000 boy to the point where he is a real asset in the business, costs that enterprise a considerable additional amount. Therefore the community can not afford, the business into which the boy goes can not afford, to have him break down, because of a weak body, poor nerves, or dissipation, just when he is beginning to bring in fair returns upon his capital cost. The first thing, then, that modern business demands in its apprentices is sound bodies, steady nerves and a good working knowledge of hygiene. These things are worth far more than a knowledge of double-entry bookkeeping; and the school, in cooperation with the parents and the community, must provide this kind of teaching.

The next essential for speed is quickness of mind, nimbleness of body and good coordination among all the senses. One doesn't acquire these, however, by stewing all day in an uncomfortable desk over a lot of books. One gets them by using all his muscles and all his senses, in a wide variety of exercises, mental, physical and manual, directed in educative ways and by rational progression, towards well-defined ends —not occult ends, seen only by the inner consciousness of the teacher, but tangible ends visible to the boy himself.

The third essential of speed is team-play. Every schoolroom should be an organism as well knit, as thoroughly balanced, as purposeful as a 'Varsity football team; for that is the kind of coordination towards which every mercantile and manufacturing enterprise is rapidly, and with full understanding of its value, tending. The teacher who still uses competition instead of cooperation as a main spur towards speed, is woefully behind the times, and loses that most valuable aid in education—working together for a common result.

Effective team-play, however, is founded upon promptness, ready obedience, willingness to subordinate one's self to the general good, enthusiasm, and that comprehensive quality called loyalty. All these are at the very root of every successful enterprise; and what modern business asks most eagerly is that the boys who come into it shall obey orders intelligently and promptly; shall see how much, instead of how little, they can accomplish to further the interests of the concern; and, in whatever they do, shall show the essential virtues of team-play: enthusiasm, self-subordination and unflagging loyalty.

But a man can not be enthusiastic and effective if he lives in a mere groove. Therefore, while the youth who is to succeed in the complexities of modern industry must be a specialist, he must be a broad one. A man may move fast in a treadmill, but he gets nowhere. On the other hand, a motorist, though tied to a roadway, makes his twenty-five miles an hour because he sticks to that well-surfaced track instead of trying to wander through bushes, potato-fields and gravel banks. He doesn't leave the road, but he sees and knows the whole surrounding territory. Consequently a fourth essential of speed is thoroughness in one line with an outlook into many lines, with an intelligent interest in many things, and with a broad attitude towards all human interests.

A fifth essential of speed is the cutting of red tape. Circumlocution, that curse of the law, is being rapidly driven out of business, because a merchant or manufacturer can not afford to waste time and lose headway in doubling and twisting. If there is a short way of doing a thing—be it in business or in school—do it; and save time, money and nervous energy.

Therefore in demanding of the high school graduate rational and orderly speed, modern business asks the teachers of those young men and women:

1. That they do everything possible to send into business life sound animals who appreciate the value of good health and who know how to conserve it;

2. That they give those pupils such studies and exercises and in such a way as to result in activity of mind, thorough coordination between mind and body, well-trained senses and an eagerness to work and to learn;

3. That all the school work be so carried on as to foster a spirit of team-play, a sense of the value and power of working together for the common weal;

4. That to this end the teacher subordinate the memorizing of facts to the inculcating of promptness, obedience and loyalty;

5. That the studies which make for breadth of view and variety of interest be emphasized, and those which make for mere information, technic and drill, be minimized;

6. That, to accomplish this, subjects like arithmetic, bookkeeping, grammar, rhetoric, etc., be cut down to their lowest terms and fewest principles, throwing out all processes and exercises which are obsolete, little-used or cumbersome, putting in all the short-cuts and labor-saving devices which are of general application; and that those subjects, such as history, economics, political and economic geography, etc., which make for breadth of view; those exercises, such as rightly conceived manual training, ordered games, freehand drawing, etc., which make for quickness and control of the body; and those general school relationships which promote team-play, loyalty, the spirit of working together for a tangible and desirable end, be fostered, amplified, and in every way, encouraged.

Above all, the community high school should be the medium for leading the boy and girl from the irresponsibility of children into the responsibility of men and women. With that end in view, the school days and weeks should be on a business basis, with long hours (diversified, of course, with a proper alternation of mental and physical activity), strict accountability on the part of the pupils, and an organization based, as nearly as possible, upon the best business and factory models. So long as youth of seventeen and eighteen do not take their high-school work seriously, they will not take business seriously. And it is this lack of seriousness, this failure to realize that success in business can come only from strict attention to business, which lies at the root of most, if not all, of the complaints made by business men against the products of American schools. Those employers find many, if not most, of the boys and girls who come for employment, unfitted for and, if I may use the word, unfittable into, the complex demands of modern business life. Remembering the story-books, they think it is because these aspirants can not write and cipher and spell. But they are fast finding out that the causes of the trouble, in most instances, are weak bodies, or untrained senses, or sluggish minds, or lack of purpose, or general immaturity, or ignorance of how to work with others, or an all-round irresponsibility, or a combination of from two to seven of these common human defects. Secondary schools can not, of course, make silk purses out of sows' ears; but they can make it their chief business to deliver to the business world boys and girls whose bodies, senses and minds have had so much organized training as heaven has permitted them to receive; who have passed out of the state of "kids" into that of men and women; who have a conception of and experience in co-operation and team-play; who know what loyalty means; and who have taken school work so seriously that they are prepared to look upon the earning of one's daily bread as something other than a listless game.

Modern business demands these things. Experience has shown that a rightly ordered secondary school system can produce them. That all schools do not is the fault partly of the teachers, partly of the employers, partly of the community in general, mainly of the parents. The fathers and mothers, and the rest of the community, must be educated to give moral and financial support to this effective type of education. But the only persons who can educate them are the schoolmasters; and they must do it in a roundabout way by gradually introducing this rational, real education into the higher and lower schools. The results will be so immediate, and in many cases so startling, as to make even the overworked business man take notice. And when he begins to realize that the school is really trying to meet his needs; when he begins to see that the millions poured into the public schools are producing efficient young men and young women, he will cease growling over his school taxes, and will turn some of the fortunes that he now gives or bequeaths to colleges into the far too lean treasuries of the higher and lower schools.

VULGAR SPECIES AND THERAPEUTIC SUPERSTITIONS[1]

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THE search for the cause of things and events exists since the appearance of man on the face of the earth. The inability to explain things reasonably and convincingly induced the thinkers of ancient times to use their imaginative faculties. The ancient explainers of natural phenomena were the poets.

> The restless mind of man ever seeking a reason to account for the marvels presented to his senses adopts one theory after another, and the rejected explanations encumber the memory of nations as myths, the significance of which has been forgotten.[1]

The continual strife with the elements, the dreadful toils and dangers of man's life, the inclemency of nature—were all attributed to a perverse divinity or demon, who delighted to inflict pain and misery upon brief-lived mortals. Such a divinity needed worship and sacrifice to propitiate him. Humanity began to fear the devil before they imagined the god. The "earthworms" created the gods of goodness to protect themselves against the spirit of evil which they had incarnated.

With fear began superstition, which is based upon fear and ignorance. The desire to know the mysterious future has given rise to a great deal of the world's store of credulity in the supernatural. The ancient philosopher who desired to divine the future by means of geometrical figures, the pretty maiden who counts the petals of the daisy or dandelion to learn whether her lover will be constant, and the business man who allows the clairvoyant to pass on the lines of his hand—are the ordinary examples in life of the vain endeavor to raise the curtain that hides what is to be. Living beings fear death—a rational fear. In order to prolong life, the body is to be kept healthy, illnesses are to be avoided and, if disease does afflict an individual, the sickness is to be cured. This is all rational. But illnesses are almost inevitable in man's life, and diseases are not always cured or curable. Instead of combating disease logically, men of all classes drew upon their imagination and hashed various absurd means and methods of treating their ailments.

Coeval with the birth of superstition was the birth of magic. The charlatan who could unscrupulously play upon the feelings of his ignorant audience had quite a mighty following in every locality where

[1] Baring-Gould, "Curious Myths of the Middle Ages," p. 151.

human beings suffered and hoped. The establishment of the Roman Church in England did not cause the old Anglo-Saxons to abandon their ancient rites and ceremonies. The inhabitants still clung to the mysterious lore of the Druids, and were only able to attach themselves fully to the new belief by retaining quite a number of the heathen superstitions. Long after the coming of the Catholic missionaries to the British Isles, there throve in merrie England hundreds of magicians who were feared even more than the holy fathers. The ignorant person ever loves to compromise. He is never certain which god is the true god, and in order not to take chances, he sacrifices to more than one divinity, lest he be left in the lurch. Palmists, fortune tellers, necromancers, magicians, clairvoyants are always secure of a very comfortable livelihood, if they do but settle in those centers where ignorance abounds. For, indeed, they seem all omnipotent to the credulous mind. They can predict the future; they can prescribe for the patient when the learned physician has given up hope; they can sell love-philters; they can cast evil spells upon our enemies; they can give us an amulet which we can wear and be forever protected against fearful maladies; they can grant good luck, and tell us how to avoid dangers and pitfalls.

Above all, let us repeat, they can give us an amulet, or charm, to wear which will make us fearless of disease.

The selling of amulets by magicians is a very lucrative business even in the present day. Sometimes it is not the necromancer, but the church, which sells charms to its adherents. The word *amulet* has quite a variety of derivations from the Roman and Arabian tongues. Amulets were so called by the Latins because of their supposed efficacy in allaying evil; "*amuletum quod malum amolitur.*" Some think that the word is derived from the Latin *amula,* which is a small vessel of lustral water carried about by the Romans. In the Arabian language, *hamalet* means that which is suspended.[2] Certain charms are supposed to be valid against all evils or ailments, others are efficacious only in certain specific instances.

People are afraid more often of an imaginary, possible misfortune than they are of the present state of infelicity. Joseph Addison says:

> As if the natural calamities of life were not sufficient for it, we turn the most indifferent circumstances into misfortunes, and suffer as much from trifling accidents as from real evils. I have known the shooting of a star spoil a night's rest; and have seen a man in love grow pale, and lose his appetite, upon the plucking of a merry-thought. A screech-owl at midnight has alarmed a family more than a band of robbers; nay, the voice of a cricket hath struck more terror than the roaring of a lion. There is nothing so inconsiderable which may not appear dreadful to an imagination that is filled with omens and prognostics. A rusty nail or a crooked pin shoot up into prodigies.

[2] William Jones, "Credulities Past and Present," London, 1898.

I shall mention several curious charms or amulets that were prevalent in the various countries of the orient and occident. Among the Chinese, iron nails which have been used in sealing up a coffin are considered quite efficacious in keeping away evil influences. They are carried in the pocket or are braided into the queue. Sometimes such a nail is beat out into a long rod or wire and is incased in silver. A large ring is then made of it to be worn on the ankles or wrist of a boy till he is sixteen years old. Such a ring is often prepared for the use of a boy if he is an only son. Daughters wear such wristlets or anklets only a few years, or for even a shorter time.[3]

Galen mentions an amulet belonging to an Egyptian king, who is said to have lived 630 B.C. It was composed of a green jasper cut in the form of a dragon, and surrounded with rays. This was applied to strengthen the stomach and organs of digestion.

The Hebrews have quite a variety of amulets or charms, each of which has a specific virtue. In the middle ages, the quack necromancers did a thriving business among the Jews that had settled in Spain. Maimonides, the great physician, wrote vigorously against them.

> Believe not in the magician or the necromancer; they do but blaspheme the name of God.[4]

Still many of the old superstitions have remained with the Jews. When a gentile physician goes into the lying-in room of the Hebrew woman he will notice placards on all the four walls, written in the ancient biblical tongue. These papers invoke the aid of the great angels for protection against the evil spirits that may attack either the newborn infant or the mother.

A mystic charm worn even at the present day bears the inscription *Abracadabra.* The word *abra* which is twice repeated in this amulet is derived from the initial letters of four Hebrew words: *Ab, Ben, Ruach Acodesch,* which signify Father, Son and Holy Ghost. During the times of the Crusades and for a long period afterwards, the very rich or the very noble carried about them, or kept hidden in a holy shrine, amulets made from a piece of wood from the true cross. As somebody has well said,

> A grove of a hundred oaks would not have furnished all the wood sold in little morsels as remnants of the true cross; and the tears of Mary, if collected together, would have filled a very large cistern.[5]

Sometimes the charms worn were not so harmless, and had no sentimentality or mystery to grant them fascinating potence. Very frequently, horrifying things and repulsive substances were carried about to ward off illness. In Egypt[6] the finger of a Christian or Jew, cut off

[3] Doolittle, "Social Life of the Chinese," II., 309.

[4] Maimonides, "More Nebbuchim."

[5] C. Mackay, "Memories of Extraordinary Popular Delusions," 1850.

[6] Lane, "Modern Egyptians."

a corpse and dried, is suspended from the neck and is reputed to have the powers of an amulet. In Flanders, a sick person imprisons a spider between two walnut shells and wears it around his neck.[7]

There were also *specific* amulets in circulation. For every ailment or unhappiness there was obtainable in the market of the necromancers, a charm which was supposed to have a certain beneficial influence for the affliction. Guttierez, a Spanish physician, who wrote a book on "Fascination" in the year 1653, states that children of that country wore amulets against the evil eye. In case a person who had the evil eye should gaze upon a child wearing this stone-charm, the vicious influence of the gaze will be attracted by the stone which will then crack.[8] For epilepsy there was in circulation a charm which had this inscription:

Jasper brings myrrh, and Melchior incense brings,
And gold Balthazar to the King of Kings;
Whoso the names of these three monarchs bears,
Is safe, through grace, of epilepsy's fears.

For convulsions, as another example, they used to wear a necklace of beads from the root of the peony. Pliny tells that for headache a remedy to be tried is the halter by which somebody has been recently hanged; this should be worn around the neck of the patient. In 1726, Philip, Earl of Chesterfield, wrote in great praise of the Goa Stone:

> The Goa Stone is an admirable preparation of various ingredients; it is made by a Jesuit at Goa; it hath the same effects with the Lady Kent's powder, but is much stronger; it is a sudorificke, and expels all poisons and humors in the blood; it is admirable in all feavours and agues; it drives out measles and small-pox.

There was a belief current in the middle ages that the cries of animals had each a significance. A very plausible arrangement of the cries was made by a certain anonymous genius. One must, however, be a scholar of Latin in order to understand what the animals were saying. Arranging the conversation of the beasts in the form of a dialogue, we have the following curious effect:

Cock: Christus natus est.
Duck: Quando, quando?
Raven: In hac nocte.
Cow: Ubi, ubi?
Lamb: Bethelem.

"Incredulity," said Ashmole, "is given the world as a punishment." It is no wonder then that human beings in order to avoid this penalty, believed all that was told them, and relied upon others to grant them the same courtesy; and then acting upon this privilege or license, helped to burden the lore of the world with tales of absurdity and incongruity.

[7] Chambers, "Book of Days," I., 372.

[8] T. H. Knowlson, "The Origin of Popular Superstitions."

No natural exhalation in the sky,
No scope of Nature, no distempered day,
No common wind, no customed event,
But they will pluck away his natural cause,
And call them meteors, prodigies and signs,
Abortions, presages and tongues of heaven.

I shall endeavor to give a list of various specifics that were recommended long ago and are still in vogue wherever ignorance abounds. I am indebted to various authors of books on magic and superstition for various references to ancient customs. The excellent "Collectanea" of Vincent MacLean has saved me a great deal of trouble and labor in the looking up of old customs and credulities.

For every evil invented by the devil, God has created a remedy. The cure was not always known, because the ingredients of the medicine were very numerous and varied. In order to obtain the remedy in its full efficiency, the portions that made up the various concoctions were to be in exact proportion, otherwise the medicament would prove futile. The numberless combinations possible were to be tried out, and those that proved beneficial were treasured. Certain localities did a roaring trade in the sale of the specific for which it was noted. In the modern times the nostrum and patent-medicine has replaced these Meccas of healing, and the descendants of the ancient sufferers and believers are now helping to fill the coffers of the quacks.

As a method of curing himself, man has attempted to rid himself of his disease by transferring it to the stranger or the foe. In Germany a plaister from a sore may be left at a cross-way to transfer the disease to a passer-by. "I am told on medical authority," writes a certain author,[9] "that the bunches of flowers which children offer to travelers in southern Europe are sometimes intended for the ungracious purpose of sending some disease away from their houses." The contagiousness of ailments were known in olden times, and this desire to cure themselves by transferring the malady to somebody else was often the cause for the outbreak of violent epidemics in the whole neighborhood. Sometimes, instead of passing off the sickness to a human being, they attempted to give it to some animals, and thus rid themselves of the affection. A child that was suffering from scarlet fever was treated by taking some of the hair of the patient and giving it, concealed in the food, to an ass, which was to contract the fever and thus cure the patient. A similar procedure was in vogue for the treatment of measles; the hair from the nape of the neck of the child was given to a dog. A patient that had rickets was passed over the back and under the belly of a donkey nine times, uttering no word but the successive numbers. The good-women advised anybody that had convulsions or fits to try this simple remedy:

[9] Tylor, "Primitive Culture," II., 137.

Every morning while fasting, the subject is to chew a piece of grass and give it to a jay to eat; when the bird dies, the cure ensues.

In northern Europe the fays, or fairies, were vested with the dreaded power of inflicting disease. Fairies were supposed to be evil spirits which might be propitiated by giving them a gracious appelation.

> By giving diseases and other evils a good name when speaking of them, the danger of bringing them upon oneself by his words, is turned away. For this reason, fairies were called *Eumenides* by the ancients, and "good people" by the Celts.[10]

Morier[11] mentions a general superstition which he found also in Persia that to relieve disease or accident the patient has only to deposit a rag on a certain bush, and from the same spot take another which has been previously left from the same motives by a former sufferer.

There are certain minor ailments which even in the present day, the experienced grandmother thinks herself quite as capable of administering to as the most respected doctor. In olden times children suffering from skin eruptions or from general ill-health were taken to certain ancient dames, who, by means of incantations and exorcism, were able to drive out the devil from the body of the child.

> In the small villages of Russia when a child is suffering from a cutaneous disease of the face, it is taken to an "old woman" who mumbles some words and spits several times into the mouth of the child.[12]

Incantations were one of the strongest weapons of defense against all the maladies. A person afflicted with ring worms, for example, takes a little ashes between the forefinger and thumb on three successive mornings, and, before having taken any food, holds the ashes to the part affected and says:

> Ringworm, ringworm red,
> Never may'st thou either spread or speed;
> But aye grow less and less,
> And die away among the ase.[13]

After scalding oneself, instead of giving way to vigorous profanity, or counting up to one hundred, as Benjamin Franklin suggested, the custom was to blow upon the injured part and repeat:

> There was two angels came from the North,
> One brought fire and the other brought frost;
> Out fire, in frost,
> In the name of Father, Son and Holy Ghost.

There is a fashion even now among the lesser civilized folks to mention the name of a saint or of a divinity, or say something "good" when

[10] J. G. Campbell, "Superstitions of the Highlands and Islands of Scotland," 1900.

[11] Morier, "First Journey through Persia," 1812, p. 230; and "Second Journey through Persia," 1818, p. 239.

[12] Kahn, "Biochemical Studies of Sulfocyanates," 1912.

[13] Ashes.

they see somebody sneezing or yawning. In Scotland, they say to one who sneezes, "Saint Columba be with you." The Jews say, "God give you health." When a child yawns, the nurse must say: "Your weariness and heaviness be on yonder gray stone." The Jews have a custom of giving a new name to a person who is in very bad health. The superstition underlying this is the belief that the Angel of Death is instructed to slay a certain person with a certain particular name. If, however, the name is changed, the angel will be unable to identify the sick man, and death will be thus robbed, for a time at least, of its victim. Among the Celts they give a road name (*Ainm Rothard*) to the person who is ill; it was given upon the luck (*Air sealbhaich*) of the person met.

Contagious diseases had quite a variety of treatment in each case. Joubert,[14] speaking of the transmissibility of illnesses, says:

> *D'ou vient qu'une maladie contagieuse se prend plustost d'un vieux a un jeune qu'au contraire. . . . S'il vray que L'argent ne donnent on apportent jamais la peste.*

The ordinary affections of childhood were treated by incantations and exorcisms, or by endeavoring to transfer the disease to the lower animals. For such a disease as smallpox, which counted its victims by the thousands every year, curious medicaments were recommended. Sheep's dung or trickings[15] were administered to such patients. Another procedure was to wrap the patient in a scarlet cloth.

> The Chinese make their children wear paper masks on the last night of the year to prevent the god of small-pox from ''pouring it out'' on them, as he is supposed to attack only pretty children, and thus disfigured they will pass by.[16]

For erysipelas they suggested chantings of witches; but this was not always to be obtained for either love nor money, for the church was quite stringent in its warfare against these old women who rode on broom-sticks and had communion with the devil. In cases where the songs of the "weird women" were not to be heard, several medleys were suggested. The ashes of a woman's hair mixed with the fat of a swine were to be locally applied; or else one half of the ear of a cat was to be cut off and the blood allowed to drop upon the part affected. A less odious procedure and one which has a little sentimentality with it was to rub the ailing part with a golden wedding ring.

The king's evil, or scrofula, was supposed to be curable by the touch of the ruler of England. Dr. Samuel Johnson, in his childhood days, was taken by his father to Queen Anne, in order to cure the child of the malady which affected him. The first king to introduce the king's touch into England was James I. Shakespeare has an allusion to the healing powers of this king in "Macbeth":

[14] Joubert—cited after MacLean's ''Collectanea.''
[15] Jackson, ''Shropshire Folk Lore,'' 1883.
[16] Doolittle, ''Social Life of the Chinese.''

Strangely visited people,
All swollen and ulcerous, pitiful to the eye,
The mere despair of surgery, he cures,
Hanging a golden stamp upon their necks,
Put on with holy prayers.
—"Macbeth," Act IV., Scene 3, line 150.

The cure of Naaman, who seems to have suffered from this disease, by the prophet Elisha (Kings, II., 5) was accomplished by advising the great general to bathe in a certain river. A very delightful cure must have been the one mentioned by Soane.[17] A person suffering from scrofula was to kiss seven virgins, daughters of the same mother, for seven days consecutively. Another remedy, less esthetic than the one just mentioned, was to tie a toad's leg around the part affected.

The great evils of cholera, black death or plague, had very many superstitious beliefs as the basis for their cure or avoidance. The condition of affairs caused by one of these dreaded diseases can be appreciated by perusing Daniel Defoe's description of the state of things before and after the fire of London. In Morocco, as a prophylactic procedure, the priests advise the people to avoid sandhills, and to keep close to the walls to avoid the evil spirits.[18] As a charm against cholera, the Japanese hang a bunch of onions or a leaf of kiri, or a rag monkey in front of their house doors.[19] In some parts of Russia, when the approach of cholera is feared, all the village maidens gather together at night, in the usual toilet of the hour, and walk in procession around their village; one girl walking ahead with an Icon, the rest following with a plow.[20]

For consumption, the white plague, which even now demands a heavy toll of human life annually, the people had very many home remedies, which probably did very little remedying. The specifics that were in vogue were rather empiric, to say the least, and sometimes altogether disgusting. To live at a butcher's shop, to suck healthy person's blood, to sleep over a cow-house, to inhale the smoke of a limekiln, to pass through a flock of sheep leaving the fold in the morning, to feed on a large white-shelled snail, to eat muggons or mugwort—all of these were current medicaments in various localities. Children who had tuberculosis were allowed to lie over night at a certain well, named in honor of a certain saint. In order to prevent the spread of this malady in the household, they buried the corpse with the face downward.

In hectic and consumptive diseases, they pare the nails of the patient, put these parings into a rag cut from his clothes, then wave their hand with the rag thrice around his head, crying "Deas Soil," after which they bury the rag in some unknown place.

[17] Soane, "New Curiosities of Literature," I., 206.

[18] Leared, "Morocco."

[19] MacLean, "Collectanea."

[20] R. Pinkerton, "Russia."

Leprosy was an affliction sent as a punishment of God, according to the beliefs of the ancients. Persons suffering from this illness were driven from the community and were compelled to go about masked, and to cry "Unclean, unclean" upon the approach of a non-leprous individual. Undoubtedly much that was called leprosy in the olden times was in reality syphilis. For a dreadful disease, a dreadful remedy was advised, and surely in those days of slavery the remedy was quite feasible for any one who was able to afford the several coins that a human life cost.

It was anciently believed that a bath made of the blood of infants will cure leprosy, and heal the flesh already petrified.

A sore throat was sometimes treated by a very unpleasant method. The sole of a stocking that had been worn for several days, was taken warm from the foot and tied about the neck of the patient. Sailors who suffer from soreness of the throat, take a raw salt herring with the bone taken out and apply it to the neck, tying a handkerchief over it and keeping it on all night.[21]

Before the discovery of the healing properties of quinine, malaria had perhaps more victims than the other severe sicknesses. At the present time, in the less civilized portions of the globe, they still apply to the magician for a cure for the ague. The chips of gallows and places of execution were thought especially efficacious, and lacking these, the branch of a maiden ash freshly cut from the tree or the water from a church font were used. Certain charms were carried about by those who feared an attack of the fever. A handful of groundsel worn on the bare breast, or else an especially blessed amulet with the inscription of the name of God upon it were suspended from the neck of persons who lived in malaria-infested neighborhoods.

Bring him but a tablet of lead with crosses (and Adonai or Elohim written on it) he thinks it will heal the ague.[22]

Another charm was prepared after the following directions: Peg a lock of hair into an oak tree and then wrench it out. As internal medication, quacks recommend pills made from pitch, or a pill made by rolling up a spider in dough and taking it several times daily; another usage was to take a spider and rub it up alive in butter and then eat the mixture, or else eat while fasting seven sage leaves seven days running. As a barometer, so to speak, of malaria, the people shut up a spider in a box "and as it languishes and dies, so will the ague."[23] Joubert,[24] speaking of the ague, said:

Est il vray que le fievre quarte s'en va par exces on yoronguerie et qu'elle ne fait jamais sonner campane; et qu'un home en est plus sain toute la rest de sa vie.

[21] A. H. Markham, "A Whaling Cruise to Baffin's Bay," 1874, p. 253.

[22] T. Lodge, "Wit's Miserie," 1596.

[23] Northal, "Folk Phrases of Four Counties," 1894.

[24] L. Joubert, "Erreurs populaires," 1579.

Not a very profitable transaction to one of the persons concerned is the following Worcestershire superstition:[25]

Go to a grafter of trees and tell him your complaint. You must not give him any money or there will be no cure. You go home and in your absence the grafter cuts the first branch of a maiden ash, and the cure takes place instantly on cutting the branch from the tree.

A writer of the sixteenth century in England says:

Tench are good plasters but bad nourishment; for, being laied on the soles of the feet, they often draw away the ague.[26]

An incantation which was to be chanted by the oldest female in the family on Saint Agnes' Eve ran as follows:[27]

Tremble and go;
First day shiver and burn.
Tremble and quake;
Second day shiver and learn.
Tremble and die;
Third day never return.

Epilepsy, the falling sickness, was ever regarded with superstitious dread. For this disease special amulets were worn. The emerald was supposed to possess the power of hindering an attack, or it would break into fragments. Another charm was a ring made of seven six-pences collected from seven maidens from seven parishes. Still others were: Hair plucked from the cross of an ass's shoulder, woven into a chain and worn; nine pieces of silver and nine three half pence collected from as many unmarried persons of the opposite sex—a ring was made from the silver and the cost of making was paid by the copper coins. In France they hung about the child's neck, as Brâssieres relates, *"un tuyau de plume d'oie fermé aux deux extremités et dans lequel est intoduit de mercure liquid."* A broth made in the skull of a dead person; lion's hair chopped up and eaten with milk; three drops of a sow's milk; toadstools fresh and small; the juice of the bracken fern squeezed out when the stem is newly cut across; the fresh blood from a decapitated criminal; a poultice of groundsel applied to the pit of the stomach to set up vomiting—were all used in the various countries of Europe. A procedure, somewhat cruel, was to take a live mole, cut off its nose, and let nine drops of blood fall upon a piece of sugar, which was then to be given to the child. In certain of the village parishes, the epileptic was advised to go into a church at midnight, and to walk three times around the communion table.

The daily cramps and aches and unpleasantnesses that are found in all families had their specific remedies. The usual belly-ache attack passes without the use of any medical agent, and will, in the very great

[25] Noake, "Worcestershire Notes and Queries," 1856.
[26] J. Cains, "History of Animals," 1570.
[27] W. Hone, "Everyday Book," 1560.

majority of cases, pass in spite of any medicament. The layman, however, suffers with aches, takes a reputed remedy, gets well, and firmly believes that it was the special mixture that he had taken which had cured him. For example, they applied in Germany a special concoction recommended by Dr. Christopher Guarnonius of the court of Rudolph II. of Bavaria (1576–1612). It is rather interesting to know how many people were able to obtain this remedy:

Recipe

The moss that had grown on the skull of a thief	2 ounces
Man's grease	2 ounces
Grease of Mummy	½ ounce
Man's blood	½ ounce
Linseed oil	2 ounces
Oil of roses	1 ounce
Sole armoniack	1 ounce

Mix well and apply locally.

For blows, wound and sores in children, the kissing of the injured part was supposed to be efficacious. The ordinary intestinal colic had quite a number of "specifics" for it. One cure which must have been quite difficult of accomplishment, except by the professional clown, was to stand on one's head for a quarter of an hour.[28] Perhaps after the exertion of standing upon one's head not only the colic but more painful diseases might have been cured. Persons who were liable to the attacks of colicky pains sometimes carried about with them wolf's dung. In his "Diary," Pepy speaks about carrying about oneself a hare's foot. Pepy also gives a prescription, which I shall here repeat:

> Balsam of sulphur 3 or 4 drops in a syrup of Coltesfotte, not eating or drinking two hours before or after. The making of this balsam was as follows: "two thirds of fine oyle, and one third of fine Brimstone, sett thirteen or fourteen hours on ye fire, simpering till a thicke stuffe lyes at ye Bottome, and ye Balsom at ye toppe. Take this off, etc.

For cramps they used coffin rings dug out of a grave, bone of hare's foot, the patella of a sheep or lamb, or the tying of a thread around the limb below the thigh. It was also thought that if a rusty old sword were hung near the bed, or if the shoes be placed T- or X-wise over the bed, or if a pan of clean water were kept under the bed, the cramp would leave the patient.

> Brimstone and vervain are no honey yet bind them to thine hand and thou shalt have the cramp.[29]

Eating buns or bread baked on Good Friday was supposed to cure diarrhœa.[30]

> Besides the cross bun, a small loaf of bread baked on Good Friday morning and carefully preserved as a medicine is good for diarrhœa. It is considered

[28] R. Hunt, "Popular Superstition," 1865.

[29] B. Melbancke, "Philotimus," 1583.

[30] G. F. Jackson, "Shropshire Folk Lore," 1883, p. 191.

that a little of the Good Friday loaf grated into a proper proportion of water is an infallible remedy for this complaint.

Joubert says:

Des amellittes avec toile d'araigne contre le mal de ventre qu'ont les enfants.

Another article of diet which the loose-boweled were advised to eat was the first rib of salted roast beef. A more vulgar procedure was to sleep with puppies for several nights until cured of this ailment.

In children, or for that matter in adults, incontinence of water was treated rather quaintly. It was the custom to give to a child who suffered with this defect three roasted mice.

The mouse, being roasted is good to be given to children . . . in their bed; to help them furder, it will dry up the fome and spattle in their mouthes.[31]

Numberless as are the aches that afflict the human being so numerous are the remedies which purport to cure these ailments. For the general aches and pains of muscles, "the laying under your pillow for nine nights a crooked six-pence that has belonged to three young men of the name of John"[32] will cause relief. Sweating was good for the usual muscular aches:[33]

For I do sweat already, and I'll sweat more;
'Tis good they say to cure the aches.

For the household toothache, it was the custom in Shropshire to apply the amputated foot of a live mole (*oont*). For intestinal worms, a live trout was laid on the stomach of the patient, and the water in which earthworms had been boiled was taken internally as a broth.

Boils and abscesses were poulticed for three days and nights, and the bandages were then deposited in the coffin of one awaiting for burial.[34] These patients were also advised "to creep under a bramble that had taken second root at the branch end, moving on the hands and knees." Another procedure which Diaxe speaks about is "walking around six, and crawling three times across the grave of one of the opposite sex on a dark night following the interment"—a rather shivery experience! For a carbuncle:

On advertit ceux qui ont carboncle de ne passer l'eau, sur pont ou sur bateau, ne en sorte que ce soit.[35]

A special amulet worn by nursing women to protect them against sore breasts was a heart-shaped medal made of the lead cut off the quarrels of a church window at midnight. Bleeding of the nose was prevented, so was it thought, by wearing a red ribbon around the neck, or by suspending from the neck a dead dried toad, or a large key. A lace

[31] Bullein, ''Bulwarke of Defence,'' 1562, p. 84.
[32] Mrs. Hannah More, ''Tawny Rachel.''
[33] Webster, ''Cure for a Cuckold.''
[34] T. Diaxe, ''Bibliotheca Scholastica Instuctissima,'' 1633.
[35] L. Joubert, *loc. cit.*

given unasked and received without thanks from one of the opposite sex will sometimes stop epistaxis.

> We see that a bone taken out from a carp's head stauncheth blood, and so will none other part of the fish.[36]

Poisoning had and still has its superstitious treatment. The unicorn's horn was remedy for all poisons. The horn of a unicorn (the animal is not to be found classified in the modern books on zoology) was worth the price of half a city.[37] It is needless to say that this remedy was not within the reach of everybody, and less poetic remedies were used by the ordinary people. The quacks, however, made huge profits selling powdered unicorn's horn to the gullible public. It is more than a suspicion that the stuff sold was made from the horns of an ox or a ram. "Plain proof declares one poison to drive out another." [38] and they certainly gave dangerous medications to persons that were poisoned. If the patient did not succumb to the original draught, he had very good chances of dying as a result of the remedy.

For the bites of animals, many queer remedies were in vogue. A patient bitten by a dog used to eat the hair of this dog. A person stung by an adder was advised to kill the animal and apply some of its fat to the wound, or else to fry the adder and strike the place bitten with the hot flesh, or else to make an ointment from its liver and apply it locally (Noake).

> 'Tis true a scorpion's oil is said
> To cure the wounds the vermin made.

The *Boston Journal of Chemistry* (1879) tells of a druggist from Texas who paid two hundred and fifty dollars for a "mad-stone" which had the powers to cure the bites of animals. A custom, which is practised by the Hottentots also, is to kill a chicken and to thrust the bitten part into the stomach of the bird, and there let it remain till the chicken becomes cold. If the flesh of the fowl becomes dark, a cure was supposed to have been affected; if not the poison had been absorbed by the person bitten.

To relieve deafness, they applied eels to the ears. For the cure of dropsy "all-flower water" was recommended. Another method for the treatment of dropsy is the one reported by Joubert:

> *Pisser durant neuf matins sur le marrube avant que le soleil L'ait touche et a mesure que la plante mourra, le ventre se desenflera.*

For the cure of rickets, they suggested sleeping on a bed of green bracken, or passing the child nine times through a holed stone against the sun. In Oxfordshire, they relieved heartache by giving the patient the last nine drops of tea from the tea-pot after the guests had been served.

[36] Scott, "Discoverie of Witchcraft," XIII., p. 10.
[37] Dekker, "Gull's Hornbook," II.
[38] Grange, "Golden Aphroditis," III.

Rheumatism and the joint pains were treated both by charms and by concoctions. To carry the forefoot of a hare, or a raw potato, or a horse chestnut in one's pocket ameliorated an attack of the severe pain that accompanies all joint affections. Sailors when attacked by rheumatism wear a flannel shirt nine times dyed. The landlubber has to be satisfied with sleeping on a hop pillow, or leaning for one night against the bellows.

> Common nostoc, commonly called star-jelly, a trembling gelatinous fungus that springs up suddenly after rain, is by superstitious persons believed to possess virtue as a vulnerary and in pains of joints.[39]

Walking in fields on Friday before sunrise was advised to patients suffering with gout. Pliny says:

> *Podagras mitigati pede leporis viventis absciso si quis secum assidue habeat.*

Dropping of excreted water upon the feet, or applying the lodestone were thought of benefit in this disease.

> *D'où vient que les chapons sont plus et plustot gouteux que le coqs si la castration est remedy à la goutte.*

For billiousness and jaundice, quite a number of the most disgusting mixtures were used. Lice seem to have been quite a current specific for this affection; lice served in all manners and form, and in all ways of preparation. Nine lice to be eaten on a slice of bread and butter;[40] or else nine lice swallowed alive,[41] were two of the most conventional ways of taking this medicine. Poor, dirty communities need never complain of jaundice, for they always have the wherewithal to cure it.

> Die of jaundice, yet have the cure about you!—lice, large lice, begot of your own dust and the heat of brick kilns.[42]

Goose dung made into pills and eaten several times a day was another very tasteful medicament, which was especially in style in Staffordshire. In Franche Comte, hawkweed and carrots are still considered specifics for jaundice. A more convincing recipe is the one recommended by Graham:[43]

> Raw eggs eaten two at rising, fasting, and one every four hours during the day at times when the stomach is empty. *Probatum est.*
>
> Fall to your cheese-cakes, curds, and clouted cream,
> Your fool, your flaunes, and swill of ale a stream
> To wash it from your livers.[44]

Cancer, it was vaguely believed in certain portions of the world, was due to the growth of a toad-like body in the human organism. The first thing that was, therefore, applied to a cancerous surface was a dried toad. The doctors recommended the following composition: To a yolk

[39] Lindley, "Vegetable Kingdom," 1846.

[40] Narsnet, "A Declaration of Popish Impostures," 1603.

[41] Isaac Walton, "Complete Angler."

[42] Beaumont and Fletcher, "Thierry and Theodoret," V., 1.

[43] Graham, "Domestic Medicine."

[44] Ben Jonson, "Sad Shepherd," I., 7.

of an egg add salt, then make a salve and apply. A prescription which was given to Pope Clement VII. to relieve his carcinoma (I believe) read as follows:

Take of

Cinnamon	10 ounces
Ginger	5 ounces
Zedoary	4 ounces
Nutmeg	3 ounces
Elder root	2 ounces
Calamus	1 ounce

Dissolve in a decoction of lemon juice mixed with wine.

Take a half pint before meals in the time when the moon is in Cancer, Leo or Virgo.

Brâssieres, speaking about the errors of medicine, relates the following procedure for the treatment of cancer:

Chacun connait ce vieux prejuge que l'on ne rencontre plus que chez de pauvres femmes du siècle dernier. Atteintes de cancer, elle nourissent avec soin, pour ne pas en etre devoreés ce pretendu animal, en appliquant tous les matins sur leur plaies une tranche fraiche de veau.[45]

For the treatment of urinary lithiasis, very many curious means were in use in the middle ages. Goat's urine was recommended by all the Arabian physicians to be taken internally. The Talmud mentions quite a remarkable cure for the kidney or bladder stone. Baas speaks of this method in a very bitter way, but it is no more vulgar than many similar customs in different countries. Baas's "History of Medicine" is rather unfair and partial in its treatment of Hebrew contributions to medical knowledge. The method to which I am referring was cited in another paper by me on the history of the lithotomy operation.[46]

A bone from the head of a carp is said to be good for apoplexy or the falling sickness.[47]

All flower water was given to patients suffering with asthma. This "all-flower water" was called *urina vaccæ.* Patients complaining of chorea were usually taken to one of the holy shrines where remarkable cures were said to be performed. Lourdes in France still boasts of the survival of this ancient custom. Emile Zola in his masterly novel, bearing the name of this city, vividly describes how the sick and suffering from all parts of France come to this town and expect complete restoration to normal health.

The next is Vitus sodde in Oyle, before whose ymage faire,
Both men and women bringing hennes for offering do repair;
The cause whereof I do not know, I think for some disease
Which he is thought to drive away from such as him do please.[48]

For shingles, herpes zoster, there was practised the following cure:

[45] A. F. E. Brâssieres, "Sur les Erreurs en Medicine," 1860.

[46] Kahn, "History of the Lithotomy Operation," *Medical Record,* 1912.

[47] J. Schroedems, "Zoology," 1659.

[48] Googe, "Popish Kingdom," 1570, p. 54.

The patient was taken to running water, where seven rushes were picked and were laid across the affected part; the rushes were then thrown into the stream. This was repeated on three consecutive days. "*Cataplasme de chair de vautour avec les vifs*" was applied locally to hare-skin disease.[49] *Si poter foureure et plumes de Vautour sur L'estomac luy peut servir en quelque chose?*[50]

Procreative disease was, of course, more inviting to quack remedies than any other ailment of any other part of the body. The richest quacks and those that do the most flourishing business, are those charlatans who pretend to cure the sexual illnesses. I shall not discuss the remedies for all genital disorders. Sterility, however, presents very interesting points, and I shall just briefly give some of the ancient customs that were common for the treatment of this "deficiency." In all countries, nulliparous women traveled to holy places and prayed in the churches of the holy saints to grant them issue. At Jarrow, in England, brides sit themselves in the chair of the Venerable Bede. The old English dramatist, Heywood,[51] relates of the traveling to holy shrines of sterile women in order to become fruitful.

> Another miracle eke I shall you say
> Of a woman which that many a day
> Had been wedded, and in all that season
> She had no child, neither daughter nor son,
> Wherefore to St. Modwyn she went on a pilgrimage,
> And offered there a live pig, as is the usage
> Of the wives that in London dwell.

In Egypt and other semi-civilized countries, the women who desire to become pregnant, pass several times silently under the corpses that hang on the gallows, or else they bathe in the dirtiest puddles where carrions and carcasses of dead animals abound.

Juvenal[52] says in one of his satires:

> *Steriles moriuntur, et illis*
> *Turgida non prodest condita pyxide Lyde.*

Another Latin writer states:

> *Credebant antiqui mulierem sterilem concipere posse, si pyxide araneam inclusam gestit in sinu.*

Sage and salts were the ordinary ingredients of the prescriptions which were given to women in order to cause them to become *enceinte.* On the other hand,

> Gold dust is taken internally when to prevent offspring is desirable. Shot is swallowed with the same intention, and also scrapings from a rhinoceros horn.[53]

A little superstition seems to be a universal trait, but it is the excess of it which has caused so much harm and misery.

[49] R. Cotgrave, "Dictionaire," 1611.

[50] P. Bailly, "Questiones Naturelles et Curieuses," 1628.

[51] John Heywood, "A mery play of Johan, Tyb, and Sir Johan," 1533, p. 27.

[52] Juvenal, "Satires," II., 140.

[53] Leared, "Morocco and the Moors," p. 281.

LESTER F. WARD AS SOCIOLOGIST

By Professor E. A. ROSS

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THE late Lester F. Ward was a many-sided man and his fifty productive years brought forth a great number of contributions to botany, paleobotany, geology, psychology and anthropology. For a long time as paleobotanist of the U. S. Geological Survey he led as it were a double intellectual life, devoting his office hours to fossil plants and his spare time to the sciences relating to man. He had two reading publics, two groups of scientific acquaintances, two sets of correspondence. When traveling about in Europe one day he might hear his own contributions discussed in a university seminar on sociology, while the next day he would be the guest of an Italian count who knew nothing of his sociological writing but loved him as a brother naturalist. Toward the latter part of his life, however, sociology engrossed his energies and it is as sociologist that he will be known to the future.

Thirty years ago when Dr. Ward made his début with his monumental "Dynamic Sociology," the influence of Spencer was completely dominant save among the handful of socialists. Social evolutionism insisted that the improvement of society must of necessity be slow. No factors could be relied on for the promotion of progress save the blind forces which had brought mankind out of prehistoric savagery. The state, being in origin and spirit coercive, could do nothing to accelerate progress, although by ill-advised intermeddling it could do much to hinder it. Beyond protecting life and property the state should keep its hands off.

Ward was the first who, digging as deep as Spencer and basing himself with equal confidence upon modern science, built up a totally different social philosophy. He rejected the dogma of the superiority of the "natural" and insisted that human progress is a matter of art, is "artificial." There is always an artificial which, from man's point of view, is better than the natural. Instead of "Back to nature!" the cry ought to be "Forward to art!" The social progress we have had has come about by the haphazard contributions of a small number of originative individuals; but the rate of movement can be enormously accelerated provided society intelligently sets about it.

The state has been coercive, but it is fit for higher purposes. We are still in the stone age of politics. It is practicable gradually to mould government into an instrument of collective intelligence. War, oppres-

Lester F. Ward.

sion, exploitation and superstition—the chief obstacles to progress—are rooted in general ignorance and may be removed by the diffusion of knowledge. Universal education is, therefore, the one means government may employ to hasten the advancement of mankind.

His "Psychic Factors of Civilization" published in 1893 laid a deeper foundation for his program of willed social progress by setting forth the rôle of mind in organic evolution. His daring comparison of "the economy of Nature and the economy of Mind" would, at any time between the sixth century and the seventeenth, have been generally regarded as impious and inspired by the devil. Twenty years ago biological adaptation was still regarded as something to pattern after. Ward showed, however, that improvement by natural selection is frightfully wasteful. Nature's way of getting results is costly and should not be imitated by man. As soon as mind comes into the world a better method of adaptation is discovered. It is, therefore, in order for intelligence to search for shortcuts to happiness. Beyond democracy Ward sees a form of government he calls "sociocracy" in which the control of the social future rather than the adjustment of private property interests will be the chief function.

Ten years later Ward gave out "Pure Sociology," in which he traced the origin of society, the course of social development and the means by which civilization had been built up. This was followed soon by "Applied Sociology," crown of his system and his last word on the problem of accelerating social progress. While insisting equally with the socialists on the lop-sidedness of modern progress and the non-participation of the masses in the fruits of the machine era, he utterly refused to pin his hope for the future to single tax, collectivism or any economic reform whatsoever. In his view no purely economic reform can put an end to exploitation, because it leaves untouched the great inequality of intelligence which alone makes exploitation possible. Education, therefore, is the antidote not only to contemporary exploitation, but to such exploitations as may be called into being by unforeseen future developments.

Ward believed that native talent or genius appears about as frequently in one social class as another, in working-class children as in the children of the well-to-do. The fact that through the centuries most of the great men have sprung from the comfortable classes simply proves the might of opportunity. The bringing of full educational opportunities within reach of all children will enable society for the first time to realize on all its latent assets of human capacity.

Ward lived to see his ideas generally accepted by thoughtful men. No longer is progress identified with the method of natural selection. To-day no one advocates surrender to the blind forces of social development. The *laissez faire* theory has been abandoned. The functions of government have greatly multiplied, especially on the side of research, education and stimulation. With this about-face Lester F. Ward had something to do. He never reached the people, but he reached the people who reached the people. His program remains yet to be realized, but the leaders are moving in the direction he pointed.

SIR JOSEPH DALTON HOOKER.

THE PROGRESS OF SCIENCE

LORD AVEBURY AND THE PASSING OF THE VICTORIAN ERA

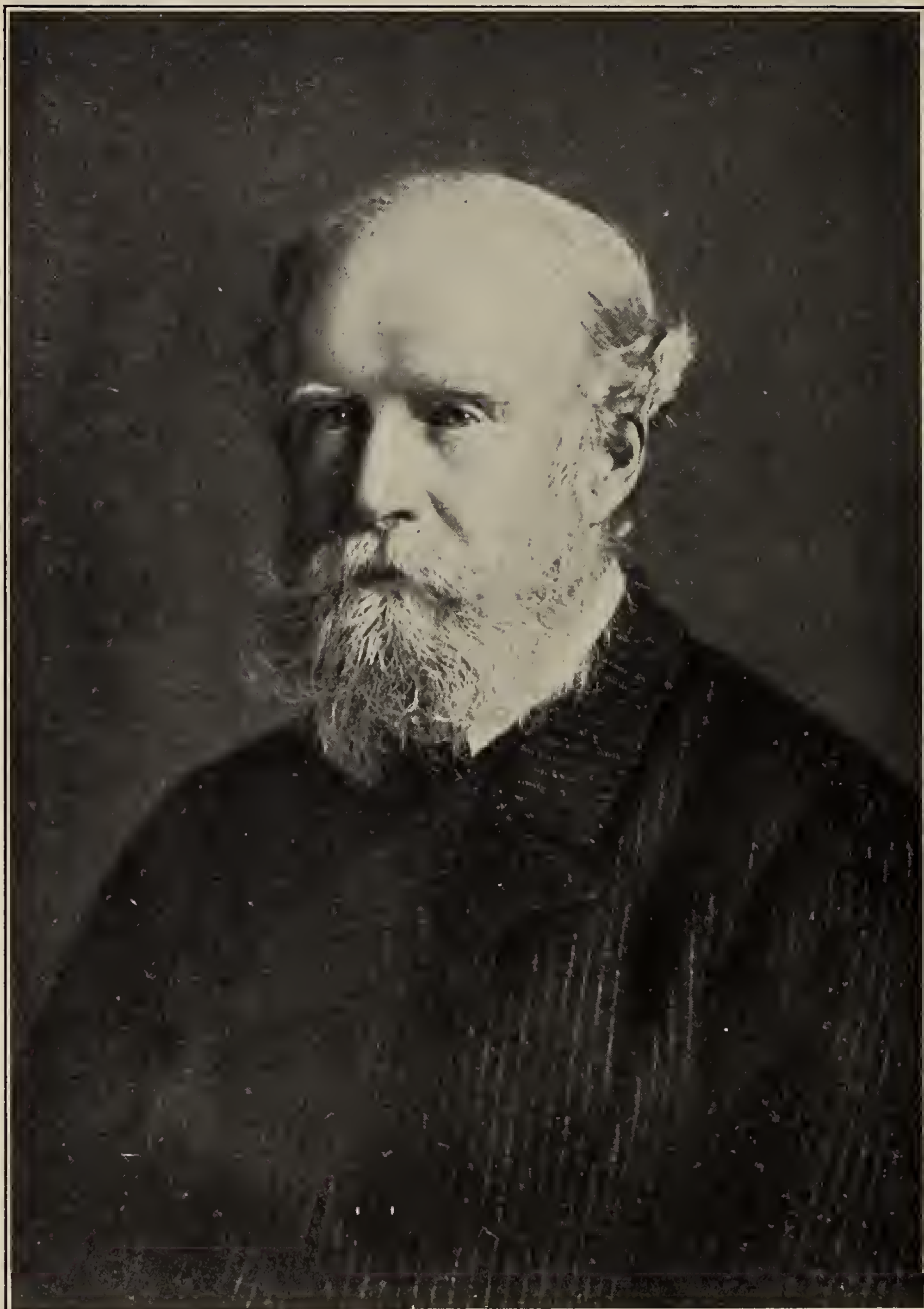
During the nineteenth century, England was clearly the leading nation of the world. Previously it had been rivaled by Italy and France, even by Austria and Spain; now it has to contend for supremacy with Germany and the United States; soon Russia and China will be added; perhaps the Balkan states and Japan. The races which successively invaded the British islands were of fine stock; their struggles and their union left a people of high quality. In the development of the applications of science England took the lead, owing to the genius of its people, the convenient supply of iron and coal and the maritime situation. Vast wealth was accumulated, the most able and vigorous of its people being the most successful. Innumerable families were established with inherited ability and wealth. From them came the great men who gave distinction to the Victorian era.

Four years ago, after comments on Darwin and Tennyson in view of the centenary of their births, it was here remarked: "The greatness of the Victorian era is now represented among the living by men of science—Hooker, Wallace, Avebury, Huggins, Galton." Only Wallace is now left, still vigorous in body and mind at the age of ninety years. One after the other the world lost Lister, Huggins and Galton; Sir Joseph Dalton Hooker died on December the tenth last, in his ninety-fifth year; Lord Avebury died on May 28 at the age of seventy-nine years.

Avebury—not every reader of the works of Sir John Lubbock will recognize him under the name he bore in the peerage—was not among the greatest men of the nineteenth century, but there is no finer example of the performance of the Victorian era. Like Hooker he inherited from his father superior natural ability directed to scientific work and at the same time ample wealth. He was perhaps without peer as an amateur, nor is he likely to have a successor. He is known for a long series of scientific and literary books which attained circulations in English and foreign editions running into the hundreds of thousands. As a neighbor and friend of Darwin's at Down he may have been influenced by him in his work on natural history, beginning with "The Prehistoric Times" and "Ants, Bees and Wasps." Equally popular with his works on anthropology, entomology and botany were his "Scenery of England" and "Scenery of Switzerland," and his books of literary philosophy, such as "The Pleasures of Life" and "The Beauties of Nature."

While writing so many books concerned with science and letters and while most active in scientific and educational organization—he was president of the British Association at its jubilee meeting and president of a long list of scientific societies—Avebury conducted the banking business which he inherited from his father. He published important brochures on currency and commerce and had large influence in the financial world. At the same time he was an active member of parliament, taking special interest in questions of education and social reform, as in initiating the movement for early closing and public holidays.

Avebury so completely represented many aspects of the Victorian era that his death typifies the passing of that great period in history. Rule by the best and work for love of the work are



Lord Avebury.

fine ideals in politics and in science, yet it is now scarcely a compliment to call a man an aristocrat and an amateur. Avebury himself could not follow the newer order. With other representatives of the old whig and liberal families, he parted from Gladstone in 1886 over the question of home rule for Ireland. He was out of sympathy with the radical and socialistic democracy into which the party to which he once belonged has moved. Amateurism in science, like aristocracy in government, is no longer credited. Avebury's books are not now read so eagerly as in the past, and it may be that such books will not hereafter be written. We have moved forward into a new age which we may hope is an advance in the civilization of the world. But the Victorian era and its great men are not less memorable because they belong to a past which can not return.

VITAL STATISTICS AND THE MARRIAGE RATE

Tables of vital statistics make an appeal to the imagination not surpassed by any writings in verse or prose. The events in the career of an individual are insignificant compared with the vast exhibit of human life displayed in tables of births, marriages and deaths. If the birth of a child is of more consequence than anything else, it is surely momentous that in a single country such as England half a million children were not born last year who would have been born if the birth rate had remained what it was a few years ago. If one tries to fancy the tragedy of each single death, it is quite beyond the range of the imagination to realize the meaning of a statement such as thirty years ago there died in England more people from scarlet fever than from cancer, whereas in 1910 there were 2,370 deaths from scarlet fever and 34,607 deaths from cancer.

Reference has been made here to birth rates and death rates as compiled in the excellent report of the registrar general of England, and it may be worth while to call attention to the data concerning marriage rates. The decreasing birth rate, the employment of women in industry and other social conditions lead many to surmise

Birth Rates, Death Rates and Marriage Rates in England and Wales for the past Forty Years. The birth rate has decreased from 36.3 to 24.4, the death rate from 22.6 to 13.5; the marriage rate has remained about stationary since 1880.

that marriage is less common now than formerly, but that is not the case. There has been little or no change in the marriage rate or in the proportion of people married in the course of the past fifty years. Curves are here drawn from the report of the English registrar general for births, marriages and deaths.

These curves exhibit the remarkable decline in the birth rate and in the death rate. If they should continue in their present course there would be neither births nor deaths in England seventy-five years hence. As a matter of fact, the death rate can not decrease much farther. The very low figure of 13.5 deaths for each thousand of the population is due not only to improved conditions and a great decrease in the deaths of children and of those under forty which can be maintained and increased, but also to the fact that a birth rate declining in the course of a single generation from 36 to 24 has given a population containing a comparatively small percentage of old people and of young children among whom deaths are most common. What will happen to the birth rate, no one can foretell. In France the births have fallen below the deaths, and this may happen in England and in Germany.

Unlike the birth rate and the death rate, the marriage rate has not altered appreciably in the course of the past forty years. It was, it is true, somewhat higher in the early seventies, but it was only 16 in the early sixties. The variation from year to year is caused by economic and social conditions, so that the marriage rate has been called the barometer of the prosperity of a nation. The lowest marriage rate in England was 14.2 in 1886; it increased to 16.5 in 1899 and has since declined to 15. The constitution of the English population is favorable to a low death rate, but to a high birth rate and a high marriage rate. Among each million of the population there were in 1901 in England 257,525 between the ages of 20 and 34; in Germany, 239,857; in France, 233,548; in Sweden, 210,773. Most marriages occur between these ages and nearly all children are born when the mother is between these ages. The excess of people of these ages in Great Britain would account for an excess of marriages and births of 10 per cent. over France and 20 per cent. over Sweden. As the English population becomes stationary we may expect a decrease in marriages and births to that extent.

In Germany as in England the marriage rate is now about the same as it was thirty years ago. It has increased somewhat in France. The percentages of women between 15 and 49 years old who were married in 1901 was: In France, 57.7; in Italy, 56.1; in the German empire, 52.8, and in England, 49.2. In the course of twenty years there was an increase in France and Italy, a stationary condition in Germany and a decrease in England. In France, where the children are the fewest, the proportion of married women is the greatest as is also the number of unlegitimized unions. The decreasing birth rate is not caused by a decreasing marriage rate. It appears that it is due to the fact that people now marry with the intention of having no children or no more children than is convenient.

SCIENTIFIC ITEMS

We record with regret the death of Dr. William Hallock, professor of physics in Columbia University, and of Dr. William McMurtrie, one of the leading industrial chemists of New York City.

The Paris Academy of Sciences has elected Professor W. M. Davis, of Harvard University, a correspondent in the Section of Geography and Navigation, in the place of the late Sir George Darwin.—The mathematical works of the late Henri Poincaré are to be published by the firm of Gauthier-Villars, under the auspices of the minister of public instruction and the Paris Academy of Sciences.

The Popular Science Monthly

Entered in the Post Office in Lancaster, Pa., as second-class matter.

CONTENTS OF THE MAY NUMBER

CONTENTS OF THE JUNE NUMBER

PRESS OF THE NEW ERA PRINTING COMPANY

Vol. LXXXIII, No. 2 AUGUST, 1913

THE POPULAR SCIENCE MONTHLY

EDITED BY J. McKEEN CATTELL

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THE SCIENCE PRESS

LANCASTER, PA. GARRISON, N. Y.

NEW YORK: Sub-Station 84

Single Number, 30 Cents Yearly Subscription, $3.00

THE

POPULAR SCIENCE

MONTHLY.

AUGUST, 1913

THE EARTH AND SUN AS MAGNETS[1]

BY DR. GEORGE ELLERY HALE

MOUNT WILSON SOLAR OBSERVATORY

IN 1891, Professor Arthur Schuster, speaking before the Royal Institution, asked a question which has been widely debated in recent years: "Is every large rotating body a magnet?" Since the days of Gilbert, who first recognized that the earth is a great magnet, many theories have been advanced to account for its magnetic properties. Biot, in 1805, ascribed them to a relatively short magnet near its center. Gauss, after an extended mathematical investigation, substituted a large number of small magnets, distributed in an irregular manner, for the single magnet of Biot. Grover suggested that terrestrial magnetism may be caused by electric currents, circulating around the earth and generated by the solar radiation. Soon after Rowland's demonstration in 1876 that a rotating electrically charged body produces a magnetic field, Ayrton and Perry attempted to apply this principle to the case of the earth. Rowland at once pointed out a mistake in their calculation, and showed that the high potential electric charge demanded by their theory could not possibly exist on the earth's surface. It remained for Schuster to suggest that a body made up of molecules which are neutral in the ordinary electrical or magnetic sense may nevertheless develop magnetic properties when rotated.

We shall soon have occasion to examine the two hypotheses advanced in support of this view. While both are promising, it can not be said that either has been sufficiently developed to explain completely the principal phenomena of terrestrial magnetism. If we turn to experiment, we find that iron globes, spun at great velocity in the laboratory, fail to exhibit magnetic properties. But this can be accounted for on either hypothesis. What we need is a globe of great size, which

[1] Address delivered upon the occasion of the semi-centennial anniversary of the foundation of the National Academy of Sciences, April 22, 1913.

FIG 1. DIRECT PHOTOGRAPH OF THE SUN WITH DOT REPRESENTING EARTH FOR COMPARISON.

has been rotating for centuries at high velocity. The sun, with a diameter one hundred times that of the earth (Fig.1), may throw some light on the problem. Its high temperature wholly precludes the existence of permanent magnets: hence any magnetism it may exhibit must be due to motion. Its great mass and rapid linear velocity of rotation should produce a magnetic field much stronger than that of the earth. Finally, the presence in its atmosphere of glowing gases, and the well-known effect of magnetism on light, should enable us to explore its magnetic field even at the distance of the earth. The effects of ionization, probably small in the region of high pressure beneath the photosphere and marked in the solar atmosphere, must be determined and allowed for. But with this important limitation, the sun may be used by the physicist for an experiment which can not be performed in the best equipped laboratory.

Schuster, in the lecture already cited, remarked:

The form of the corona suggests a further hypothesis which, extravagant as it may appear at present, may yet prove to be true. Is the sun a magnet?

Summing up the situation in April, 1912, he repeated:

The evidence (whether the sun is a magnet) rests entirely on the form of certain rays of the corona, which—assuming that they indicate the path of projecting particles—seem to be deflected as they would be in a magnetic field, but this evidence is not at all decisive.

There remained the possibility of an appeal to a conclusive test of magnetism: the characteristic changes it produces in light which originates in a magnetic field.

Before describing how this test has been applied, let us rapidly recapitulate some of the principal facts of terrestrial magnetism. You see upon the screen the image of a steel sphere (Fig. 2), which has been

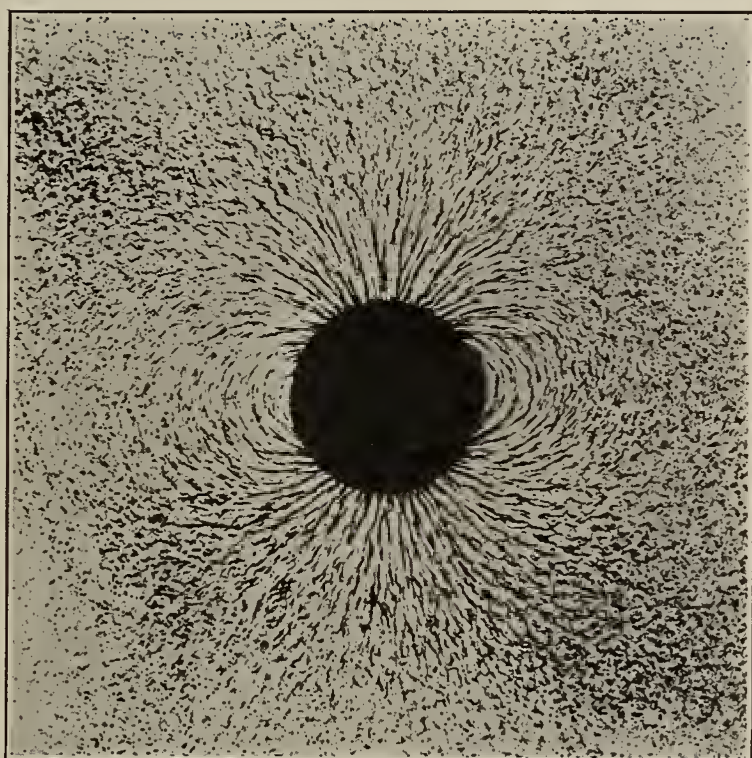

FIG. 2. LINES OF FORCE OF A MAGNETIZED STEEL SPHERE.

strongly magnetized. If iron filings are sprinkled over the glass plate that supports it, each minute particle becomes a magnet under the influence of the sphere. When the plate is tapped, to relieve the friction, the particles fall into place along the lines of force, revealing a characteristic pattern of great beauty. A small compass needle, moved about the sphere, always turns so as to point along the lines of force. At the magnetic poles, it points toward the center of the sphere. Midway between them, at the equator, it is parallel to the diameter joining the poles.

As the earth is a magnet, it should exhibit lines of force resembling those of the sphere. If the magnetic poles coincided with the poles of rotation, a freely suspended magnetic needle should point vertically

FIG. 3. THE NON-MAGNETIC YACHT *Carnegie.*

downward at one pole, vertically upward at the other, and horizontally at the equator. A dip needle, used to map the lines of force of the earth, is shown on the screen. I have chosen for illustration an instrument designed for use at sea, on the non-magnetic yacht *Carnegie* (Fig. 3), partly because the equipment used by Dr. Bauer in his extensive surveys represents the best now in use, and also because I wish to contrast the widely different means employed by the Carnegie Institution for the investigation of solar and terrestrial magnetic phenomena. The support of the dip-needle is hung in gimbals, so that observations may be taken when the ship's deck is inclined. The smallest possible amount of metal enters into the construction of this vessel, and where its use could not be avoided, bronze was employed instead of iron or steel. She is thus admirably adapted for magnetic work, as is shown by the observations secured on voyages already totaling more than 100,000 miles. Her work is supplemented by that of land parties, bearing instruments to remote regions where magnetic observations have never before been made.

The dip-needle clearly shows that the earth is a magnet, for it behaves in nearly the same way as the little needle used in our experiment with the magnetized sphere. But the magnetic poles of the earth do not coincide with the geographical poles. The north magnetic pole, discovered by Ross and last visited by Amundsen in 1903, lies near Baffin's Bay, in latitude 70° north, longitude 97° west. The position of the south magnetic pole, calculated from observations made in its vicinity by Captain Scott, of glorious memory, in his expedition of 1901–04, is 72° 50′ south latitude, 153° 45′ east longitude. Thus the two magnetic poles are not only displaced about 30° from the geographical poles: they do not even lie on the same diameter of the earth. Moreover, they are not fixed in position, but appear to be rotating about the geographical poles in a period of about 900 years. In addition to these peculiarities, it must be added that the dip-needle shows the existence of local magnetic poles, one of which has recently been found by Dr. Bauer's party at Treadwell Point, Alaska. At such a place the direction of the needle undergoes rapid change as it is moved about the local pole.

The dip-needle, as we have seen, is free to move in a vertical plane. The compass needle moves in a horizontal plane. In general, it tends to point toward the magnetic pole, and as this does not correspond with the geographical pole, there are not many places on the earth's surface where the needle indicates true north and south. Local peculiarities, such as deposits of iron ore, also affect its direction very materially. Thus a variation chart, which indicates the deviation of the compass needle from geographical north, affords an excellent illustration of the irregularities of terrestrial magnetism. The necessity for frequent and accurate surveys of the earth's magnetic field is illustrated by the fact that the *Carnegie* has found errors of five or six degrees in the variation charts of the Pacific and Indian oceans.

In view of the earth's heterogeneous structure, which is sufficiently illustrated by its topographical features, marked deviations from the uniform magnetic properties of a magnetized steel sphere are not at all surprising. The phenomenon of the secular variation, or the rotation of the magnetic poles about the geographical poles, is one of the peculiarities toward the solution of which both theory and experiment should be directed.

Passing over other remarkable phenomena of terrestrial magnetism,

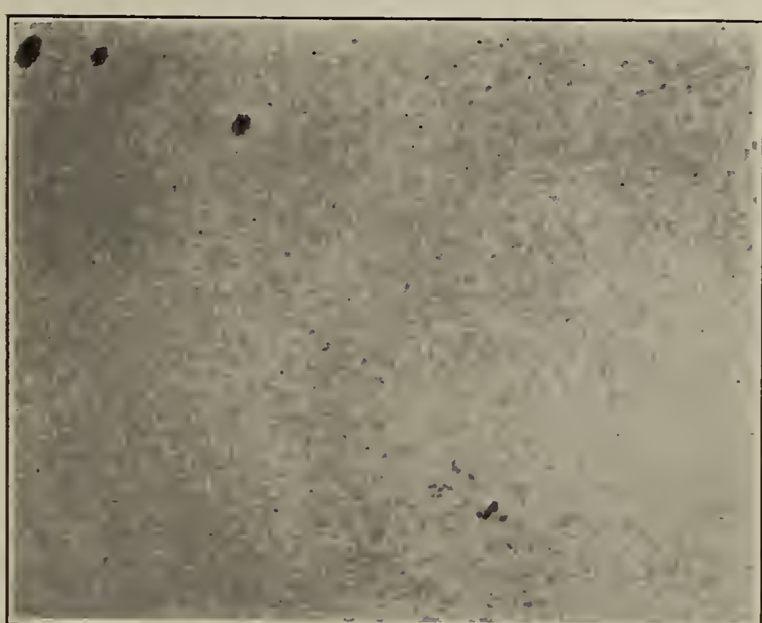

Fig. 4. Direct Photograph of Part of the Sun, April 30, 1908.

we come to magnetic storms and auroras, which are almost certainly of solar origin.

Here is a photograph of the sun, as it appears in the telescope (Fig. 4).[2] Scattered over its surface are sun-spots, which increase and decrease in number in a period of about 11.3 years. It is well known that a curve, showing the number of spots on the sun, is closely similar to a curve representing the variations of intensity of the earth's magnetism. The time of maximum sun-spots corresponds with that of reduced intensity of the earth's magnetism, and the parallelism of the two curves is too close to be the result of accident. We may therefore conclude that there is some connection between the spotted area of the sun and the magnetic field of the earth.

We shall consider a little later the nature of sun-spots, but for the present we may regard them simply as solar storms. When spots are numerous the entire sun is disturbed, and eruptive phenomena, far transcending our most violent volcanic outbursts, are frequently visible. In the atmosphere of the sun, gaseous prominences rise to great heights. This one, reaching an elevation of 85,000 miles, is of the quiescent type, which changes gradually in form and is abundantly found at all phases of the sun's activity. But such eruptions as the one of March 25, 1895, photographed with the spectroheliograph of the Kenwood Observatory, are clearly of an explosive nature. As these photographs show, it shot upward through a distance of 146,000 miles in 24 minutes, after which it faded away.

When great and rapidly changing spots, usually accompanied by eruptive prominences, are observed on the sun, brilliant displays of the aurora (Fig. 5) and violent magnetic storms are often reported. The magnetic needle, which would record a smooth straight line on the photographic film if it were at rest, trembles and vibrates, drawing a broken and irregular curve. Simultaneously, the aurora flashes and pulsates, sometimes lighting up the northern sky with the most brilliant display of red and green discharges.

Birkeland and Störmer have worked out a theory which accounts in a very satisfactory way for these phenomena. They suppose that electrified particles, shot out from the sun with great velocity, are drawn in toward the earth's magnetic poles along the lines of force. Striking the rarified gases of the upper atmosphere, they illuminate them, just as the electric discharge lights up a vacuum tube. There is reason to believe that the highest part of the earth's atmosphere consists of rarified hydrogen, while nitrogen predominates at a lower level. Some of the electrons from the sun are absorbed in the hydrogen, above a height of 60 miles. Others reach the lower-lying nitrogen, and descend to levels from 30 to 40 miles above the earth's surface. Certain still

[2] Figs. 4, 6 and 7 represent the same region of the sun, photographed at successively higher levels.

Fig. 5. The Aurora.

more penetrating rays sometimes reach an altitude of 25 miles, the lowest hitherto found for the aurora. The passage through the atmosphere of the electrons which cause the aurora also gives rise to the irregular disturbances of the magnetic needle observed during magnetic storms.

The outflow of electrons from the sun never ceases, if we may reason from the fact that the night sky is at all times feebly illuminated by the characteristic light of the aurora. But when sun-spots are numerous, the discharge of electrons is most violent, thus explaining the frequency of brilliant auroras and intense magnetic storms during sun-spot maxima. It should be remarked that the discharge of electrons does not necessarily occur from the spots themselves, but rather from the eruptive regions surrounding them.

Our acquaintance with vacuum tube discharges dates from an early period, but accurate knowledge of these phenomena may be said to begin with the work of Sir William Crookes in 1876. A glass tube, fitted with electrodes, and filled with any gas, is exhausted with a suitable pump until the pressure within it is very low. When a high voltage discharge is passed through the tube, a stream of negatively-charged particles is shot out from the cathode, or negative pole, with great velocity. These electrons, bombarding the molecules of the gas within the tube, produce a brilliant illumination, the character of which depends upon the nature of the gas. The rare hydrogen gas in the upper atmosphere of the earth, when bombarded by electrons from the sun, glows like the hydrogen in this tube. Nitrogen, which is characteristic of a lower level, shines with the light which can be duplicated here.

But it may be remarked that this explanation of the aurora is only hypothetical, in the absence of direct evidence of the emission of electrons by the sun. However, we do know that hot bodies emit electrons.

Here is a carbon filament in an exhausted bulb. When heated white hot, a stream of electrons passes off. Falling upon this electrode, the electrons discharge the electroscope with which it is connected. Every one who has to discard old incandescent lamps is familiar with the result of this outflow. The blackening of the bulbs is due to finely divided carbon carried away by the electrons, and deposited upon the glass.

Now we know that great quantities of carbon in a vaporous state exist in the sun, and that many other substances, also present there, emit electrons in the same way. Hence we may infer that electrons are abundant in the solar atmosphere.

The temperature of the sun is between 6,000° and 7,000° C., twice as high as we can obtain by artificial means. Under solar conditions, the velocity of the electrons emitted in regions where the pressure is not too great may be sufficient to carry them to the earth. Arrhenius holds that the electrons attach themselves to molecules or groups of molecules, and are then driven to the earth by light-pressure.

In certain regions of the sun, we have strong evidence of the existence of free electrons. This leads us to the question of solar magnetism and suggests a comparison of the very different conditions in the sun and earth. Much alike in chemical composition, these bodies differ principally in size, in density and in temperature. The diameter of the sun is more than one hundred times that of the earth, while its density is only one quarter as great. But the most striking point of difference is the high temperature of the sun, which is much more than sufficient to vaporize all known substances. This means that no permanent magnetism, such as is exhibited by a steel magnet or a lodestone, can exist in the sun. For if we bring this steel magnet to a red heat, it loses its magnetism, and drops the iron bar which it previously supported. Hence, while some theories attribute terrestrial magnetism to the presence within the earth of permanent magnets, no such theory can apply to the sun. If magnetic phenomena are to be found there, they must result from other causes.

The familiar case of the helix illustrates how a magnetic field is produced by an electric current flowing through a coil of wire. But according to the modern theory, an electric current is a stream of electrons. Thus a stream of electrons in the sun should give rise to a magnetic field. If the electrons were whirled in a powerful vortex, resembling our tornadoes or water-spouts, the analogy with the wire helix would be exact, and the magnetic field might be sufficiently intense to be detected by spectroscopic observations.

A sun-spot, as seen with a telescope or photographed in the ordinary way, does not appear to be a vortex. If we examine the solar atmosphere above and about the spots, we find extensive clouds of luminous calcium vapor, invisible to the eye, but easily photographed with the

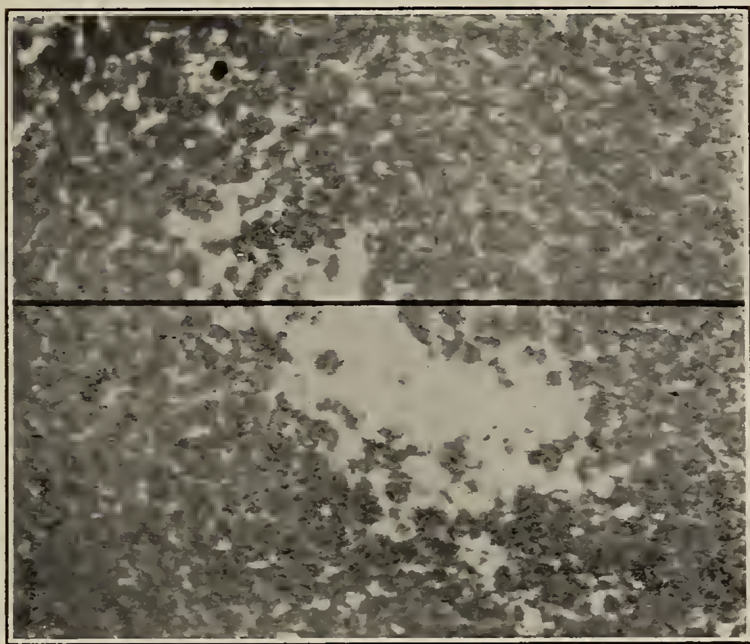

FIG. 6. CALCIUM (H_2) FLOCCULI PHOTOGRAPHED WITH THE SPECTROHELIOGRAPH, APRIL 30, 1908.

spectroheliograph, by admitting no light to the sensitive plate except that radiated by calcium vapor. These calcium flocculi (Fig. 6), like the cumulus clouds of the earth's atmosphere, exhibit no well-defined linear structure. But if we photograph the sun with the red light of hydrogen, we find a very different condition of affairs (Fig. 7). In this higher region of the solar atmosphere, first photographed on Mount Wilson in 1908, cyclonic whirls, centering in sun-spots, are clearly shown.

The idea that sun-spots may be solar tornadoes, which was strongly

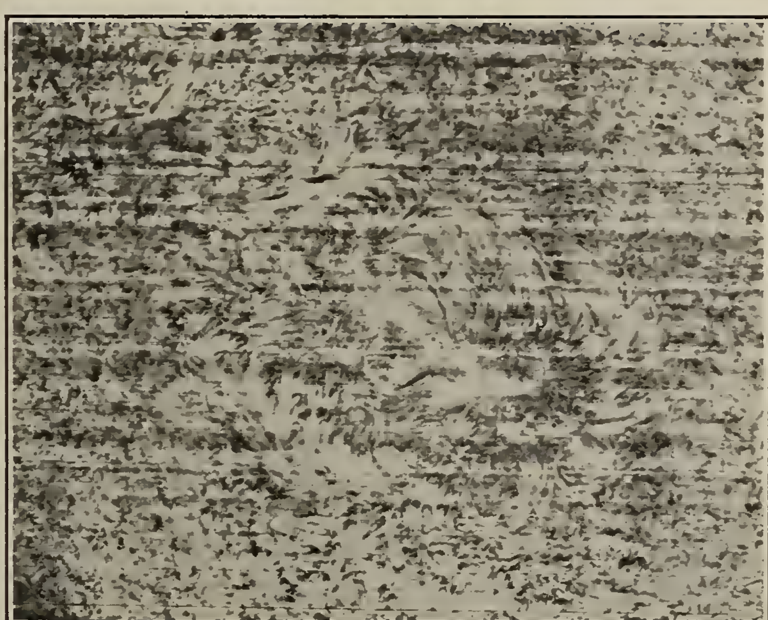

FIG. 7. HYDROGEN ($H\alpha$) FLOCCULI PHOTOGRAPHED WITH THE SPECTROHELIOGRAPH, APRIL 30, 1908.

suggested by such photographs, soon received striking confirmation. A great cloud of hydrogen, which had hung for several days on the edge of one of these vortex structures, was suddenly swept into the spot at a velocity of about 60 miles per second. More recently Slocum has photographed at the Yerkes Observatory a prominence at the edge of the sun, flowing into a spot with a somewhat lower velocity.

Thus we were led to the hypothesis that sun-spots are closely analogous to tornadoes or water-spouts in the earth's atmosphere (Fig. 8).

FIG. 8. WATER-SPOUT.

If this were true, electrons, caught and whirled in the spot vortex, should produce a magnetic field. Fortunately, this could be put to a conclusive test, through the well-known influence of magnetism on light discovered by Zeeman in 1896.

In Zeeman's experiment a flame containing sodium vapor was placed between the poles of a powerful electro-magnet. The two yellow sodium lines, observed with a spectroscope of high dispersion, were seen to widen the instant a magnetic field was produced by passing a current through the coils of the magnet. It was subsequently found that most of the lines of the spectrum, which are single under ordinary conditions, are split into three components when the radiating source is in a sufficiently intense magnetic field. This is the case when the observation is made at right angles to the lines of force. When looking along the lines of force, the central line of such a triplet disappears (Fig. 9), and the light of the two side components is found to be circularly polarized in oppo-

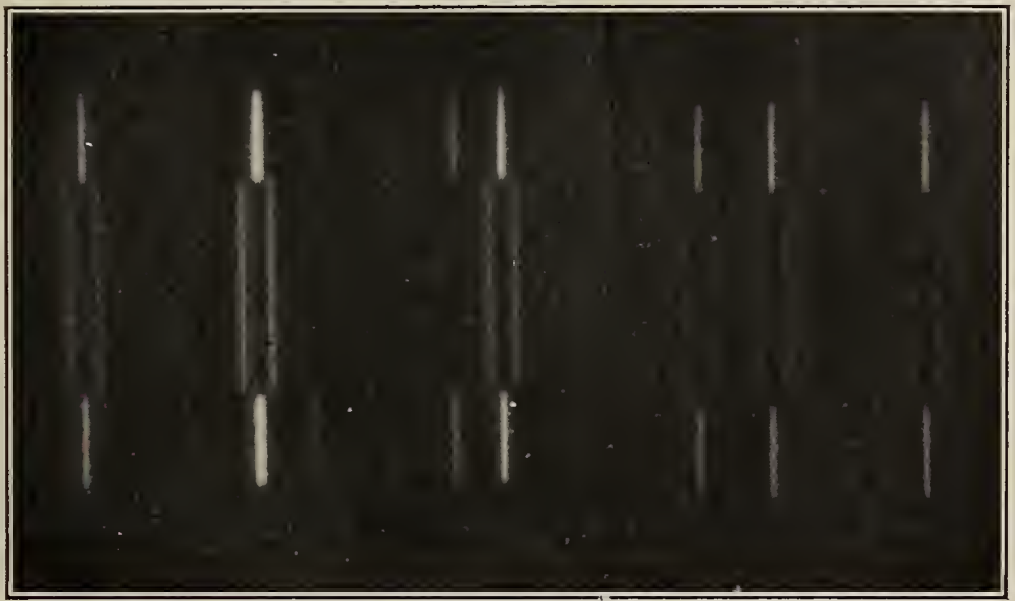

FIG. 9. ZEEMAN DOUBLET PHOTOGRAPHED IN LABORATORY SPECTRUM. The middle section shows the doublet. The adjacent sections indicate the appearance of the spectrum line in the absence of a magnetic field.

site directions. With suitable polarizing apparatus, either component of such a line can be cut off at will, leaving the other unchanged. Furthermore, a double line having these characteristic properties can be produced only by a magnetic field. Thus it becomes a simple matter to detect a magnetic field, at any distance, by observing its effect on light emitted within the field. If a sun-spot is an electric vortex, and the observer is supposed to look along the axis of the whirling vapor, which would correspond with the direction of the lines of force, he should find the spectrum lines double, and be able to cut off either component with the polarizing attachment of his spectroscope.

I applied this test to sun-spots on Mount Wilson in June, 1908, with the 60-foot tower telescope, and at once found all of the characteristic features of the Zeeman effect. Most of the lines of the sun-spot spectrum are merely widened by the magnetic field, but others are split into separate components (Fig. 10), which can be cut off at will by the observer. Moreover, the opportune formation of two large spots, which appeared on the spectroheliograph plates to be rotating in opposite directions (Fig. 11), permitted a still more exacting experiment to be tried. In the laboratory, where the polarizing apparatus is so adjusted as to transmit one component of a line doubled by a magnetic field, this disappears and is replaced by the other component when the direction of the current is reversed. In other words, one component is visible alone when the observer looks toward the north pole of the magnet, while the other appears alone when he looks toward the south pole. If electrons of the same kind are rotating in opposite directions in two sun-spot vortices, the observer should be looking toward a north pole in one spot and toward a south pole in the other. Hence the

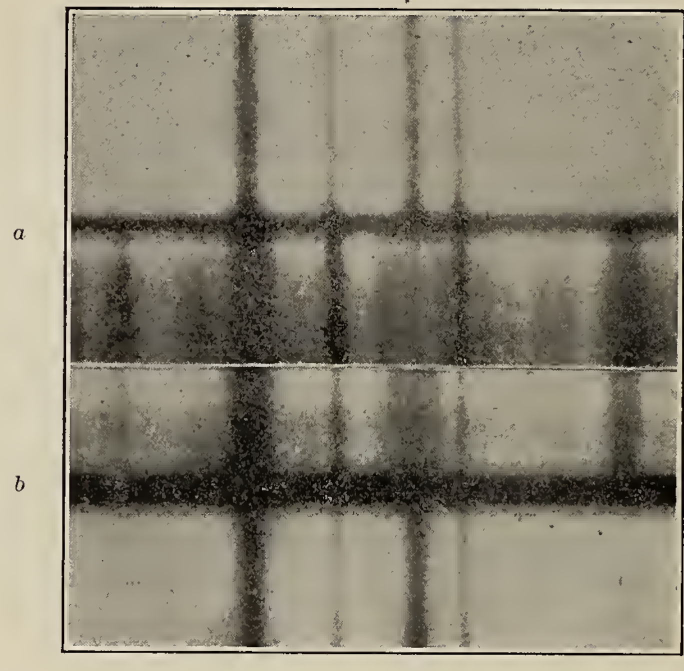

Fig. 10. a, b, spectra of two sun-spots. The triple line indicates a magnetic field of 4,500 gausses in a, and one of 2,900 gausses in b.

opposite components of a magnetic double line should appear in two such spots. As our photographs show, the result of the test was in harmony with my anticipation.

I may not pause to describe the later developments of this investigation, though two or three points must be mentioned. The intensity of the magnetic field in sun-spots is sometimes as high as 4,500 gausses, or nine thousand times the intensity of the earth's field. In passing upward from the sun's surface, the magnetic intensity decreases very

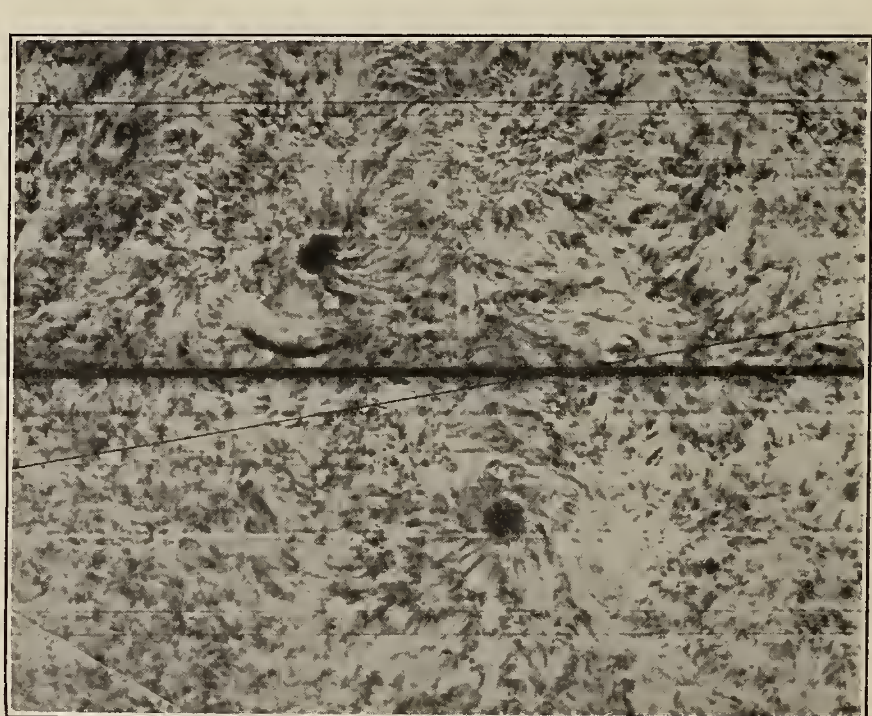

Fig. 11. Right- and Left-handed Vortices surrounding Sun-spots indicated by the distribution of hydrogen ($H\alpha$) gas. Photographed with the spectroheliograph.

rapidly—so rapidly, in fact, as to suggest the existence of an opposing field. It is probable that the vortex which produces the observed field is not the one that appears on our photograph, but lies at a lower level. In fact, the vortex structure shown on spectroheliograph plates may represent the effect, rather than the cause of the sun-spot field. We may have, as Brester and Deslandres suggest, a condition analogous to that illustrated in the aurora: electrons, falling in the solar atmosphere, move along the lines of force of the magnetic field into spots. In this way we may perhaps account for the structure surrounding pairs of spots, of opposite polarity, which constitute the typical sun-spot group. The resemblance of the structure near these two bipolar groups to the lines of force about a bar magnet is very striking, especially when the disturbed condition of the solar atmosphere, which tends to mask the effect, is borne in mind. It is not unlikely that the bipolar group is due to a single vortex, of the horse-shoe type, such as we may see in water after every sweep of an oar.

We thus have abundant evidence of the existence on the sun of local magnetic fields of great intensity—fields so extensive that the earth is small in comparison with many of them. But how may we account for the copious supply of electrons needed to generate the powerful currents required in such enormous electro-magnets? Neutral molecules, postulated in theories of the earth's field, will not suffice. A marked preponderance of electrons of one sign is clearly indicated.

An interesting experiment, due to Harker, will help us here. Imagine a pair of carbon rods, insulated within a furnace heated to a temperature of two or three thousand degrees. The outer ends of the rods, projecting from the furnace, are connected to a galvanometer. Harker found that when one of the carbon terminals within the furnace was cooler than the other, a stream of negative electrons flowed toward it from the hotter electrode. Even at atmospheric pressure, currents of several amperes were produced in this way.[3]

Our spectroscopic investigations, interpreted by laboratory experiments, are in harmony with those of Fowler in proving that sun-spots are comparatively cool regions in the solar atmosphere. They are hot enough, it is true, to volatilize such refractory elements as titanium, but cool enough to permit the formation of certain compounds not found elsewhere in the sun. Hence, from Harker's experiment, we may expect a flow of negative electrons toward spots. These, caught and whirled in the vortex, would easily account for the observed magnetic fields.

The conditions existing in sun-spots are thus without any close parallel among the natural phenomena of the earth. The sun-spot vortex is not unlike a terrestrial tornado, on a vast scale, but if the

[3] King has recently found that the current decreases very rapidly as the pressure increases, but is still appreciable at a pressure of 20 atmospheres.

whirl of ions in a tornado produces a magnetic field, it is too feeble to be readily detected. Thus, while we have demonstrated the existence of solar magnetism, it is confined to limited areas. We must look further if we would throw new light on the theory of the magnetic properties of rotating bodies.

This leads us to the question with which we started: is the sun a magnet like the earth? The structure of the corona, as revealed at total eclipses, points strongly in this direction. Remembering the lines of force of our magnetized steel sphere, we can not fail to be struck by their close resemblance to the polar streamers in these beautiful photographs of the corona (Fig. 12) taken by Lick Observatory eclipse parties, for which

Fig. 12. Solar Corona, showing Polar Streamers.

I am indebted to Professor Campbell. Bigelow, in 1889, investigated this coronal structure, and showed that it is very similar to the lines of force of a spherical magnet. Störmer, guided by his own researches on the aurora, has calculated the trajectories of electrons moving out from the sun under the influence of a general magnetic field, and compared these trajectories with the coronal streamers. The resemblance is apparently too close to be the result of chance. Finally, Deslandres has investigated the forms and motions of solar prominences, which he finds to behave as they would in a magnetic field of intensity about one millionth that of the earth. We may thus infer the existence of a general solar magnetic field. But since the sign of the charge of the outflowing electrons is not certainly known, we can not determine the polarity of the sun in this way. Furthermore, our present uncertainty

FIG. 13. 150-FOOT TOWER TELESCOPE.

as to the proportion at different levels of positive and negative electrons, and of the perturbations due to currents in the solar atmosphere, must delay the most effective application of these methods, though they promise much future knowledge of the magnetic field at high levels in the solar atmosphere.

Of the field at low levels, however, they may tell us little or nothing, for the distribution of the electrons may easily be such as to give rise to a field caused by the rotation of the solar atmosphere, which may oppose in sign the field due to the rotation of the body of the sun. To detect this latter field, the magnetic field of the sun as distinguished from that of the sun's atmosphere, we must resort to the method employed in the case of sun-spots—the study of the Zeeman effect. If

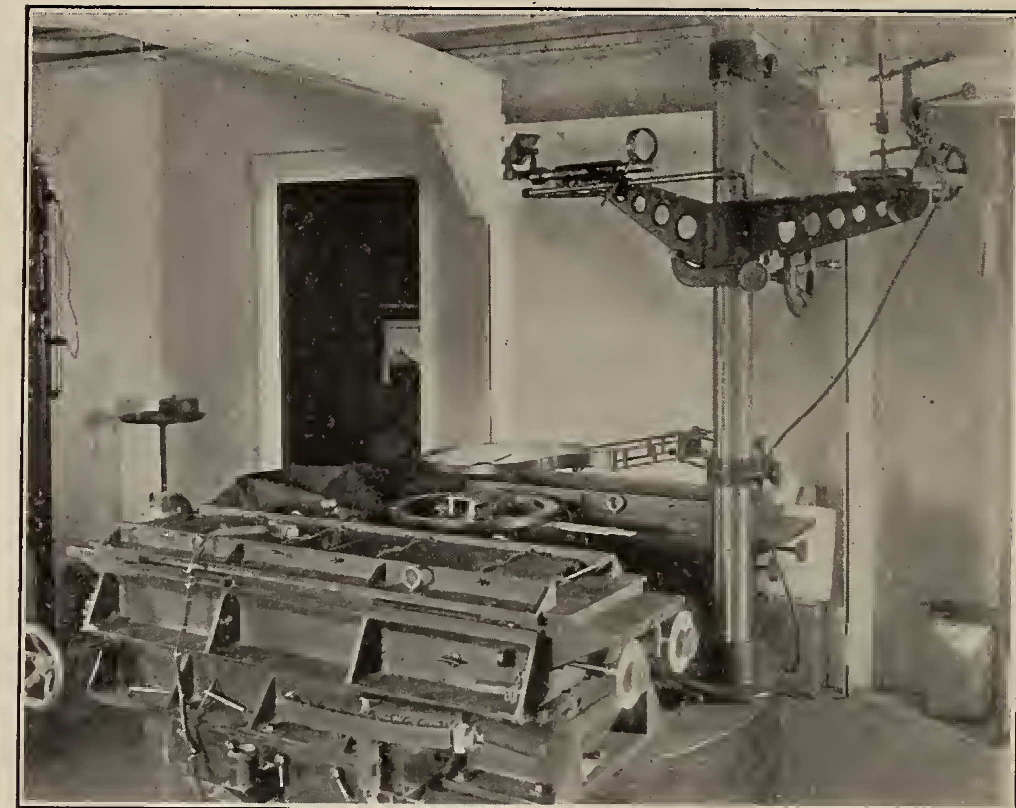

Fig. 14. Head of the 75-foot Spectrograph of the 150-foot Tower Telescope.

this is successful, it will not only show beyond doubt whether the sun is a magnet: it will also permit the polarity of the sun to be compared with that of the earth, give a measure of the strength of the field at different latitudes, and indicate the sign of the charge that a rotating sphere must possess if it is to produce a similar field.

I first endeavored to apply this test with the 60-foot tower telescope in 1908, but the results were too uncertain to command confidence.

Thanks to additional appropriations from the Carnegie Institution of Washington, a new and powerful instrument was available on Mount Wilson for a continuation of the investigation in January, 1912. The new tower telescope has a focal length of 150 feet (Fig. 13). To prevent vibration in the wind, the cœlostat, second mirror and object-glass are carried by a skeleton tower, each vertical and diagonal member of which is enclosed within the corresponding member of an outer skeleton tower, which also carries a dome to shield the instruments from the weather. In the photograph, we see only the hollow members of the outer tower. But within each of them, well separated from possible contact, a sectional view would show the similar, but more slender members of the tower that supports the instruments. The plan has proved to be successful, permitting observations demanding the greatest steadiness of the solar image to be made.

The arrangements are similar to those of the 60-foot tower. The solar image, 16½ inches in diameter, falls on the slit of a spectrograph

(Fig. 14) in the observation house at the ground level. The spectrograph, of 75 feet focal length, enjoys the advantage of great stability and constancy of temperature in its subterranean vault beneath the tower. In the third order spectrum, used for this investigation, the D lines of the solar spectrum are 29 millimeters apart. The resolving power of the excellent Michelson grating is sufficient to show 75 lines of the iodine absorption spectrum in this space between the D's. Thus the instruments are well suited for the exacting requirements of a difficult investigation. For it must be borne in mind that the problem is very different from that of detecting the magnetic fields in sun-spots, where the separation of the lines is from fifty to one hundred times as great as we may expect to find here. Thus the sun's general field can produce no actual separation of the lines. But it may cause a very slight widening, which should appear as a displacement when suitable polarizing apparatus is used. This is so arranged as to divide the spectrum longitudinally into narrow strips. The component toward the red end of the spectrum of a line widened by magnetism should appear in one strip, the other component in the next strip. Hence, if the sun has a magnetic field of sufficient strength, the line should have a dentated appearance. The small relative displacements of the lines on successive strips, when measured under a microscope, should give the strength of the magnetic field.

The above remarks apply strictly to the case when the observer is looking directly along the lines of force. At other angles neither component is completely cut off, and the magnitude of the displacement will then depend upon two things: the strength of the magnetic field and the angle between the line of sight and the lines of force. Assuming that the lines of force of the sun correspond with those of a magnetized sphere, and also that the magnetic poles coincide with the poles of rotation, it is possible to calculate what the relative displacement should be at different solar latitudes. These theoretical displacements are shown graphically by the sine curve on the screen (Fig. 15).

We see from the curve that the greatest displacements should be found at 45° north and south latitude, and that from these points they should decrease toward zero at the equator and the poles. Furthermore, the curve shows that we may apply the same crucial test used in the case of sun-spots: the direction of the displacements, toward red or violet, should be reversed in the northern and southern hemispheres.

I shall not trouble you with the details of the hundreds of photographs and the thousands of measures which have been made by my colleagues and myself during the past year. In view of the diffuse character of the solar lines under such high dispersion, and the exceedingly small displacements observed, the results must be given with some reserve, though they appear to leave no doubt as to the reality of the effect. Observations in the second order spectrum failed to give satisfactory indications of the field. But with the higher dispersion of the third order eleven independent determinations, made with every possible precaution to eliminate bias, show opposite displacements in

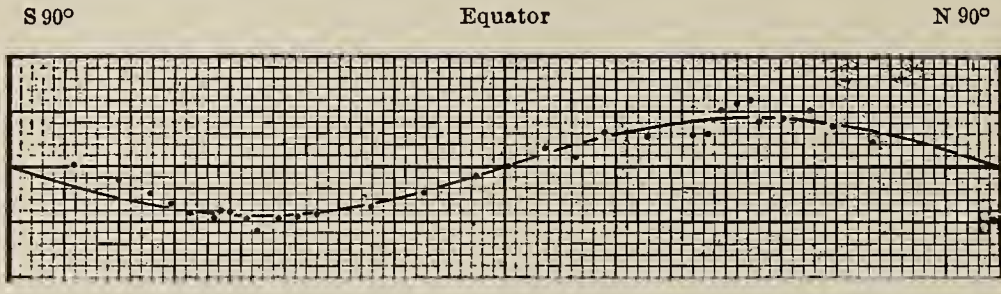

FIG. 15. The curve represents the theoretical variation of the displacements of spectrum lines with the heliographic latitude. The sun is assumed to be a magnetized sphere with its magnetic poles coinciding with the poles of rotation. The points represent mean values of the observed displacements. Vertical scale: 1 square = 0.001 mm. = 0.0002 Angström.

the northern and southern hemispheres, decreasing in magnitude from about 45° north and south latitude to the equator. Three of these determinations were pushed as close to the poles as conditions would permit, and the observed displacements may be compared with the theoretical curve (Fig. 15). In view of the very small magnitude of the displacements, which never surpass 0.002 Angströms, the agreement is quite as satisfactory as one could expect for a first approximation.

The full details of the investigation are given in a paper recently published.[4] The reader will find an account of the precautions taken to eliminate error, and, I trust, no tendency to underestimate the possible adverse bearing of certain negative results. It must remain for the future to confirm or to overthrow the apparently strong evidence in favor of the existence of a true Zeeman effect, due to the general magnetic field of the sun. If this evidence can be accepted, we may draw certain conclusions of present interest.

Taking the measures at their face value, they indicate that the north magnetic pole of the sun lies at or near the north pole of rotation, while the south magnetic pole lies at or near the south pole of rotation. In other words, if a compass needle could withstand the solar temperature, it would point approximately as it does on the earth, since the polarity of the two bodies appears to be the same. Thus, since the earth and sun rotate in the same direction, a negative charge distributed through their mass would account in each case for the observed magnetic polarity.

As for the strength of the sun's field, only three preliminary determinations have yet been made, with as many different lines. Disregarding the systematic error of measurement, which is still very uncertain, these indicate that the field-strength at the sun's poles is of the order of 50 gausses (about eighty times that of the earth).

[4] *Contributions from the Mount Wilson Solar Observatory*, No. 71.

Schuster, assuming the magnetic fields of the earth and sun to be due to their rotation, found that the strength of the sun's field should be 440 times that of the earth, or 264 gausses. This was on the supposition that the field-strength of a rotating body is proportional to the product of the radius and the maximum linear velocity of rotation, but neglected the density. Before inquiring why the observed and theoretical values differ, we may glance at the two most promising hypotheses that have been advanced in support of the view that every large rotating body is a magnet.

On account of their greater mass, the positive electrons of the neutral molecules within the earth may perhaps be more powerfully attracted by gravitation than the negative electrons. In this case the negative charge of each molecule should be a little farther from the center of the earth than the positive charge. The average linear velocity of the negative charge would thus be a little greater, and the magnetizing effect due to its motion would slightly exceed that due to the motion of the positive charge. By assuming a separation of the charges equal to about four tenths the radius of a molecule (Bauer), the symmetrical part of the earth's magnetic field could be accounted for as the result of the axial rotation.

This theory, first suggested by Thomson, has been developed by Sutherland, Schuster and Bauer. But as yet it has yielded no explanation of the secular variation of the earth's magnetism, and other important objections have been urged against it. While it should not be rejected, the merits of other theories must not be overlooked.

Chief among these is the theory that rests on the very probable assumption that every molecule is a magnet. If the magnetism is accounted for as the effect of the rapid revolution of electrons within the molecule, a gyrostatic action might be anticipated. That is, each molecule would tend to set itself with its axis parallel to the axis of the earth, just as the gyrostatic compass, now coming into use at sea, tends to point to the geographical pole. The host of molecular magnets, all acting together, might account for the earth's magnetic field.

This theory, in its turn, is not free from obvious points of weakness, though they may disappear as the result of more extended investigation. Its chief advantage lies in the possibility that it may explain the secular variation of the earth's magnetism by a precessional motion of the magnetic molecules.

On either hypothesis, it is assumed, in the absence of knowledge to the contrary, that every molecule contributes to the production of the magnetic field. Thus the density of the rotating body may prove to be a factor. Perhaps the change of density from the surface to the center of the sun must also be taken into account. But the observational results already obtained suggest that the phenomena of ionization in the solar atmosphere may turn out to be the predominant influence.

The lines which show the Zeeman effect originate at a comparatively low level in the solar atmosphere. Preliminary measures indicate that certain lines of titanium, which are widely separated by a magnetic field in the laboratory, are not appreciably affected in the sun. As these lines represent a somewhat higher level, it is probable that the strength of the sun's field decreases very rapidly in passing upward from the surface of the photosphere—a conclusion in harmony with results obtained from the study of the corona and prominences. Thus it may be found that the distribution of the electrons is such as to give rise to the observed field or to produce a field opposing that caused by the rotation of the body of the sun. It is evident that speculation along these lines may advantageously await the accumulation of observations covering a wide range of level. Beneath the photosphere, where the pressure is high, we may conclude from recent electric furnace experiments by King that free electrons, though relatively few, may nevertheless play some part in the production of the general magnetic field.

In this survey of magnetic phenomena, we have kept constantly in mind the hypothesis that the magnetism of the earth is due to its rotation. Permanent magnets, formerly supposed to account for the earth's magnetic field, could not exist at the high temperature of the sun. Displays of the aurora, usually accompanied by magnetic storms, are plausibly attributed to electrons reaching the earth from the sun, and illuminating the rare gases of the upper atmosphere just as they affect those in a vacuum tube. Definite proof of the existence of free electrons in the sun is afforded by the discovery of powerful local magnetic fields in sun-spots, where the magnetic intensity is sometimes as great as nine thousand times that of the earth's field. These local fields probably result from the rapid revolution in a vortex of negative electrons, flowing toward the cooler spot from the hotter region outside. The same method of observation now indicates that the whole sun is a magnet, of the same polarity as the earth. Because of the high solar temperature, this magnetism may be ascribed to the sun's axial rotation.[5] It is not improbable that the earth's magnetism also results from its rotation, and that other rotating celestial bodies, such as stars and nebulæ, may ultimately be found to possess magnetic properties. Thus, while the presence of free electrons in the sun prevents our acceptance of the evidence as a proof that every large rotating body is a magnet, the results of the investigation are not opposed to this hypothesis, which may be tested further by the study of other stars of known diameter and velocity of rotation.

[5] The alternative hypothesis, that the sun's magnetism is due to the combined effect of numberless local magnetic fields, caused by electric vortices in the solar "pores," though at first sight improbable, deserves further consideration.

EUGENICS: WITH SPECIAL REFERENCE TO INTELLECT AND CHARACTER[1]

By Professor EDWARD L. THORNDIKE

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BY eugenics is meant, as you all know, the improvement of mankind by breeding. It has been decided by those responsible for this lecture—Mrs. Huntington Wilson and the president and trustees of the university—that its topic shall be the intellectual and moral, rather than the physical, improvement of the human stock.

Common observation teaches that individuals of the same sex and age differ widely in intellect, character and achievement. The more systematic and exact observations made by scientific students of human nature emphasize the extent of these differences. Whether we take some trivial function—such as memory for isolated words, or delicacy of discrimination of pitch—or take some broad symptom of man's nature, such as his rate of progress through school, or ability in tests of abstract intellect, or even his general intellectual and moral repute—men differ widely. Samples of the amount and distribution of such differences are given in Charts 1, 2 and 3. Chart 1 relates that of 732 children who had studied arithmetic equally long, one could get over a hundred examples done correctly in fifteen minutes, while others could not get correct answers to five. Even if we leave out of account the top three per cent., covering all the records of 60 or over, we have some children achieving twenty-five times as many correct answers as other children.

Chart 2 shows that when four hundred children who had had similar school training were given each the same amount of practise in certain work in division, some improve not at all, and others enormously. Chart 3 shows that of children in the same school all of the same year-age (thirteen), some have done the work of the eight grades of the elementary school and of one or two years of the high school, while others have not completed the work of a single year. Still less competence at intellectual tasks could be found by including children from asylums for imbeciles and idiots.

The differences thus found amongst individuals of the same sex and age are due in large measure to original, inborn characteristics of the intellectual and moral constitution of the individuals in question. They are, it is true, in part due to differences in maturity—one thirteen-year-old being further advanced in development than another. They are

[1] A lecture given at Columbia University, in March, 1913.

also due in part to differences in environment, circumstances, training—one sort of home-life being more favorable than another to progress through school, for example. Each advance in the study of individual

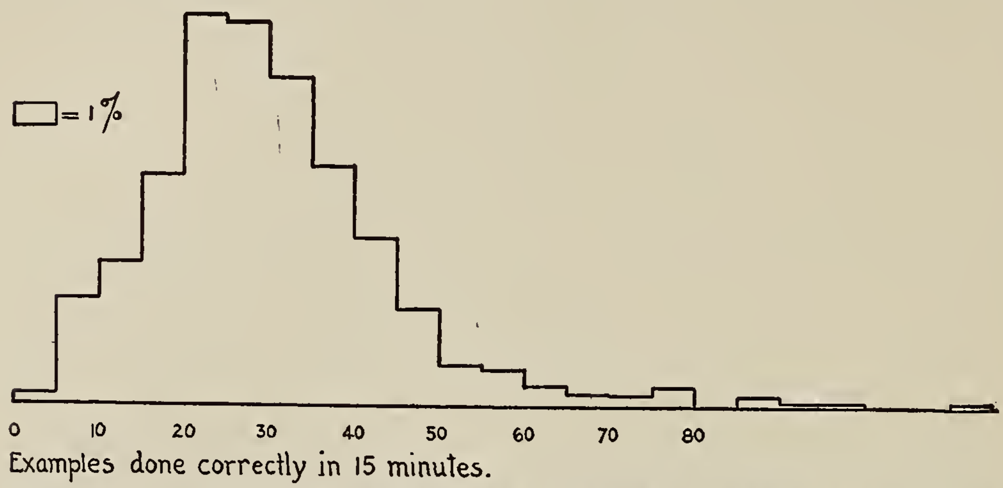

CHART 1. THE RELATIVE FREQUENCIES OF DIFFERENT DEGREES OF ABILITY IN ADDITION IN THE CASE OF FOURTH-GRADE PUPILS.

differences, however, shows that differences in maturity and differences in the circumstances of nurture account for only a small fraction of the differences actually found in individuals of the same general environment of an American city in 1900–1912. Long before a child begins

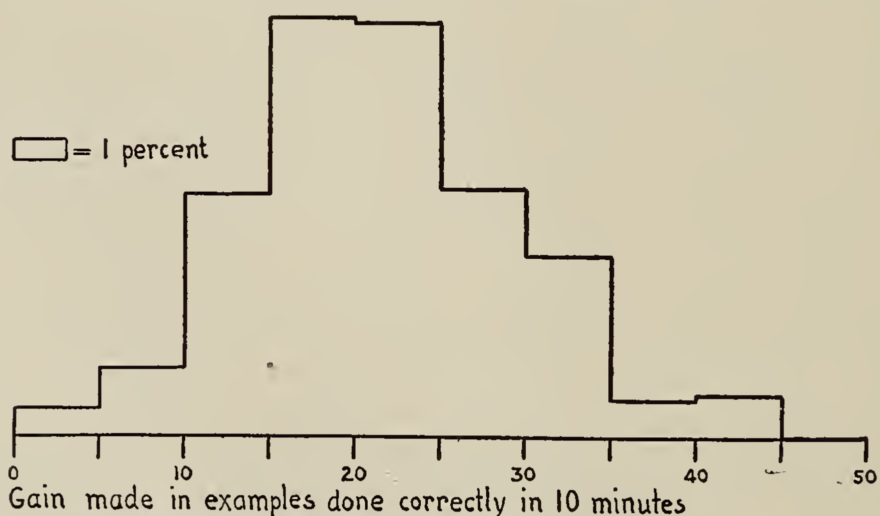

CHART 2. THE RELATIVE FREQUENCIES OF DIFFERENT AMOUNTS OF GAIN FROM FIFTY MINUTES OF PRACTISE IN DIVISION, IN THE CASE OF PUPILS OF THE SAME SCHOOL GRADE.

his schooling, or a man his work at trade or profession, or a woman her management of a home—long indeed before they are born—their superiority or inferiority to others of the same environmental advantages is determined by the constitution of the germs and ova whence they spring, and which, at the start of their individual lives, they *are*.

Of the score or more of important studies of the causes of individual differences which have been made since Francis Galton led the way, I do not find one that lends any support to the doctrine of human initial

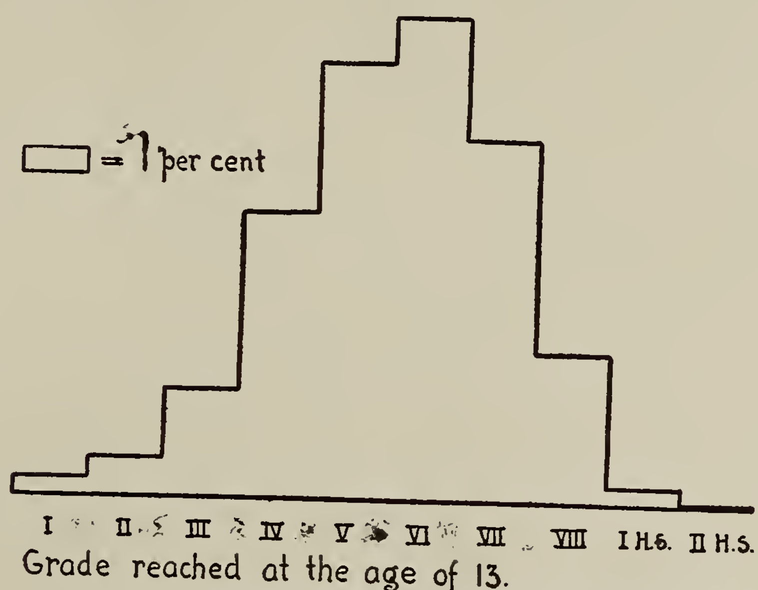

CHART 3. THE RELATIVE FREQUENCIES OF DIFFERENT AMOUNTS OF PROGRESS IN SCHOOL OF THIRTEEN-YEAR-OLD CHILDREN.

equality, total or approximate. On the contrary, every one of them gives evidence that if the thousand babies born this week in New York City were given equal opportunity they would still differ in much the same way and to much the same extent as they will in fact differ.

We find, for instance, that the children of certain families rank very much higher in certain psychological tests of perception, association and the like, than the children of certain other families. Now if this difference were due to the difference between the two groups of families in environment—in ideals, customs, hygienic conditions and the like—it should increase greatly with the age of the children in some rough proportion to the length of time that they are subject to the beneficent or unfavorable environment. It does not. One family's product differs from another nearly as much at the age of 9 to 11 as at the age of 12 to 14.

Again, if inequalities in the environment produce the greater part of these differences, equalizing opportunity and training should greatly reduce them. Such equalization is found by experiment to reduce them very little, if at all. Chart 4 shows, for example, the result of equal amounts of training applied to two groups of adults whom life in general had previously brought to the conditions shown at the left of the chart. The trait chosen was addition; from life in general one group had gained the ability to do twenty-seven more additions per minute than the other group, accuracy being equal in the two groups. At the end of the special training the superior individuals had gained on the average 28 additions per minute, while the inferior individuals gained only 10 additions per minute. As a result of this partial equalization of opportunity, the superior individuals were farther ahead than ever! If equality of opportunity has no equalizing effect in so easily alterable a trait as rapidity in addition, surely it can have little power in such

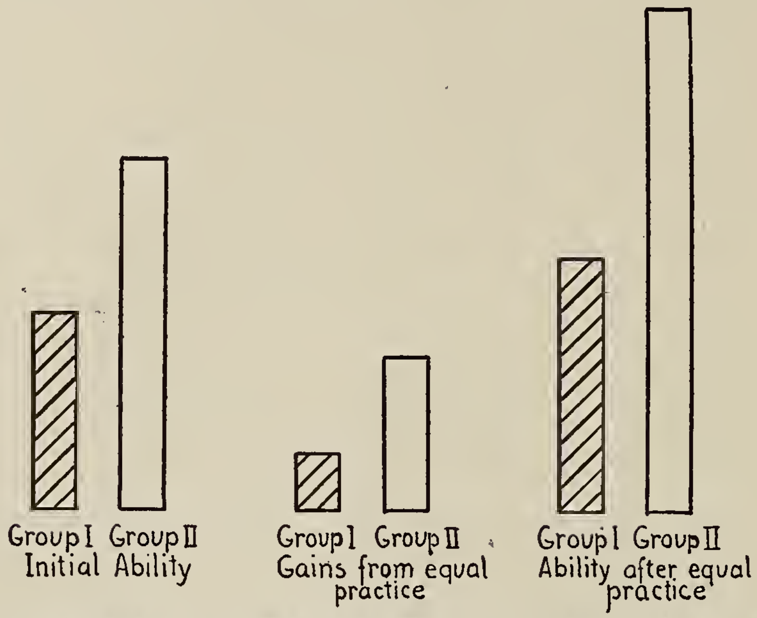

CHART 4. THE RELATION OF THE GAINS FROM EQUAL AMOUNTS OF PRACTISE IN THE CASE OF INDIVIDUALS OF HIGH AND LOW INITIAL ABILITY.

traits as energy, stability, general intellectual power, courage or kindliness.

Men differ by original nature. With equal nurture of an inferior sort they progress unequally to low stations; with equal nurture of a superior sort they progress unequally to high stations. Their absolute achievements, the amounts of progress which they make from zero up, are due largely to the environment which excites and directs their original capacities. Their relative achievements—the amounts of progress which they make, one in comparison with another—are due largely to their variations one from another in original capacities.

The man's original nature, too, has large selective power over his environment. The thousand babies will in large measure each create his own environment by cherishing this feature and neglecting that, amongst those which the circumstances of life offer. As Dr. Woods has well argued, the power of the environment to raise or lower a man is very great only when the environment is unavoidable. We must remember that one of these babies, if of mean and brutal nature, can by enough pains avoid industry, justice and honor, no matter how carefully he is brought up; and that one of them of intellectual gifts can, if he cares enough, seek out and possess adequate stimuli to achievement in art, science, or letters, no matter how poor and sordid his home may be.

If, a hundred years ago, every boy in England could have had as good opportunity—each of the sort fitted to his capacities—as Charles Darwin had, the gain for human welfare would probably have been great; but if every boy then could have had as good inborn capacity for science, art, invention, the management of men—or whatever his strongest capacity was—as Charles Darwin had for science, the gain for welfare would certainly have been enormous.

The original differences in intellect, character, and skill which characterize men are related to the families and races whence the individuals spring. Each man's original mental constitution, which so largely determines how much more or less he will do for the world's good than the average man of his generation, is the product of no fortuity, but of the germs of his parents and the forces which modify the body into which they grow—is the product, as we are accustomed to say, of heredity and variation. The variation within the group of offspring of the same parents is large—a very gifted thinker may have an almost feeble-minded brother—but the variation between families is real. A feeble-minded person's brothers will be feeble-minded hundreds of times as often.

The general average tendency of the original intellectual and moral natures of children to be like the original natures of their ancestry is guaranteed beforehand by the accepted principles of biology. Direct evidence of it is also furnished by investigations of the combination of original and acquired differences which human achievements, as they stand, display. The same studies which find differences of nurture hopelessly inadequate to account for differences of ability and achievement, find that original capacities and interests must be invoked precisely because achievement runs in families, and in a manner or degree which likeness in home training can not explain. Galton found that the real sons of eminent men had a thousand times the ordinary man's chance of eminence and far excelled the adopted sons of men of equal eminence. Woods has shown that, when each individual is rated for intellect or morals, the achievements of those sons of royal families who succeeded to the throne by paternal death and thus had the special attention given to crown princes and the special unearned opportunities of succession, have, in the estimation of historians, been no greater than those of their younger brothers.

Children of the same parents resemble one another in every mental trait where the issue has been tested, and resemble one another nearly or quite as much in such tests as quickness in marking the A's on a sheet of printed capitals or giving the opposites of words, to which home training has never paid any special attention, as they do in adding or multiplying, where parental ambitions, advice and rewards would be expected to have much more effect, if they have any anywhere.

Mr. Courtis, who has been assiduously studying the details of ability in arithmetic in school children, finds, as one sure principle of explanation, the likeness of children to parents—and this even in subtle traits and relations between traits, of whose very existence the parents were not aware, and which the parents would not have known how to nurture had they known of their existence.

Dr. Keyes has recently made an elaborate study of various possible causes of the rate of progress of a child through the elementary school. He traces the effects of defective vision, of sickness, of moving from one school to another, and so on, but finds nothing of great moment until he happens to trace family relationships. Then it appears that certain families are thick with "accelerates," or pupils who win double promotions, whereas other families are thick with retarded pupils, who require two years to complete a normal year's work. Of 168 families, only 30 contain both an "accelerated" and a "retarded" pupil, whereas 138 show either two or more accelerates or two or more retarded pupils. The differences in home training are here not allowed for, but, in view of what has been found in other cases, it appears certain that the rate at which a child will progress in school in comparison with his fellows is determined in large measure before he is born.

In intellect and morals, as in bodily structure and features, men differ, differ by original nature, and differ by families. There are hereditary bonds by which one kind of intellect or character rather than another is produced. Selective breeding can alter a man's capacity to learn, to keep sane, to cherish justice or to be happy.

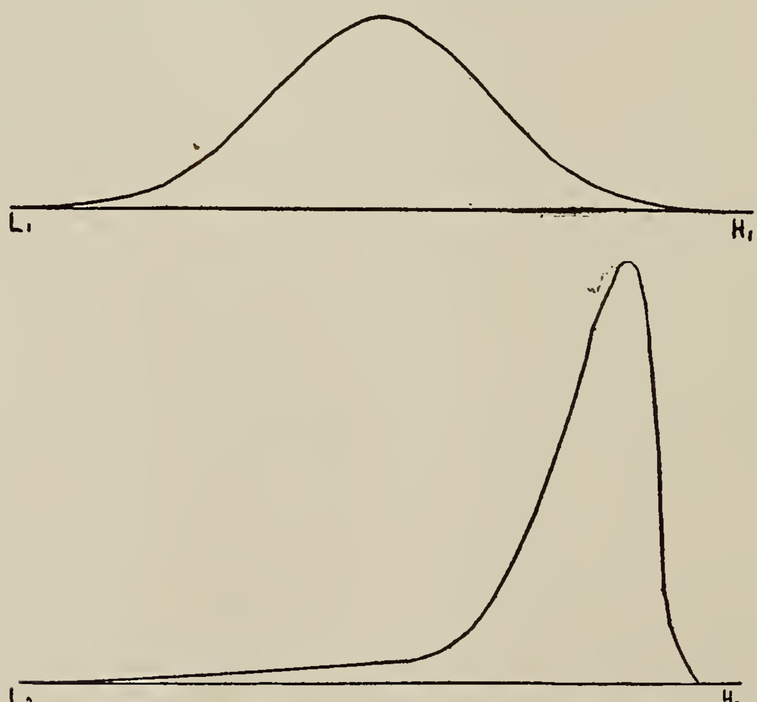

Chart 5. The Improvement Possible by Selective Breeding. The upper surface being taken to represent the existing distribution of intellect, the lower surface represents what might be expected from, say, ten or twenty generations of breeding exclusively from the apparently best tenth of human intellects.

Let the lines L_1H_1 and L_2H_2 in Chart 5 be identical scales for the original capacity for intellect, or virtue, or any desirable human trait. Let the surface above line L_1H_1 represent the distribution of this original capacity amongst men to-day. There is every reason to believe that wise selective breeding could change the present state of affairs, at least to that shown above L_2H_2, within relatively few generations. Perhaps it could do even more. There is every reason also to believe that each step of improvement in the original nature of man would, in and of itself, improve the environmental conditions in which he lives and learns.

So much for the general possibility of eugenics in the case of intellect, morals and skill—for what should soon be in every primer of psychology, sociology and education, and be accepted as a basis of practise by every wise family, church and state.

The next question concerns the *extrinsic* effects of selective breeding for intellect or for morals, the possibility of injuring the race indirectly by a change in, say, intellect which in and of itself is desirable. If we breed horses for speed, they are likely to lose in strength and vigor; do we run such risks in breeding men for intellect, or for morals, or for skill? This question has been neglected by the hortatory type of enthusiasts for eugenics. It has also not received the attention which it deserves from the real workers for racial improvement, probably because the psychological investigations which answer it are little known. They do, however, give a clear and important answer—that there is practically no chance whatever of injury from selective breeding within a race for intellect, or for morality, or for mental health and balance, or for energy, or for constructive ingenuity and skill—no risk that the improvement of any one of these will cause injury to any other of them, or to physical health or happiness. The investigations have found that, within one racial group, the correlations between the divergences of an individual from the average in different desirable traits are positive, that the man who is above the average of his race in intellect is above rather than below it in decency, sanity, even in bodily health. Chart 6 shows, for example, the average *intellect* of each of the groups, when individuals are graded 1, 2, 3, 4, etc., up to 10 on a scale for *morality*, according to Woods's measurements of royal families. I may add that the effect of chance inaccuracies in Woods's ratings, whereby one individual is rated as 8 or 10 when he should have been rated 9, or is rated 4 or 8 when he should have been rated 6, is to make this obtained and shown relation of intellect to morals *less close* than it really is.

Nature does not balance feeble-mindedness by great manual dexterity, nor semi-insane eccentricities by great courage and kindliness. Correlation of divergences up or down from mediocrity is the rule, not compensation. The child of good reasoning powers has better, not worse, memory than the average; the child superior in observation is superior in inference; scholarship is prophetic of success out of school; a good mind means a better than average character. The fifty greatest warriors of the world will be above the average man as poets. The fifty greatest artists of the world will be better scientists than the average. Genius of a certain type does, *via* the nervous temperament, ally itself to eccentricities of a certain type; and very stupid men can not be rated as insane because they are already idiots; but on the average the most

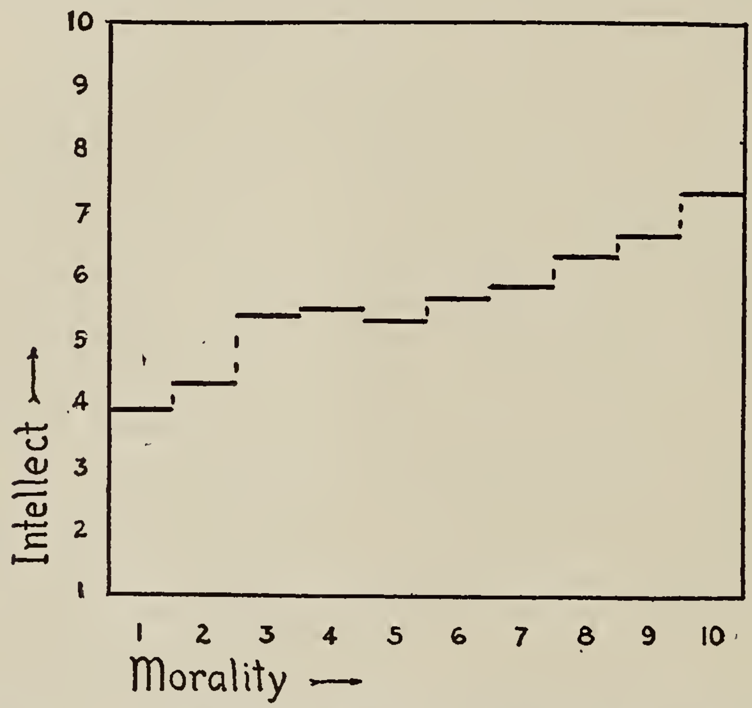

CHART 6. THE RELATION BETWEEN INTELLECT AND MORALITY IN EUROPEAN ROYAL FAMILIES. After Woods.

intellectual tenth of the population would, under equal conditions of strain, furnish fewer lapses into insanity than its proportional quotum.

Selective breeding for superior intellect and character does not then require great skill to avoid injurious by-products or correlatives of intrinsically good traits. *Intrinsically good traits have also good correlatives.* Any method of selective breeding, then, which increases the productivity of intellectually or morally good stock over that of poor stock, will improve man, with one possible added requirement—that breeding should be for fertility as well, should not be suicidal, should not make the race better, but at the same time put an end to it altogether!

It might be that there was a necessary inverse correlation in human nature between fecundity and high intellectual and moral station whereby, the better men became, the fewer offspring they would have; and whereby, at a certain limit of super-manhood, reproduction would cease. Certain changes of the birth-rate with time, and certain variations in it amongst groups, have given some students the impression that intellect, at least, is, by natural necessity, inversely correlated with fecundity.

It is hard to find the facts by which to either verify or refute the notion, current in superficial discussions of human nature and institutions, that such is the case. Sad testimony to man's neglect of the question which of all questions perhaps concerns him most—the simple question of which men and women produce the men and women of the future—is given by the fact that almost no clear and reliable evidence is available concerning the relations of fecundity to intellect, morality, energy, or balance. The most significant evidence is that collected by Woods in the case of royal families. Woods gives the number of children living till 21 in the case of each individual of the royal families which he studied. From them I have made the summaries noted on Charts 7 and 8. Each of these sets of facts is of course the

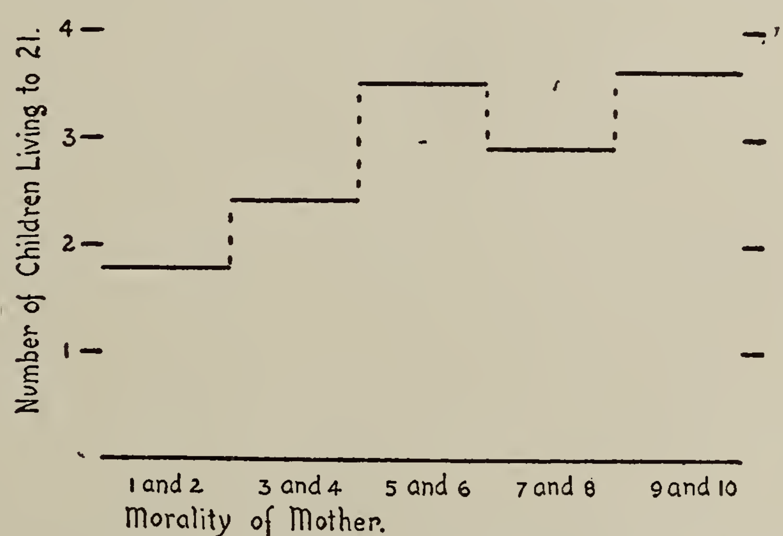

CHART 7. THE RELATION OF MORALITY OF MOTHER TO NUMBER OF CHILDREN.

result of the constitutional fecundity of the women in question plus certain very intricate cooperating circumstances; and neither can be taken at its face-value. What the birth rate would have been had the constitutional capacity of each woman worked under equal conditions, can only be dubiously inferred. My own inference from relevant facts concerning the studies of differentiated birth rates with which I am acquainted is that morality, mental health, energy, and intellect perpetuate a family, and that wherever the *really* better, or saner, or stronger, or more gifted, classes fail to equal the really worse, ill-balanced, feeble or stupid classes, it is a consequence of unfortunate circumstances and customs which are avoidable and which it is the business of human policy to avoid. Society may choose to breed from the bottom, but it does not have to.

No great ingenuity or care then seems necessary to make fairly rapid improvement in the human stock. The task is only the usual one of any rational idealism—to teach people to want a certain thing that they ought to want, and to change social usages so as to satisfy this new want. The same sort of tuition whereby men are learning to want those

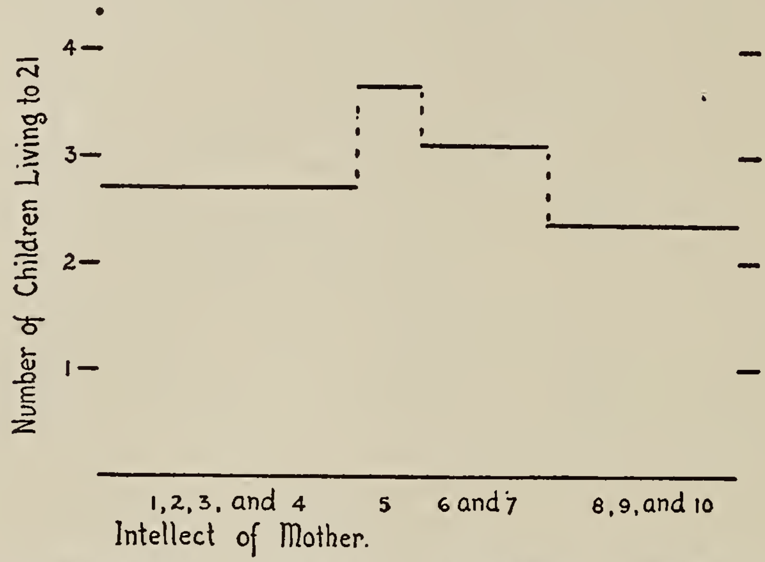

CHART 8. THE RELATION OF INTELLECT OF MOTHER TO NUMBER OF CHILDREN.

who are alive with them to be healthier, nobler and more capable, will serve to teach us to want those who are to live with our children's children to be healthier, nobler and more capable. Provided certain care is taken to favor the sane, balanced type of intellect rather than the neurotic, any selective breeding which increases the fecundity of superior compared to inferior men, and which does not produce deterioration in the physical and social conditions in which men live, will serve.

The danger of deterioration in physical and social conditions from breeding for intellect and morals is trivial. The effect is almost certain to be the opposite—an improvement in physical and social conditions. The more rational the race becomes, the better roads, ships, tools, machines, foods, medicines and the like it will produce to aid itself, though it will need them less. The more sagacious and just and humane the original nature that is bred into man, the better schools, laws, churches, traditions and customs it will fortify itself by. There is no so certain and economical a way to improve man's environment as to improve his nature.

Each generation has of course to use what men it *has* to make the world better for them; but a better world for any future generation is best guaranteed by making better men. Certain worthy customs of present civilization may be endangered by rational control of who is to be born, though this seems to me unlikely. In any case, we may be sure that if the better men are born they will establish better customs in place of those whose violation made their birth possible.

It is not by a timid conservatism sticking to every jot and tittle of the customs which gifted men of the past have taught the world, that we shall prevent backsliding: it is far safer to trust gifted men of the present and future to keep what is good in our traditions, and to improve them. The only safe way to conserve the good wrought by the past is to improve on it.

It is beyond the province of this lecture to devise biologically helpful and socially innocuous schemes of selective breeding, but I may be permitted to record my faith that if mankind to-day really wanted to improve the original nature of its grandchildren as much, say, as it wants to improve the conditions of life for itself and its children, and believed certain facts of biology and psychology as effectively, say, as it believes that wealth gives power or that disease brings misery, appropriate schemes for selective breeding would be devised well within the span of our own lives.

Any form of socially innocuous selective breeding will improve the stock by reproducing from those members of it who have shown, by ancestral and personal achievement, with due allowance for favorable or unfavorable circumstances, the superiority of the germ plasm which they bear. But some forms may be far more effective than others according to the way in which the original components of intellect, character, energy, skill, stability and the like in the germs are constituted. Suppose, for example, that the original germinal basis for human intellect consisted in the presence of a certain constant something, call it "I_n, the determiner for intellect," in the germ or ovum. The fertilized ovum, which is the human life at its beginning, could then have I_n double, if both the germ and ovum had it; I_n single if one or the other had it; or could lack I_n, as it must if neither had it. Suppose that the consequences of these three conditions were that the I_nI_n individuals would tend, with fair conditions in life, to be specially gifted; that the I_n individuals would tend to be of "normal" intellect; that the individuals lacking I_n would tend to be feeble-minded. It is then the case that of the germs produced by the individual who had I_nI_n at the start of his life, each contains I_n, that of the germs produced by the individual who had I_n at the start of his life, half have I_n and half lack it, and that of the germs produced by the individual who lacked I_n at the start of his life, no one has I_n. Consequently, by discovering the individuals who lacked I_n at the start of life and preventing them from breeding, we could rapidly reduce feeble-mindedness. By discovering the individuals who had I_nI_n at the start of life and breeding exclusively from them, we could eradicate feeble-mindedness and ordinariness both, leaving a race of only the specially gifted. The discovery could be made in a few generations of experimental breeding; and the exclusion, of course, could be made one generation after the discovery.

This supposition will be recognized by many of you as a simplified case of Mendelian inheritance of a unit character due to the presence or absence of a single determiner which can either be or not be in a germ or ovum, and which "segregates."

No case quite so simple as this can be true of human intellect, but something approximating it has been suggested as perhaps true.

Suppose, on the other hand, that the germinal basis for intellect consists in the presence, in the germ or ovum, of one or more of four determiners—I_1, I_2, I_3 and I_4—contributing amounts 1, 2, 3 and 4 of intellectual capacity. The fertilized ovum could then have any one of 256 different constitutions ranging from the entire absence of all these determiners to the presence of each one "duplex"—*i. e.*, in both germ and ovum. If such duplex presence meant that the two contributions combined additively, the original intellect of the individual could range from 0 to 20. Individuals, all of one same original intellect—10—might be of very different germinal constitutions, and so of very different possibilities in breeding. If two individuals, each of original intellect 10, were mated, it might be the case that their possible offspring would range in intellect from 0 to 20, or it might be that they could not go below 8 or above 12.

If the number of germinal determiners of intellect is increased to five or six, the task of telling the constitution of the germs produced by any individual of known original intellectual capacity is enormously increased; and the research needed to guide the best possible breeding of man is very, very much more laborious. Moreover, instead of hoping to bring man to the best possible status (subject to the appearance of new desirable mutations) by a few brilliant rules for marriage, we must then select indirectly and gradually by parental achievement rather than directly by known germinal constitution, just as animal and plant breeders had to do in all cases until recently, and just as they still have to do in many cases. Only after an elaborate system of information concerning family histories for many generations is at hand, can we prophesy surely and control with perfect economy the breeding for a characteristic which depends on the joint contributions of five or six determiners. For it is just as hard to "breed in" a determiner that raises intellect or morality only one per cent. as it is to "breed in" one which raises it a hundred per cent.—provided, of course, the latter determiner exists. And it is thousands of times harder to discover the distribution of a determiner in the human race's germs when it is one of ten that determine the amount of a trait, than when it is one of two.

The germinal determination of intellect, morality, sanity, energy or skill is, so far as I can judge, much more like the second complex state of affairs than the first simple one. Important observations of the inheritance of feeble-mindedness and insanity have been made by Davenport, Goddard and Rosanoff, which they interpret as evidence that original imbecility is due to the absence of a single determiner, and that an originally neurotic, unstable mental organization is explainable almost as simply. It is with regret that I must assure you that these observations are susceptible of a very different interpretation. Much as I should like to believe that these burdens on man's nature are each carried in heredity in a single package, which selective breeding can shuffle off in a generation or so, I can not. A eugenics that assumes that intellect, morality, sanity and energy are so many single niches in the germs which selective breeding can, by simple transfers, permanently fill, is, I fear, doomed to disappointment and reaction. I dare to believe that the time will come when a human being idiotic by germinal defect will be extinct like the dinosaur—a subject for curious fiction and for the paleontology of human nature; but I have no hope that such a change can be made with the ease with which we can change short peas to tall, curly-haired guinea pigs to sleek, or plain blossoms to mottled ones.

There is another fundamental question whose answer is needed for the most economical selective breeding of human nature, a question which time permits me only to mention, not to describe clearly. Stated as a series of questions, it is this: Do the germs which a man produces —his potential halves of offspring—represent a collection peculiar to *him*, or only a collection peculiar to some *line*, or *strain*, or *stock*, or *variety*, of mankind of which he is one exemplar?

Suppose a hundred men and a hundred women to exist, each with identical germinal constitutions, so that, say, in every case one tenth of the germs (or ova) would be of quality 5; one fifth, of quality 6; two fifths, of quality 7; one fifth, of quality 8; and one tenth, of quality 9. Suppose that they mated and had five hundred offspring. Suppose that the best fifty of this second generation married exclusively among themselves; and similarly for the worst fifty. Would the offspring of *these* two groups differ, the children of the best fifty being superior to the children of the worst fifty? Or would this third generation revert absolutely to the condition of the grandparental stock whence they all came; and be alike, regardless of the great difference in their parentage?

Does the selection of a superior man pay because his superiority is, in and of itself, a symptom of probable excellence in his germs; or only because his superiority is a symptom that he is probably of a superior "line" or strain?

That the second answer of each pair may be the true one, is a natural, though not, I think, an inevitable, inference from the work of Johanssen, Jennings and others. They have found selective breeding within any one pure line futile, save when some peculiar and rare variations have taken place within it. Their work is of very great importance and forms the best introduction to the general problem of the limits to human racial improvement. I regret that time is lacking to describe these studies of heredity within one "pure line." It is from such that eugenics may hope to learn valuable lessons in economy of effort and exactness of expectation. I have, however, already taken too much of your time with the problems of the exact laws whereby good men have good offspring and whereby breeding for strength, wisdom and virtue may be most effective.

In the few minutes that remain let me sum up what might perhaps have been entitled the A B C of eugenics in the realm of mind.

I have tried to show that, in intellect and character, men differ, by original nature, in some sort of correspondence to the ancestry whence they spring, so that by selection of ancestry the intellect and character of the species may be improved; to show also that injurious by-products of such selective breeding are very easily avoided, if indeed they occur at all; and, finally, to state some of the problems whose answers will inform us of just how the original intellect and character of one man does correspond with that of his ancestors, and so of just the best ways to discover the best strains and to perpetuate them.

I hope to have made it clear that we have much to learn about eugenics, and also that we already know enough to justify us in providing for the original intellect and character of man in the future with a higher, purer source than the muddy streams of the past. If it is our duty to improve the face of the world and human customs and traditions, so that men unborn may live in better conditions, it is doubly our duty to improve the original natures of these men themselves. For there is no surer means of improving the conditions of life.

It is no part of my office to moralize on these facts. But surely it would be a pitiable thing if man should forever make inferior men as a by-product of passion, and deny good men life in mistaken devotion to palliative and remedial philanthropy. Ethics and religion must teach man to want the welfare of the future as well as the relief of the cripple before his eyes; and science must teach man to control his own future nature as well as the animals, plants, and physical forces amongst which he will have to live. It is a noble thing that human reason, bred of a myriad unreasoned happenings, and driven forth into life by whips made æons ago with no thought of man's higher wants, can yet turn back to understand man's birth, survey his journey, chart and steer his future course, and free him from barriers without and defects within. Until the last removable impediment in man's own nature dies childless, human reason will not rest.

EDUCATION THROUGH READING

By Dr. E. BENJAMIN ANDREWS

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THERE is a wide variety of motives any one of which may lead a person to become a reader. Sir John Herschel wrote:

> Were I to pray for a taste that should stand me in stead under every variety of circumstances, and be a source of happiness and cheerfulness to me during life, and a shield against its ills, it would be a taste for reading.

A Suwanee reviewer deals with reading as an elegant pastime, the mental profit yielded by it being considered incidental. The reading of books as he thinks of it is to be classed with the viewing of pictures, a sort of esthetic exercise, delightful, uplifting, cultivating and, incidentally, informing, not resorted to, however, for the sake of information, at least not primarily for the sake of this, but for the refined pleasure to be derived from the exercise.

Reading for pleasure and diversion is perfectly legitimate when people have time and inclination for this; and it is well to urge those having time for it to cultivate also the inclination; but that is not the aspect of reading to which we would draw attention now. It is proposed to discuss reading as an earnest occupation, carried on with the direct purpose of drilling and storing the mind, its pleasurable and esthetic results, important as they are in themselves, being quite secondary. The theme, then, is reading as a distinct, invaluable, and too little recognized educational resource.

Consider first the very great encouragements to reading which now exist, and then note certain methods for responding to these encouragements, for utilizing the magnificent and ever-improving opportunities to read profitably opened to all in our modern life.

A cordial invitation to wide reading is extended by the presence all about us of ample literature, representing every department of thought, in forms perfectly convenient and incredibly cheap.

Carlyle said:

> Of all things which men do make here below by far the most momentous, wonderful and worthy are the things we call books.

And Macaulay:

> I would rather be a poor man in a garret with plenty of books than a king who did not love reading.

"Oh for a booke and a shady nooke,
Eyther in doors or out,
With the green leaves whispering overhead,
Or the street cryers all about.

"Where I may read all at my ease
Both of the new and old,
For a jolly good booke wherein to looke,
Is better to me than gold."

Not to speak of good old books, to be had in the stalls for a song, of the newspapers, which contain not a little good reading matter, especially in their Sunday editions, or of the innumerable magazines better and worse, there are editions of nearly all the world's literary masterpieces which are low-priced enough for the poorest and at the same time elegant enough for all but the most fastidious. You can find low-cost library editions and five-cent pocket editions, well printed, on good paper, with readably large type, suitable for all the demands of any undergoing the pangs of literary thirst. Not alone the masterpieces are so represented; but thousands of less pretentious though very useful books. Good reading matter is almost thrust upon us now.

This vast literary treasury contains riches from every gold-bearing region of the earth. The best specimens of antique and of foreign letters are there, having been translated into our tongue, in most cases, by capable scholars, and thus rendered accessible to such as read only in English. The best works of Plato and Aristotle, of Cicero, one of the world's greatest literators, of Boccaccio, Petrarch and Dante, of Leibnitz and Kant, Schiller and Goethe, indeed of all the mightiest German, Italian and French writers, can not only be read by us all at our leisure but can be owned by nearly all who would wish to own them.

This is no argument against learning foreign languages. Not every good product of foreign pens has been Englished. To become acquainted with the most recent best things written abroad you must read the originals. It is true, further, that no translation ever made or ever possible can carry with it across the chasm separating tongue from tongue the entire meaning, or the delicate shades of meaning, or the rich stylistic aroma, of a true literary work. It is nevertheless a benediction of the first order that in so many cases where we can not consult a literary original, we can possess ourselves of the author's main thoughts. Petrarch and likewise Keats read Homer in translation. If we can not topographically survey a country, scanning intimately its by-ways, it is worth a great deal to be able to travel leisurely its highways.

Besides the cheap edition and the translation, there is the free library. Those who are or think they are too poor to purchase much literary material, can, in any considerable center of population, find and read all that they need of it in some public library, without money and without price. The public libraries in the principal cities offer the most ample and inviting opportunities for reading, and these opportunities are growing richer every year. Public libraries are enlarging and new ones opening. In nearly every state, a Library Commission is planting libraries in small places and carrying traveling libraries to the remotest hamlets. Quite as important, librarians are mastering their trade, becoming more and more able to make libraries available to such as use them.

The opportunities for securing information and culture through reading, which are now presented by low-priced editions, good translations and free libraries, constitute, together, a potent appeal to us to read.

Another such appeal lies in the certainty that by properly using these privileges any one of us can become a well-informed, well-educated person. "Reading makes the full man," says Francis Bacon.

Says Lecky ("Map of Life, Conduct and Character"):

> While the tastes which require physical strength decline or pass with age, that for reading steadily grows. If it is judiciously managed reading is one of the most powerful means of training character and disciplining and elevating thought. It is eminently a pleasure which is not only good in itself but enhances many others. By extending the range of our knowledge, by enlarging our powers of sympathy and appreciation, it adds incalculably to the pleasures of society, of travel, of art, to the interest we take in the vast variety of events which form the great world-drama about us. To acquire this taste in early youth is one of the best fruits of education, and it is especially useful when the taste for reading becomes a taste for knowledge, and when it is accompanied by some specialization and concentration and by some exercise of the powers of observation.

Mere reading by itself alone can of course never produce the ideal education. Reading can not wholly take the place of schooling. The seminary, student conferences and debates, the class, class drill, oral explanations from arousing and able instructors, the inspiration which each student derives from the student body about him, and the other thousand and one stimulating associations connected with every good school, exert an influence which books and reading are powerless to produce. One who has never been subject to these influences, be he the most omnivorous and painstaking reader in the world, is unfortunate. Get all the schooling you can. If possible couple it with your reading. Irregular schooling is better than none, and so is a poor teacher. None of us are too old or too learned to be benefited by a term or a course of lessons or lectures in school, college or university. However, if you have never been able to avail yourself of these excellent aids in the training of mind, and if you are now and henceforth unable to do so, do not despair. You can read, and your chances are enviable.

Studious, persistent familiarity with noble letters will place you among the knowing, and it is worth all the effort it can possibly cost you. It will give you, if not the ideal education, a real education, broad, full, useful, enjoyable, a fortune which wealth could not buy. It will keep you from being a boor and make you a cultivated person instead. You may grow to be a connoisseur, a critic, an authority in some department of literature, philosophy, art or science. If you persist, though no degree ever crown your attainments, you may yet be able to instruct masters and doctors. Short of this, the possibilities of profit from reading are indefinitely rich and great. It is a sort of mental suicide if we neglect them.

In these last words, to make the argument specially strong, we have been supposing the case of the people who possess little or no school training. But such as have enjoyed that training, however long, ought nevertheless to appreciate the advantages of reading. If familiarity with books can not take the place of mental drill, no more, certainly, can mental drill take the place of familiarity with books. If you already possess a good foundation laid in school build upon it by reading. The chances of profiting in this way ought to impress you as much as if you had been less fortunate in respect to schooling.

The existence of low-cost editions and of excellent translations of good books, made accessible through free libraries and otherwise, is calculated to bring to bear upon us all a moving incentive to read. If we yield to this incentive, whoever we are and whatever mental advantages we may have enjoyed hitherto, the result will be invaluable mental cultivation and improvement.

Some one will interpose: "I do not love to read; it is a bore. I hate books. If I am to get good from reading you must tell me how I may develop interest in them."

How sad the confession that one does not love to read. Compare Edward Gibbon's avowal that he would not exchange his love of reading for all the gold of the Indies.

Two sorts of people avoid reading, those with very little intelligence and those possessing such unusual intelligence and originality that their minds keep busy without external stimulus. The dull ones can not perhaps be helped much; the others need only proper direction in order to find good reading a perpetual delight.

An intelligent person who dislikes reading is nearly sure to be deeply interested in something; in games, in hunting, in some kind of animals or sort of mechanism. Get a first-rate book discussing his hobby and see if you can not bait his taste therewith. Most likely he will read that and call for another and another. These books will suggest still others and your man is a reader.

If all such traps fail, get your protégé to read a thrilling short story, or touch him with a live coal of patriotic verse like Oliver Wendell Holmes's

> Ay, tear her tattered ensign down,
>   Long has it waved on high,
> And many an eye has danced to see
>   That banner in the sky.

With this poem should always go a brief historical account of its interesting origin and effects.

No matter, at first, how ill-written the novel may be, if only it is fetching. One of Conan Doyle's "Adventures of Sherlock Holmes" would well fulfill this office. If a man were not interested in these pieces you would be justified in giving him up. But most would be interested. The story would catch the mind and launch it, and the good work would be begun. Well begun would in this case be far more than half done. From the short story the learner would pass to higher and better story themes out into prose fiction at large and into poetry. After a while he would need no more attention, as the novel he began with might lead to the reading of historical novels, histories and essays, placing him upon a literary life, proving independent and happy in that direction.

Let us now go on to inquire how we can effectively respond to the incentives impelling us to read, how utilize the facilities for reading made available by modern conditions, how gain the mental advancement which reading may bring.

One precept to this end is: save the scraps of your time. Diligently hoard and use those odds and ends of hours which so easily run to waste and which most people let run to waste. Five minutes once or half a dozen times a day, after rising, before retiring, waiting for meals, at recess or during some other lull in school work, now pass unimproved, which are probably salvable by nearly every one. Such bits of time are eminently suitable for memorizing choice verse. One reader thus imbibed the following draught of nectar from an Irish poet named Davis:

> Sweet thots, bright dreams my comfort be,
>   I have no joy beside;
> Oh, throng around and be to me,
>   Power, country, fame and bride!

On holidays many throw away whole hours together. In most cases such lost instants make up in the course of a year several days, perhaps weeks, which ought to be turned to profitable account.

Few can afford the eyesight strain necessary to read in railway carriages; but a well-lighted railway station, if you happen to be detained in it, is an eminently fit place for reading. Against such occasions, more or less frequent in every life, always go equipped with a pocket edition of some choice author. "A book of verses underneath the bough" or whereever else you camp is a fitting companion.

In urging this employment of spare fragments of time, we are not forgetting the need which all have of recreation. Our bodies must of course be rested when they are weary, and so must our minds. Time spent in reading when you are too tired to read is not saved, but lost. The most healthy person sometimes needs the fullest possible relief from mental exercise, and that during the day. For all this it is true that change of mental activity, as from our regular work to a delightful book, affords mental rest of a most valuable order. If your dinner is ten minutes late you need not take up Euclid or the "Principia." Use Thackeray, or even a comic paper.

A second precept toward utilizing one's reading opportunities is: Carefully select your matter. Here comes up the very important question, what to read. Answer: In the first place, negatively, it does not pay to spend much time upon newspapers or upon ordinary magazines. Not that one may not fish up from these great seas now and then a pearl; but that the average time and labor cost of such pearls is too great. Also eschew ordinary fiction and ordinary poetry, save now and then an hour when the mental alimentary canal, lacking tone, can keep down nothing but broth. Life is too short to read all that is truly excellent; it is certainly too short to read much of what is just passable.

Read more books and less periodical literature. A bad habit has arisen in this matter. The great ability, along with the timeliness, of many magazine pieces now, has had the unfortunate effect of turning readers from board to paper covers. A new book we ignore because *Book Notes* or the *Critic* or the *Dial* or the *Outlook* or some other sheet has had a review of it. But the best possible review of a book is no substitute for the book. As well dine upon odors from a hotel kitchen. Read all the reviews that appeared upon Lecky's "History of England in the Eighteenth Century"; then take time and go through the work itself. You will find it a new world. Equally great is the error men make in reading so few old books. A few years ago it was found, by questioning, that only one out of a class of a hundred and ten college seniors knew anything about Milton's prose works. Many who consider themselves fairly well read have never touched Bacon's "Essays" or the "Pilgrim's Progress." Such as do read many books, among them, too, books which came out before the Spanish War, often mistakenly avoid the most precious works because they are bulky. To master Masson's "Life of Milton" or Spedding's "Life of Bacon" is a liberal education. It is at once a wonder and a misfortune that so few essays are read now. The rage is all for poetry instead. Colleges and universities offer a hundred lectures on poetry to one on prose *belles lettres*. So far as one can observe, the noble essays of Hume, Macaulay and Montaigne are nearly forgotten. Interest in this class of literature should be revived.

Rarely has a busy man or woman the time to peruse the whole of an author, however famous. It would rarely be of use to read wholes, even with amplest leisure. It is the mark of a great writer to have uttered a good deal of trash; and it is almost a sure proof of a reader's pedantry if he has read all which a given author has published, unless he has done so to hunt up errors or peculiarities. It shows that he has read not *con amore,* but merely that he might boast. Too many read just to be able to say they have read. The desire of reputation for attainments often outruns the desire for attainments. One young lady who said she had read Shakespeare was asked if she was familiar with Romeo and Juliet. She replied that she had often read Romeo, but that Juliet was somehow always out of the library when she called for it.

As already said, we can not read all even of the best; which remark naturally forces a search for some principle or principles by which to make selection. Two principles suggest themselves, one objective, the other subjective. The objective one is that the very greatest classics in the world's literature, Homer, Plato, Dante, Shakespeare and Goethe, should be more or less familiar to all. The subjective principle is: Consulting your occupation or your bent, select some specialty in letters and do your main reading with reference to that.

If you are a member of a profession your stock and standard reading ought to be related to that profession, not narrowly, of course, but generally, in a way to give life, breadth and atmosphere to your daily toil, relieving the tedium of homely tasks and spreading a hue of intelligence over business which but for this might seem leaden. Every great branch of mental work by which men earn bread has, besides the technical volumes which set forth its laws, a side literature, little technical, which connects it by a seamless web with polite letters. This is the library where a professional man should do his main reading.

A teacher, for instance, who has to teach literature or history should, for general reading, cultivate literature or history at large. The course to pursue in these cases is obvious. But how if chemistry or physics, or biology is your department? In such a case read the history of the science and of science in general, the biographies of great scientific discoverers and the excellent fiction and verse to which scientific men and scientific interest have given birth. Thus a physiographer would read, among other things, Shelley's "Cloud"; perhaps also his "Ode to the West Wind." There is no more interesting and there is no more valuable reading than well-written biographies of scientific men. The history of scientific discovery widens into the history of discoveries in general and this into the history of civilization.

If you have no profession, being only a person of leisure, let your reading follow your bent. Deal with poetry or essays, with history or science, with philosophy or art, as may best suit your fancy. Make yourself an authority on some particular author or cluster of authors, or upon the literature of a race or of a century. In a case of this sort the cautions to be observed are: Keep your reading unitary and systematic, and do not try to cover too much ground. If you have no bent, read history and biography.

One means, then, to the utilizing of opportunities for reading is: Hoard, miserly, your minutes; and another is: Choose carefully your matter. We now go on to speak of a third means, and it is: Methodically digest and conserve; methodically conserve and digest. Either form of phrasing the rule is correct, for we conserve our mental attainments by digesting them and we digest them by conserving.

Many people read vastly, yet never have much to show for it, because they trust to interest and memory to retain what ought to stay with them, using no method for assisting memory. It is a great mistake. Memory is invaluable, of course, and should be hard worked. The exercise of piling up in one's memory nuggets of literary gold can not be commended too highly. Still, the reader who employs no mnemonic apparatus, no mechanism, no ways and means for supplementing memory work, is an intellectual prodigal. What means or contrivances can be suggested for conserving and digesting the useful matter with which reading supplies the mind?

We must learn to assort as we read, to attend to what has meaning for us and pass lightly over the rest. "Some books," says Bacon, "are to be tasted, others to be swallowed, and some few to be chewed and digested." Few books are worth reading word for word. Much can be skipped without loss. Many a good book is of such a character that if you begin by carefully perusing the preface and table of contents, so as to discover the author's train of thought, you can read the rest at the average rate of three or four pages per minute. This reading at a gallop is a knack into which one grows by long practise. You gradually acquire a feeling for what you want and fix the mind on that alone. Thought is thus freer to master "for keeps" the passages deserving this, which is as important as the ignoring of the rest. The question, "Understandest thou, then, what thou readest?" is as pertinent as it is old.

Take notes in reading, partly to fix attention, helping you recall in general what you may never need or care to recall in detail, and partly to make fast for future consultation the matters which most forcibly impress you. No one can tell you, and you can not prescribe to yourself, when, upon what occasion, upon what sort of a passage to take a note. Feeling, prescience, second sight, must guide. Many data that you put down will never seem to profit you, but the note-taking may be no whit the less valuable for this. Thought going into the mind may change form, as food turns into blood, but it is never lost.

However, though the jotting down of impressions against paragraphs read is never, in itself, useless, it is none the less proper to warn you against writing too many of these memoranda. Very frequent or very long pauses for that purpose not only consume time but also interrupt interest and dim the impression made on you by the author's thought as a whole. Moreover, it is pleasant to reflect that the older you grow in the reading business the less you will need to remit reading for the sake of a note and the less likely you will be to do so unnecessarily. Take notes, then, but not too many.

Notes should be written in ink, legibly, each with careful reference to book, chapter and paragraph or page. You will never know which of your many entries you may by and by wish to appeal to, and it would be a pity in time of need, to have aid near, of which, owing to negligent writing, you could not avail yourself. Use for notes very ordinary blank books, or pads, of good paper, writing on only one side of a leaf, so that each leaf may be readily detached if necessary. Take notes, not many, but few, perfectly plain, and on easily detachable leaves.

We have been explaining that the reader must "take" notes: We now urge that he must "make" notes, by which is meant something additional and more important. The new point is this: that you should not be satisfied with thinking your author's thoughts after him, but should follow out all fertile suggestions made by him, into reflections of your own. Horace Bushnell used to say that he could never possibly read a book through. If it did not "find" him he threw it away on that account. If it did "find" him he was early beguiled by it into independent cogitations, which interested him more than the author's, so that he deserted the book on their account. These reactions of the readers's own mentality are the very best fruit of reading. Encourage them: give up to them: let them divert and master you. The book which drives you from itself by rousing you to amend, refute or amplify its teaching is precisely the book you need. It is life-giving food for your mind.

You here discover what was meant by the remark that we digest mental stores in conserving them and conserve them by digesting.

All thought-germs of your own, no less than the plants not your own that you culled from the other man's garden; the original matters no less than the memoranda, must be laid away, so many green flowers, for preservation in note-books. Use one and the same series of books for both sorts of products.

So far as you can manage it, whether with the notes you have taken or with the notes you have made, confine each note to one subject and to one page of the book, leaving the rest of the page blank. If a note covers most of the page, leave the next page blank. If, in your hurry, you have written too much on a page, or have mixed two subjects in one note, take early opportunity to separate item from item, placing each on a page by itself. In making these adjustments and transfers, use scissors, write as little as possible, and make no fuss or parade of nicety. The entire operation of writing and registering notes—we can not too much emphasize this—should be as simple, informal and rapid as possible, lest the labor of it and the time consumed by it should disgust you with the plan.

Some day, after your notes have become a little voluminous, it will interest you to glance them over. You will be surprised at their richness, and nearly every item will appeal to you with greater zest than when you placed it there. Each that was more or less original at first will now sweep your thought further on, while nearly every mere registry of some one else's idea will now compel your mind to bring up ideas out of its own depths. Before you are aware you will whip out your fountain pen and begin to make additions. Your thought treasures will swell as you count the precious metal they contain; and this result will recur each time you take account of stock. You will often need to insert new pages. Just pin them in or paste them slightly at the edge, making the mechanical exertion of the process from first to last as simple and little tiresome as can be.

Later, you will some time be called on for an essay or a paper on some topic of which you are known to be fond. Turning through your notes you will find most that you wish to say all ready to your hand, needing only that you detach the proper leaves, bring them together in order, slightly amplified, it may be, and write neat bridges between them. Spurts of fresh and original cogitation will almost inevitably accompany this recension process, and these, of course, will not be rejected.

THE GENESIS OF PERSONAL TRAITS

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AS a principle of evolutionary theory, it may be stated that the environment stands to the organisms within it in one group of relations during the long evolution of races and species. The part played by the environment in the development of an individual is equally important, but so unlike in character that it must be treated independently. Phylogeny and ontogeny are governed by their own laws; yet they are elements in one harmonious whole. If carefully studied, either will show the part objective conditions play in progress. I have already touched upon phylogenetic problems in earlier articles,[1] where I tried to show that while the inheritance of characters follows biologic laws, the release of characters takes place under the stimulus of environing conditions. The external environment is not active at conception or when characters are formed before birth. Each individual must be brought into contact with external conditions through his own experience to evoke the characters heredity has given him. He recapitulates the history of his ancestors with regularity; yet the biologic effects of this race experience may lie dormant within him, if external stimuli do not evoke them at the proper time. The individual in whom they are undeveloped is retarded, and shows in his conduct defects which in the contest of life put him behind other persons of like heredity but with a more stimulating environment.

The principles of ontogeny can not, however, be elucidated in this way. They are to be traced in the epochs of child development rather than in those of race evolution. If the environment has no influence, such studies are a waste of time; but if environing conditions have influence their power over the successive stages of child growth may be detected. The early stages will be less under environment control. But each later state would be more subject to the retardations and accelerations imposed by objective conditions. Each environmental shortcoming would be reflected in some personal defect; and every acceleration due to favorable conditions should be measurable in increased vigor. Men reflect their defects in appearance, their perfections are revealed in their activity not in their bodily structure.

In attempting to show the relation of environmental control to the various stages of child development I shall rely upon this principle. *Biologic characters* are positive and show themselves in normal persons. *Defects,* being negative, indicate the absence of characters or an imper-

[1] "The Laws of Environmental Influence," October, 1911, and "Types of Men," March, 1912.

fect development of them. A defective child goes through the stages of its development more slowly than the normal child, and fails to reach the later stages. Such a child has not a different heredity from the normal child, but simply a less complete expression of it. If this is true, defects measure environmental control. Every defect has some objective cause which acts as a check on normal growth. We make progress, therefore, in the study of defects as we connect them with bad environments.

We can thus detect physical defects. To ascertain and measure mental defects the needed criterion is found in the law of the association of ideas. If a mental defect has at its basis a harmful association of ideas, we may confidently affirm that its origin is environmental. All ideas are postnatal, and hence all associations must be formed after birth. We do not need a biologic character to create a new association of ideas, but only some reorganization of experience. In harmony with these facts and principles there should be four stages of child development, which appear in the following order:

1. The elementary life stage.
2. The sensory stage.
3. The stage of bone formation.
4. The motor stage.

On the basis of this analysis, there should be a type of man who has the elementary vital functions, but lacks the later organic developments. That such a type exists can be shown, and its indices readily pointed out. This type has high cheek bones, a sloping forehead, a flat, broad nose, and a defective lower face and chin. The central part of the face is fully developed, while its upper and lower parts are imperfect. The people of this type are short in stature, broad at the hips, and round-headed. All the vital functions are normally developed, but the later stages of growth are defective. Such people thrive in a simple environment, especially if they have a pictorial religion and a conventionalized morality.

A second physical type is also easily described. Here the upper part of the head is fully developed, and the central part of the face is defective; the nose is peaked and narrow at the base; the teeth are bad; the mouth is small; and the chin is pointed. This physical description has a meaning that can be readily interpreted. The retardation has taken place late in pregnancy after the brain has passed through its initial development. A child's face lengthens downward as the child matures. A weak, short lower-face indicates, therefore, a stoppage of growth after the middle-face and upper-face have been formed. A person of this type is likely to be short and thin and have a poorly developed bone structure. The type is usually regarded as intellectual when contrasted with the first type, which is often designated as sexual.

These differences among men are too plainly marked to be overlooked. The usual judgment is, however, that they are due to heredity. This claim I will not argue; I shall merely show that the differences lend themselves to another interpretation. As the mind goes through successive stages in its development after conception, may not each stage have an environmental complement which reacts on it and helps or hinders its growth? In any case, when we examine the two contrasted physical types from this point of view, some claims may be made as to their genetic meaning. The first type has been retarded early in pregnancy; the other at a later period. The retardation in the one case may be due to defective nutrition or excessive sex excitation; in the other it is perhaps the result of irritants in the mother's system. Facts that make satisfactory evidence in support of these suppositions are hard to obtain, but a justifiable theoretical position is taken by assuming that, in the one case, the child is carried an abnormally long time in the womb, while in the other birth is premature.

To render my classification clear it is important to contrast the stages in a child's development that occur before and after birth. The prenatal stages are physical, and physical defects are cases either of prenatal retardation or acceleration before birth. Postnatal development, on the other hand, is mainly mental, and mental defects have their origin in the association of ideas, which comes necessarily after birth. This simple distinction students of development fail to make; consequently, they confuse relations which would otherwise be obvious.

Let me carry my contrast one step further. The sensory development of a child is prenatal; the motor development is postnatal. The delay of motor development is due to the fact that bones are needed to serve as fulcrums on which the muscles act. These bones can not harden until after birth. The head is formed before birth; the bones solidify after birth. It is, of course, the difficulty of child-bearing that causes the delay of motor development. The sensory stage precedes the motor stage of growth by several years, and from this fact important consequences follow. At birth the sensory powers are fairly complete. The stomach is ready for food, and the circulatory system is active. The early impressions of the child come from these sources alone; it lacks the motor coordinations which make adjustment to the environment effective. Immediately after birth, all impressions are sensory, and are bound together by mental associations in which there are no motor elements. Such associations may easily become disjustive.

The mental life of a child should be pictured as arising from the activity of a number of partially organized psychic centers. Each center has stored up some latent energy which becomes active when adjacent centers are aroused. A stimulus started by any external disturbance excites these centers to activity with the result that a mental impression is formed. A succession of these arousals fix definite grooves along which mental excitation moves. Trains of sensations thus arise which can not be called either adjustive nor disjustive. They move through the brain along the line of greatest surplus energy and of themselves yield results of neither value nor detriment. The child would live, think, remember and forget; he would neither gain nor suffer by this automatic thought. Only after bones grow can it make the motor coordinations on which adjustment depends.

Very different effects follow strong, vivid impressions to which the motor powers are not ready to respond. These strong stimuli passing over into action prematurely tax the motor organs and disarrange them. Such effects are permanent, and *motor strains* are brought on that render future development abnormal. When a child walks too soon, the strains are readily seen, and it is generally recognized that the ill effects endure. If this is true of a child a year old, would not strong mental excitement in a child four weeks old produce even greater disorders, disturb motor development, and, reacting on the mental life, make it abnormal? Mental disorders are usually interpreted as wrong association of ideas bound together by strong sensory connections. The derangement is thought to be confined to the sensory system. The disorders are, however, not sensory, but motor. The premature activity of motor powers caused by sensory excitement produces strains that persist. The abnormal parts when excited arouse trains of thought that are disjustive. A strong person can repress them; he can even exclude them from consciousness; but when he sleeps or is weakened in any way, they intrude into his consciousness and disturb the normal flow of ideas.

Another way of presenting this thought is to contrast it with the theory of a subconscious mind. Here it is assumed that a sensory underworld exists in which ideas are stored. From this mental cavern, they break forth to disturb the normal consciousness on which adjustment depends. The connection between thoughts should not be associations, but movements. Subconscious trains of thought are in reality movements. They are, however, morbid disjustive movements, performed beyond the realm of consciousness. Could we really see what takes place, their motor origin would become apparent. The subconscious is a disjustive motor realm deprived of normal external connections.

Sensory excitement in an infant starts premature motor reactions which strains the unformed parts. It thus leaves permanent effects that appear in consciousness as disjustive trains of thought. There is thus a disjustive world in the background of every individual who has experienced sensory storms in infancy. The shock he then felt was not a shock to his mental associations, but to his motor coordinations. The child should live in his present sense impressions, and forget them when other agencies start new trains of thought. The lasting impressions have another origin. Strong stimuli, whether coming from the external world or from internal disorders, arouse the partly formed motor centers and create in them an abnormal activity. Motor strains, bone displacements, muscular irregularities and undue local sensitiveness are thus caused, which force disjustive trains of thought into consciousness with each renewed activity. All such thinking must be suppressed before adjustment is effected.

Motor domination begins about the fourth year and ends ten years later. It is the means by which adjustment is secured. Sensory trains of thought are adjustive only when they help men to foresee the elements of future adjustment. Their usefulness comes after the motor adjustments are formed. Any reversal of this order produces a disjustment which is intensified if motor strains have been produced by the premature activity. These disjustments are due to the abnormalities of the child's environment and to wrong notions of education. Parents not only fail to guard their children against sensory storms, but they introduce artificial trains of thought under the mistaken notion that vivid concepts and well-organized memories are an aid in a child's development.

Environmental maladjustments thus have three leading causes: defective nutrition, poisons formed within the system, and premature motor activity. The first two are prenatal, the third is due to the later development of the motor than of the sensory powers. In their genetic manifestations these maladjustments show themselves as retardations, accelerations and motor strains. Their pathological effects become sex morbidness, senility and motor morbidness. As mental phenomena, they become egotism, dogmatism and mysticism.

Symbolism is an intense form of mysticism and beyond it are visions, hallucinations, subconsciousness and finally double personality. The essence of them all is the same. Some of the motor powers do not readily come under the control of the will. The amount of this disruption of personality varies, but its presence is always a manifestation of motor disorder.

The important facts to be recognized are the difference between senility and morbidness and the two distinct sources of morbidness, the one in sex disorders and the other in motor strains. Senility is a sensory condition making mental associations difficult or impossible to alter. The causes of morbidness lie not in the brain but in the body. It is thus a pathological, not a mental disorder. Morbid parts are easily excited to action and act apart from, or in opposition to, the dominant personality as expressed in the will.

To simplify this argument still more I shall divide mental reactions into three groups, visual, motor and senile. Visual reactions involve no movement of thought beyond itself. Motor reactions create thought movements which end in activity. Senile reactions create a sequence with no elements not found in antecedent mental concept. Colored areas pass before us in visual thought. Limiting sequences follow one another in senile thought. The dominance of spatial concepts indicate premature sensory associations preventing the outward movement of thought to unexplored regions. The dominance of fixed sequences in thought reveals a lack of energy and of objective adjustment. Motor thought begins not in established mental associations but in bodily movements, aroused by external contacts. If movement precedes thought, action is adjustive; when thought determines movement abnormal mental states or senile limitations cause thought to flow on without any adjustive tests of its truth. Normally each thought should start a train of muscular activity leading to adjustment. Thought should be transformed into movement, and movement into thought. The morbid intensity of particular centers prevents this by forming a series of related ideas instead of transforming thought into movement. Visual or word repetitions are thus the marks of morbidness due to motor strains. This dance of sensory ideas with no accompanying activity is, however, regarded not as a defect but as an excellence. Such abnormalities are regarded as native powers when they should be recognized as acquired disjustments. Few readers will be willing to admit this. To do so would call into question conventional standards and strike at cherished literary and artistic concepts.

I can make my meaning clear by example better than by argument. When the American Academy of Political and Social Science was formed, President James and I had a discussion as to the title of the organization. He contended that the title should contain an "and," and I was equally firm in the opinion that the "and" should be omitted. He argued that without the "and" the scope of the society would not be regarded as comprehensive, while I asserted that with it the title would lack a definiteness in aim. It was a long time before I realized what was the real difference between President James and myself. I found that I, myself, was constantly tending to put "ands" in sentences and to pile adjectives on top of one another. When I made a short, crisp sentence I came back to it, thinking that I had left something out. This feeling was often so strong that I could not get away from the sentence until I had added something, or balanced it, as a rhetorician would say. I finally hit on the cause of my feeling, or at least an explanation that seemed satisfactory. The place where this tendency was strong was where the word had some closely related synonym, which, stored in my subconscious memory, strove to express itself and troubled me until I dragged it forth and made it a companion of the word I had used. If I had no double associations of words I wrote easily, but the flow of thought was checked at points where double associations existed. There I either expressed my thought twice or underwent a mental conflict until I drove the related word out of consciousness. The title to which I have called attention is an illustration of this. One group of our societary associations is with Greece and another with Rome. *Political* Science brings up the one group of associations, *Social* Science the other. If a writer has but one set of associations, a single word will fully express his meaning; but if he *knows* two languages and has a double set of words, each must find expression to relieve the subconscious memory. A style of this nature is called literary. With the single set of expressions the writer seems abrupt. A complaint is often made that I am elliptical in expression. I doubt not that many a reader has said this already in reading this article. If, however, he will go back to the places where I seem to have left out some step in the sequence of the thought, he may find that at that point he has some double association of words that I have disregarded. A fluent writer says in each sentence, or at least in each paragraph, "my thought is so in Greek, it is so in Latin, and finally so and so in English." The good writer in this sense uses all the synonyms in his own or the reader's mind before he passes along to the next topic. He brings up the whole range of his reader's sensory associations instead of calling for will power to suppress them. Concise, straightforward construction demands will power to follow. Every idea is then expressed once and only once. Those who are dominated by sensory associations can not readily follow such a writer. Like birds they fly several times around a spot before lighting.

This means that an ornate style is a defect and not a mark of genius. The study of languages weakens the will, or, to state the thought in another way, it prevents the growth of motor coordinations. If so, children should not be taught two languages. Moreover, they should be corrected when they use many adjectives or words of more than two syllables. Only short, concise expressions can come quickly enough to aid a child in his decisions. Any delay in the formation of trains of thought retards action and prevents the growth of will power. Only the child who thinks more quickly than he acts can develop adjustive reactions and thus escape from the domination of sex and sensory associations. The effects of these double word associations are everywhere visible.

I shall offer additional illustrations from the field of art, where sex and sensory dominance also has a crushing power. Time and space can not be directly pictured in art; nor can rest and motion be portrayed. These relations are brought into consciousness only through associations with surfaces and lines. Pictures are either color masses, or perspectives taking the thought beyond the visualized surfaces to the real world back of them. Most pictures combine these two factors, surfaces and lines. The differences among pictures is in the proportion and relation of these factors. If the color masses are in the foreground, and the lines creating the perspective in the background, the picture indicates a sensory dominance on the part of its maker. If the lines are in the foreground, and the surfaces are thrown into the distance by the perspective, the picture creates a motor impression and is admired by those with a motor dominance.

Colored surfaces stop the movement of the eyes and give relief to those with weak muscular adjustments. Lines keep up the muscular tension and give pleasure to those who because of strong eye muscles really enjoy eye tension. The movement and strain force the thought from the line into the indefinite background. We think of what we do not see instead of the surfaces in sight. This gives the basis of clear thought and of idealism.

The love of color masses may therefore be considered like ornate word expressions, an indication of physical defect. Such people have weak eyes and a shortage, not a surplus, of character. Movement aids motor dominance. An arrest of movement divides up the attention and gives to the disjustive elements of personality a chance for expression. The repressed elements in a motor personality are sex and fear. Surfaces are pleasurable that excite sex feelings or repress sensations of fear. The dominant surface associations are therefore related to either sex or safety. Rich, deep colors have a sex association, while regularity of outline gives a sense of security. Design might be defined as the art of making timid people feel safe. This end is accomplished by the endless repetition of some elementary figure. If on approaching a building the observer sees a mass of accurate details, he assumes that the floors have been carefully constructed and that the elevator has been recently inspected. Domes always give the same sense of relief. A building with no visible roof gives to timid people a feeling of instability. Regular fences likewise arouse a feeling of safety. Banks seem to remove the fear of their depositors by supplying a multitude of bars and posts, ostensibly to protect the deposits; but any observant person realizes that the real protection lies in the vaults and not in these shams.

As I was walking by Columbia University with one of its professors, he said, "Look at that fence. Is not it beautiful?" "Yes," I replied, "the chickens are safe. But you should remember that farmers now guard their property from sneak thieves by barb wire. Some generations hence your successor will be making the same exclamation you are making, as he gazes at the imitation barb-wire fence which will then surround Columbia." Was he artistic, or was I?

The same question of natural artistic appreciation arises when a person from a flat country compares his ideas of beauty with the inhabitant of a mountainous region. I was reared in a part of the West so flat that measurements were needed to find which way the water would run. There were no domed hills to evoke the feeling of safety, or wooded backgrounds to furnish protection from the unknown beyond. The sweep of the eye reached to eternity; parallel lines came together in the dim distance. Such a picture—all lines and no surfaces—makes the beholder think not of the present reality, but of its unseen complement. The sensualist of the wooded mountains divides the real into its parts, gets beauty out of the contrasted zones and is satisfied. The idealist blends the real into one unit and creates for himself a complement out of the unseen. Beauty is thus a relation between the seen, contrasting element with element, or it is the force that drives the beholder from the seen to the hidden background.

When I came into contact with conventional art, it took me a long time to see what made it attractive. I disliked the contrasted surfaces and the obtrusiveness of its sex and safety associations. New pictures gave me pleasure, because they evoked in me a realization of the beyond. Sculpture was even more satisfying, because the absence of a background forces the artist to rely for his effect wholly on lines, instead of on contrasted surfaces.

Furniture also has its motor and sensory effects. A chair elaborately designed makes one think of the pleasure of sitting in it; a chair with lines arouses the thought of some one you would like to have in it. A table with surfaces makes the beholder think of gorging the richly-colored food that should be on it. A table in which lines dominate arouses the thought of company and serious conversation. Lines bring in the absent. Surfaces eject from their folds a rich content. The bareness of the one and the completeness of the other give beauty.

The essence of my position is the conflict of the motor powers with the earlier formed sex and sensory centers. Adjustment at adolescence is motor; disadjustment is sexual and sensory. The normal child fights its way into motor dominance and by the struggle makes its character. The abnormal remain under sex and sensory control. This would be readily admitted in cases where the abnormalities are so marked as to unbalance the mind. The milder cases, where sex and sensory impressions exert a disjustive pressure, are viewed as natural traits. Those who exhibit them are often regarded as superior to those with complete motor control. The real test of a natural trait is its tendency to strengthen the personality of its possessor. Evolution creates unity of control. Mechanisms for *expression* are organic: mechanisms for *repression* are due to the association of ideas, and hence postnatal in origin. There are no organic repressions. They all have a social origin.

In the case of a child all repression is bad. Conscious morality should begin with maturity, and then should be a relative pressure, not an absolute prohibition. The child should be protected by an environment that prevents the formation of premature sensory associations. A man with a strong personality would result. With the change would come a simpler language and a morality that evokes character. The longer childhood and the delayed education bring compensation in a longer working period and in new forms of social activity from which would come a better art, a higher morality and a purer religion.

THE SEQUENCE OF SCIENCES IN THE HIGH SCHOOL

By JOSIAH MAIN

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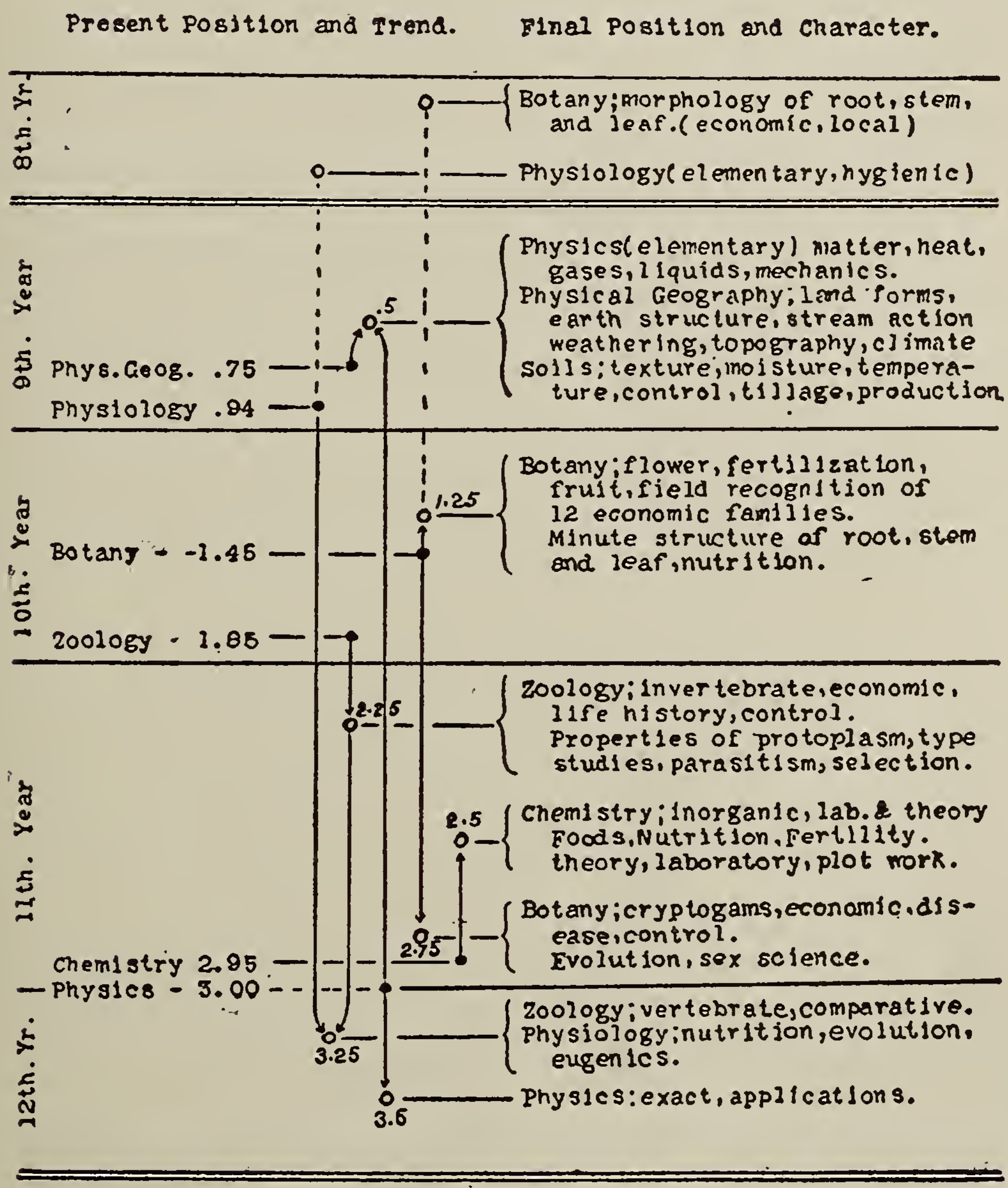
OF all the questions to which educational committees and journals have been devoted, the problem of what the high school sciences shall be, and the order in which they shall be given, shows least progress toward final agreement. The two phases, what they shall be, and where each shall go, are so related that they can not be considered separately, for while we are fixing the one, we find that we have forced the other out of place. The problem is complicated by the introduction of a third unknown factor of how the sciences shall be affected by the introduction into the high school of industrial subjects, such as agriculture, which includes many applications of science. And it should be stated that no debate of this subject can be very profitable that does not include in the premises an agreement as to what sciences should be undertaken below the high school.

High school mathematics has a logical sequence that admits of little variation. History has a chronological sequence which must be observed, at least within its larger units; and literature has a genetic sequence which finds its counterpart in the development of the child. The science group, on the contrary, is split into distinct sciences, each of which in the hands of its specialist and advocate contends for the place of vantage in the latter part of the course, where all the others may contribute to its dignity by preparing its way and making straight its paths. Thus, for example, botany and chemistry are each politely saying to the other, "after you." Meanwhile the result of this internal disagreement is to break the unity of science, thus greatly impairing the value of each division, while weakening the ability of the whole group to properly assert itself in the larger claims of the several groups.

The "unity of science" implies a dependence between different sciences which will usually be found to be mutual and argues equally well forward or backward. One method of compromising conflicting claims for precedence is to divide a science into two portions, the elementary to be given in the first year, or earlier, as an introductory science, and the advanced phase placed in the last year of the course. This method is specially suited to such a science as physics, whose rapid growth in recent years has accumulated more subject-matter than the average high school can properly treat in a year. Such a proposition is suggested in the report adopted by the secondary department of the National Education Association in July, 1911, on "The Articulation of High School and College." In its report of 1893, the Committee of Ten suggested a similar treatment of the subject of geography, a recommendation that seems to have had little influence on subsequent practise.

Despite the variety of opinion as to what the sequence of high

Sequence of High School Sciences.



school science should be, experience has established a generally accepted order, agreeing more or less with the authoritative report of the Committee of Ten. Recent high school courses of study of the twenty-one largest cities in Illinois, omitting Chicago and its environs, give interesting data concerning the present practise. The method of using these data was to give the value .5 to a science offered any time in the first year, 1.5 if offered in the second, 2.5 in the third and 3.5 in the fourth year. For each subject, the value was taken as determined by the printed course, and the sum of the twenty-one values divided by twenty-one to find the average. Thus should each offer a particular science in the first year, the average would be a value of .5; but should any offer it at a later date the effect would be to raise that value an amount agreeable to the year in which found, subject to the reduction due to averaging. The averages thus obtained for the six sciences susceptible to this treatment were as follows:

Physical geography	.75	Zoology	1.85
Physiology	.94	Chemistry	2.95
Botany	1.45	Physics	3.00

The order given in the table is the prevailing order in these schools, the chief value of the table being to show the relative, rather than the actual positions. For it is apparent that the natural tendency to vary is restricted within the limits 0 and 4, the beginning and close of the high school course, with the result that reducing a science from the high school into the grades inequitably destroys its influence on the average, and that intermediate values may result from averaging extremes as well as means, while all averages tend unduly toward the middle value.

The figures should also be interpreted in the light of a statute requiring physiology to be taught in the first year of the high school, and another which requires geography and physiology of all candidates for teachers' certificates, all the remaining sciences but chemistry being required for the first grade certificate.

In an investigation of 48 high schools "principally in the Middle West," Miss Ada L. Weckel[1] obtained data which give almost the same sequence, though not the same values for these subjects, the only difference being that physiology, probably because it is not so firmly bound in place by statute in other states as in Illinois, has migrated to a position between botany and zoology. Mr. E. E. Ramsey[2] in a similar investigation of the high schools of Indiana and other states of the Middle West gets corroborative results.

The recommendation of the Committee of Ten concerning geography was that the more elementary portions constitute the "physical geography" of the first year, while the more technical portions be carried over to the last of the course. Though no school was found to divide the subject for an elementary and an advanced treatment they generally agree with the recommendation by placing it in the first

[1] *School Science*, May, 1911.

[2] *School Science*, December, 1911.

year, variations from which showed a tendency to carry it over to the last year.

No recommendation of the committee has been more generally observed in practise than the one placing botany and zoology in the second year. However, these two subjects, at first closely associated, show an unmistakable drift from their moorings, botany moving downward toward the first year, as shown in Miss Weckel's investigations, and zoology moving toward the third year or being eliminated. Botany is subjected to two opposing influences, which will probably divide it into two distinct portions.. The introduction of agriculture below the high school is already resulting in the injection of much elementary botany into the elementary grades, while the leading botanists insist on giving high school botany a character that would move it in the other direction. The migration of zoology to the third and fourth years, to be followed by physiology, as located by the Committee of Ten, would make possible an evolutionary treatment of the combined subject that is much to be desired.

The recommendation of the committee regarding physics and chemistry has not been respected. It will be recalled that the conference to whom the committee assigned those subjects recommended a placement identical with the one now prevailing; but owing to their division of physical geography into an elementary and an advanced portion, the committee reversed that order so that physics might precede and prepare for the advanced work in physical geography. The reason for this reversal not proving well founded, the recommendation of the conference should prevail. This would agree with the present evident tendency to relieve the physics difficulty by putting its elementary phases into a first-year science course and leaving the more technical and quantitative treatment for the last year of the course.

The proverbial inertia of school curricula makes unsafe any *laissez faire* method of establishing the sequence of high school sciences. But it must not be thought that the present sequence is to any considerable extent the result of neglect. What then are the influences that have established this order of treatment?

Doubtless authoritative recommendation of competent committees have been a strong influence. Also, the accrediting system of the colleges and universities, by requiring a certain character of work offered in admission, have indirectly determined its location in the course. And an increasing complexity and supposed dependence of subjects has been a component of the final result. The tendency to place general and prescribed courses before special and elective courses has been a strong influence. Other temporary causes are the supply and demand of scholarship in high school teachers and their preparation for the different sciences, and the relative expense of equipment which the different sciences demand. Finally to be mentioned as a powerful factor is the recency of introduction of the various sciences to the course. All subjects shown in the high school course have entered it from above, having been handed down from the colleges, and tend to gravitate from the latter part of the course toward the earlier, until they find their supposed level in youthful capacity. Thus chemistry, the most recent introduction, has probably not yet exhausted its downward tendency.

Yet the foregoing influences are all more or less superficial and transient. Deeper than them all is a rational motive that has sometimes found its expression through them and should ultimately control the sequence of science in the high school.

With the young the learning process involves a great deal of muscular reaction. This necessity of motor expression diminishes with advancing years and the accumulation of an interpretive stock of motor experience with things. The size of the muscles involved in these reactions is an index of the stage of development of the learner. And since the accuracy and promptness of every muscle seem capable of unlimited improvement by education, they, too, indicate stages of development. On final analysis, the correct gradation and sequence of all rational school subjects will probably be found to conform to muscular development. The difficulties in high school sciences mostly inhere in the formulæ with which the teacher short-circuits his explanations or the verbiage with which he covers his ignorance. Whatever is definite is easy. Uncertain or confused things, only, are difficult and anything worth knowing may be taught the adolescent by a competent teacher.

Applying this test of motor adjustments, a solution of the problem of high school science will at the same time determine the correct sequence of the different phases of agriculture in the schools. All of the subjects involve the use of both the large and the small muscles. Subjects demanding more use of the finer muscles go later in the course than those involving more use of the coarser. Those requiring skill and accuracy of the larger muscles may often have an early or late treatment, or both. First-year high school students are familiar with or may make all of the adjustments demanded by such work as geography, soils, stream action, farm machines and elementary physics. Tillage, the study of the corn plant and ear, the morphology of root, stem and leaf, and budding, grafting, pruning and spraying involve motor adjustments appropriate to the grammar grades. The examination of cells, fibro-vascular bundles, and the stamens and pistils of most plants, and the making of biological drawings, work which exercises the finer muscles of accommodation, the preparation of slides and the adjustment of the microscope, do not belong below the second year of the high school. And correlated with the botany may appropriately be placed budding, grafting, spraying and pruning in a more rational form and demanding a higher grade of skill. School gardening, exercising, as the work does, the larger body muscles, is appropriate to the primary grades. Nature study may be defined as the most appropriate muscle culture known to the schools in that it automatically adjusts itself to the stage of development of the pupil. Until some one defines more definitely than has yet been done the character of animal husbandry best suited to the schools that subject may go anywhere in the course. When the need and the opportunity for the drawing of correct animal conformation are appreciated, it will be given an advanced position. Exercises in advanced physics demand delicate adjustments appropriate to the last year of the high school course, which position also agrees with the mathematical requirements of the subject. Accurate use of dissecting instruments, the fine balance, fragile glassware and c.p. reagents, and the making of a pure culture and keeping it pure, demand muscular skill not to be found below the third year of the high school course.

Influenced by this factor, the high school sciences will find their places, and the sequence of the different phases of agriculture that are naturally correlated with them will, by the same process, have their positions determined.

THE RELATION OF CULTURE TO ENVIRONMENT FROM THE STANDPOINT OF INVENTION

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THE relation between man's life and the physical make-up of the earth has always been a serious problem. In our schools we often hear the doctrine that geography is nothing more than the study of peoples in their adjustment to the particular part of the earth they inhabit. This emanates from the teachings of the great German geographers Humboldt and Ritter, to whom the physical features of the earth were the determining factors in the distribution of life. Later Ratzel took up the problem from a strictly human or anthropological point of view and gave us the term anthropo-geography. The rapid development of anthropology during the past twenty years, and especially its recent trend toward a cultural point of view, has again brought to the front this question of relationship between human activities and physical geography. To anthropology the problem becomes rather fundamental, and while not by any means so inclusive as it must be to anthropo-geography, which must depend upon the truth of the assumption for its existence, is nevertheless one whose solution is a matter of some consequence. Thus the question of culture and environment becomes the common concern of at least two sciences, geography and anthropology.

A full discussion of the subject would take us over the whole field of geography and anthropology; hence, we may here consider but a few points. As a rule, those who discuss this problem know a great deal more of geography than they do of anthropology and indeed it is but recently that we had at hand anything like a complete collection of data on the culture of even one non-historic group of people. As field-anthropologists are now industriously increasing our knowledge of such peoples, it may not be out of place to discuss the general problem from the standpoint of these data.

In such discussions it is convenient to make a provisional distinction between cultural phenomena and biological phenomena and the most convenient is that based upon heredity. The strictly anatomical characters, physiological and psychological functions are innate, while culture is not innate but acquired by the individual during life by imitative or educative processes. We can thus set over on one side man's biological equipment, his bodily functions, mental characters, instincts, etc., as against or in contrast to the cultural characters, or products of these activities in social life.

The biologists have given us some idea of the kind of physiological equipment man is born with and the psychologists have made some progress in the description of the psychological equipment, all of which is no doubt familiar to the well-educated. On the other hand, the development of anthropology has been so rapid and the points of view so illy formulated that a few remarks as to the character of culture seem necessary. On one point all students are agreed, viz.: that it is the functioning of the psychic part of man that produces culture. When it comes to assigning cultural phenomena to specific psychic activities there is some difference of opinion, but for the most part it is recognized that since culture is not inherited it must be a construct and as such is largely the work of the intelligence. For a long time many psychologists and sociologists have seen in this distinction one of their most important problems. To them it appears that social progress or cultural change of any kind is in last analysis the production or creation of something by the psychic activities of individuals, which process has been regarded as invention. In practical life we are accustomed to apply this term to ingenious mechanical devices, but in fact anything produced by our psychic activities, whether it be a new game, a word, a picture, a song, etc., is the same kind of thing and one to which the term may be applied. Any such invention taken up by a social group of people becomes thereby a trait of culture.

Culture as anthropologists use that term is a complex of elements as varied as those making up our own lives. Most geographers, however, give their attention almost exclusively to the economic aspects of culture, or to those traits listed in anthropological literature under the head of material culture. This, no doubt, comes about because it is in these phases of life that culture and geography are in most direct contact; language, religion, literature, art, family organization, etc., are less articulated with geographical phenomena, but geographers are quite given to sweeping them all into the economic category and claiming the most intimate contact throughout. It is clear, however, that the primary problem is to be found in the relation between man's material culture and the earth, which for convenience we shall designate as the environment. Our question then becomes as to what kind of a relation exists between material traits and environmental characters.

Material traits, such as methods of preparing food, the manufacture and use of tools, the methods of the chase, weaving, pottery, etc., are clearly inventions, and if the environment has anything like a determining or a causal rôle in the making of culture, such must be manifest in the inventive processes themselves. Our problem here is complicated by the existence of two stages or steps. In the first place some individual must develop the idea and demonstrate it; then it must be taken up by others and become more or less common to the social group. The invention, however, remains such regardless of its fate at the hands of social selection. Yet we must consider several possibilities since it is conceivable that the environment might be the determining factor in the selection alone, leaving the individual free to invent as he choose. Hence, our discussion falls under two heads: (*a*) The relation of the environment to invention; (*b*) to the selection, or socialization of inventions.

One of the fundamental problems in the investigation of invention has been the determination of what the process really is. It is in a way a creative process, but it must have something to work upon; it can not make something of nothing. We need not, however, distress ourselves with the puzzle as to whether there can ever be a distinctly new idea, for an invention in the cultural sense is a new relation assumed or observed between old experiences rather than an experience itself. When the geographers claim that all concrete experiences involved in such an invention must come from the environment, they are on indisputable ground. Thus it is undoubtedly due to the presence of snow that the Eskimo invented the snow house and to experience with birchbark that the Eastern Woodland Indians devised the bark-covered tipi. The real problem is as to whether there is anything in the very nature of birchbark as a part of the environment that necessitates the invention of a certain peculiar kind of house. Unless one holds to an ancient belief, he must assuredly say that there is no such necessity. It is true that a person who never experienced birchbark directly or by hearsay could not have made the invention, and if he had, it could not have passed into practise unless the material was made available by the environment. Thus it is clear that the environment furnishes the materials from which inventions are made and which thereby enter into the so-called material cultures of peoples. But the essential thing in an invention is the relation between experiences. In the case of birchbark the relation between bark experience and house-building experience can have no existence outside of the psychic life of man, the environment can lay no claim to it. Its production must emanate from the human mind and not from the earth. It seems, therefore, that we have here an answer to our query, for by the nature of the inventive process the determining factor is found in mental activity. Environment furnishes the materials and in that sense only limits invention. To invent a birchbark-covered house a man must have lived among birch trees, but the mere living there does not require such an invention.

We have noted that an invention becomes a cultural trait when taken up by many individuals. In this case the relation is handed on and on by education and imitation and so cultural traits are after all based upon a recognized relation between experiences. The causes that lead to the adoption or rejection of an invention must be recognized as the chief factors in the determination of culture, but we must note that they are selective only and not real producers of new things. As in the previous discussion our quest for the producer ends at the threshold of the inventive process. In this case, however, we start not with the unrelated experiences, but with the invention already made and offered to society.

Many of the factors entering into the choice of society are familiar to the general reader, for in sociological literature will be found lengthy discussions of prejudice, tradition, the function of the genius, etc. These, it will be observed, are social, or human factors, and are not due to the environment. Yet when we take material culture alone it must be recognized that with respect to it these social forces are less active. The experience of the world is that while a savage will throw away a stone knife and substitute a steel one after the first trial, he will be very slow to change a religious practise and especially a social custom. We may expect then greater opportunities for the socialization of material inventions and that industrial progress will be more rapid. But there is a fallacy here, for while it is true that a savage will quickly substitute a steel knife, it will be otherwise if one of his tribe attempts to develop the manufacture of knives, or even engages in extensive trade with knives, for then at once there will be a conflict with social customs. Nevertheless, it is probably true that most improvements in weapons, tools, etc., will, when demonstrated by the inventor, find little resistance and in most cases positive encouragement. The criterion would then be the usefulness of the new invention. Thus to a roving people a birchbark house might be an improvement, provided birchbark was readily attainable or transportable. Here the environment appears as a selective factor because the adoption of any particular set of traits appears finally as an adjustment between the community and the environment. But, as such, the environment is a passive factor, for the inventions that happen to fit sufficiently well to survive pass into the cultural complex, while the others fall by the wayside. And, after all, we must not forget that the fitness of an invention is a matter of judgment and that many a maladjustment to the environment passes as the superior trait because of an error in social judgment. It is truly surprising how ill-fitting the adjustments may be and still give men time and strength to maintain family, religious and political organizations of considerable complexity. We see then that while an invention must work to survive, there is no guarantee that it will be given a fair trial and be allowed to stand according to its deserts. Its fitness is chiefly a matter of social belief, and as such subject to all the ills and vagaries of folk thought.

In general it seems that the tendency of some geographers is to lay very great stress on the part played by the environment in the development of culture. Because they see how the environment sets limitations to human culture, or inventions, they sometimes assert that in it are to be found the causes producing cultures. A more acceptable view seems to be that which recognizes the province of the environment in deciding as to what may not become a part of human experience, but that among the experiences it makes possible is a wide range, in fact almost infinite range, of yet to be discovered relationships among which are many that may enter into the culture of the future, if both the man and the hour come. If in the discussion of this question we do not lose sight of the inventive nature of the processes producing material cultures and the curious psychic origin of the underlying relationship of ideas, on the one hand, and the passive limiting character of the geographical environment on the other, we shall not be led far astray. It is natural that in the study of geography emphasis should be given to the physical, faunistic and floral characters of the environment, but this should not warrant the assumption that these characters will in themselves be a sufficient explanation of the cultural differences observed among the peoples of the earth. It is also to be expected that anthropologists will overweight the value of the psychic factor in the formation of cultures because they deal in the main with such phenomena, but they in turn must not ignore the limiting character of the environment. The value of such discussions as this can only consist in holding each group of investigators to the proper recognition of the relations between their respective fields. Environment *vs.* culture may never cease to be the debatable ground over which the opposing parties struggle with varying fortunes, but we believe that a little analysis of the phenomena will reveal the chief factors, make evident their relative values and so lead to saner views.

THE FUTURE OF THE NORTH AMERICAN FAUNA

BY THE LATE WALTER L. HAHN, PH.D.

THAT the animal life of North America is changing is a statement requiring no proof. Every one knows that deer, elk, moose, wolves, bison and many other animals are no longer found in places where they were once numerous. Nearly every one also knows that some pests, such as rats and mice and several noxious insects, have been brought to this country from Europe, while the potato beetle and some other species, natives of North America, have multiplied and extended their range.

It is impossible, within the limits of this paper, to specify all the changes that have taken place and are now in progress. Hence it will be my aim to point out certain general tendencies, and certain general influences at work upon our fauna, the word fauna being a somewhat technical term used to designate the sum total of the animal life, great and small, in any circumscribed region.

If asked why the great game animals have disappeared from certain regions, most people would doubtless say, "Indiscriminate slaughter has exterminated them." This answer is undoubtedly correct as far as it goes. For a full explanation of all of the changes that have taken place in our fauna we must seek deeper reasons. Why has not "indiscriminate slaughter" exterminated the mice and rats and other noxious creatures against which we have waged ceaseless war for many generations? In other words, what are the biological and physical conditions that determine whether an animal species shall survive or perish in modern America?

A living organism, even the simplest, is a thing of vastly greater complexity than any mere chemical compound or any physical law. We know how to kill individual organisms, but frequently we do not know what will exterminate a species. If a lion and a lamb lie down together, we know which will be on the inside. But if a given number of lions and a given number of lambs inhabit a great area we can not predict the exact results; and this illustrates the futility of trying to make a definite analysis of the future of any particular species.

I shall now consider the future of North American animals from the general standpoints of size, habitat, relation to man, fecundity, mental traits, and finally give a few interesting facts not comprehended in the above classification.

Size

Size is the most obvious characteristic possessed by an animal. Whether we are naturalists or sportsmen, or neither, we instinctively classify all animals as large or small. Likewise there is nothing about our fauna so obvious as the fact that the larger animals are disappearing. The bison is gone, except for a few small and protected herds. The elk, moose, caribou, mountain sheep, antelope, cougar and grizzly and black bears are gone, except in sparsely settled regions. On the other hand, rodent pests swarm throughout every city, and the field mice, ground squirrels, cabbage butterflies, house-flies and hosts of other small insects continue to make trouble for the agriculturist.

Large size increases the value of an animal whose products are useful and hence makes it more desirable game for the pioneer who hunts to supply his larder and also for the sportsman who hunts for the sake of trophies. Large size also makes an animal apparently more dangerous if it has rapacious habits. I say *apparently,* for the microscopic *bacillus tuberculosis* kills more people in North America every year than all the beasts of prey have killed on the same continent since Columbus first sighted San Salvador, while the house-fly, disseminating the germs of typhoid fever and kindred diseases, is more deadly than all the wolves, panthers and rattlesnakes.

Sometimes we find related species having the same habits and living in the same region, but differing in size. Invariably the larger species is more sought after and diminishes more rapidly than the smaller. Squirrels illustrate this statement very well. In the northeastern United States three species of tree squirrels were once abundant. All had very similar habits, and ate practically the same kind of food. The fox squirrel and the gray squirrel are now on the verge of extinction in many places, while their smaller relative, the little red squirrel, thrives. Likewise the coyote fares better in contact with civilization than does the wolf, and the cottontail rabbits thrive where the larger jack rabbits and snowshoe hares are being exterminated.

Eight species of woodpeckers were once abundant in the forests all over the eastern states. Six of these are still common while the two largest species are extinct except in a few inaccessible swamps.

Large size means great strength. In the past this has been an advantage, within certain limits, by making an animal invincible to the attack of other animals. It is of no avail in stopping bullets, and hence is a disadvantage to a species that must count civilized man as one of its enemies.

The animals of the future, not only in North America but the world over, will have a smaller average size, and most large species will cease to exist unless they are domesticated.

Habitat

Some animals live, either by preference or necessity, in the forest; some live in meadows or prairies; some prefer uplands and some swamps; others must live in the water. A few are adapted to life in a variety of situations.

By far the greater part of North America east of the Mississippi River was at one time forest clad. The trees have been cleared away from this region until now they are limited to scattered tracts a fraction of a square mile in area with a few larger forests still more widely separated.

The species that live chiefly in the forest include among the larger kinds elk, moose, caribou, Virginia and western black-tailed deer, and black and grizzly bears. Smaller forest-dwelling species include several kinds of lynxes, the fisher, marten, Canada porcupine, several species of squirrels, as well as many birds, snakes and lesser animals. Species that live habitually in the open include the bison, antelope, coyote, jack rabbit, prairie dog, many kinds of mice, birds, snakes and smaller creatures. Among the species that get along equally well in the forest and open country, we may notice the red fox, certain mice and birds, woodchuck and chipmunk and there are many others.

It will require no argument to show that all of the forest-inhabiting species I have named are diminishing and if space permitted this could be shown for nearly every forest-loving species concerning which we have the data to form an opinion.

Turning to the plains species, we find the bison and antelope have diminished because of their large size, economic value and gregarious habits. The jack rabbit is also diminishing in regions thickly settled and the prairie dog has been found so destructive that measures have been systematically undertaken to exterminate it.

The animals mentioned above, although the most conspicuous ones of the prairies, comprise only a fraction of one per cent. of the fauna of that region, and when we consider the remainder we find many animals that, if not everywhere increasing, are at least extending their range. There is abundant proof that the "cotton-tail" rabbit of the prairies, which is a different species from that of the Atlantic Coast states, has in recent times extended its range eastward to Ontario and western New York. Some of the native field mice and ground-squirrels are working eastward.

The Harris sparrow, a typical bird of the western prairies, was reported from Indiana a few years ago for the first time. The Dickcissel, field sparrow, chipping sparrow and many others have certainly become more widely distributed in the central states than they were half a century ago. Some of the meadow butterflies are becoming more numerous in the same region and there is some reason to think that certain fishes are spreading eastward across Illinois and Indiana, the border states of the prairie region. Just how general this eastward migration may be among the various classes we do not know, but a reason for it is not difficult to find. Clearing the forests has brought about conditions somewhat similar to those of the prairies, and the small species that can exist in the pastures, meadows and roadsides now find congenial surroundings farther east, and in the east competition is less severe than it was formerly because the forest fauna has diminished.

In this connection it is worthy of note that there is also a slight but rather general tendency of our fauna to migrate northward. This may be the latter end of a general northward migration begun some thousands of years ago when the great ice sheet that then covered most of northeastern North America began to retreat. There were few, if any, animals in the region at that time, but, as the ice melted, and the climate became warmer, the region was again occupied by a fauna migrating into it from the south. At present this migration is not rapid enough to be of much importance.

In my brief enumeration above I mentioned several species that seem to do equally well in wooded or treeless regions. These are the species that are fitted *par excellence* to survive, and, barring some that are ill adapted because of special modifications, they are the ones that are holding and will continue to hold their own in point of numbers.

Animals inhabiting fresh water are beavers, muskrats, ducks, geese, snipe, frogs, fishes, mussels, crayfishes and a host of other animals, small in size but numberless in individuals.

What is the tendency among these animals? To answer this question we must consider the physical changes in the bodies of water. Swamps have been drained and their bottoms converted into gardens and cultivated fields. River courses are straightened and the waters confined within their banks. Sewage and refuse dumped into streams pollute their waters, and sometimes wipe out the fauna completely, and always injure the larger species. Forests are cleared away, with the result that streams, once dotted with placid pools, now become raging torrents at one season and dry channels at another.

Such changes can not fail to have a disastrous effect on all classes of aquatic animals. The diminution of waterfowl, food and game fishes, muskrat and beaver, which is the result, is too well known to need comment; the decrease of small animals is almost as great.

It may be argued that the work of drainage is counterbalanced by the digging of canals and the building of reservoirs for irrigation. There is no question but that building great reservoirs in arid regions will somewhat increase the aquatic fauna of the surrounding districts. But the isolation of these bodies of water and the obstructions in their outlets will preclude any general immigration to their waters; and their fauna, for the most part, will be restricted to minute animals, insects and food fishes artifically introduced.

It can be asserted with certainty that there is a general tendency for aquatic animals to disappear.

Relation to Man

At first thought we might assume that useful species will survive and injurious ones will be wiped out, since man is the all-powerful lord of creation. But the most useful animals are the ones that disappear first. This is because of the unfortunate fact that man is a selfish being and thinks more of the satisfaction of his immediate desires than of the good of his race. Fortunately for the animals concerned, we are waking up to their value and many useful species are now reared in small numbers in a state of semi-domestication and there is a possibility that deer, foxes and many other animals valuable for food or fur will some day be fully domesticated.

On the other hand, it is true that injurious habits tend to bring about the extermination of a species. The venomous snakes are eminently fitted for protection from natural enemies. Their deadly nature has caused man to war upon them and in some localities his warfare has met with so much success that the once dreaded copperhead and rattlesnake are now extinct. The fear in which the pioneers held panthers, wolves, lynxes and other beasts of prey, played a large part in their early extermination.

Fecundity

There is another group of noxious animals against which man rages in impotent wrath. These are the mice and rats, the potato beetles, scale insects, flies and various other injurious insects. Among all of these creatures small size plays an extremely important rôle in the protection of the species. If a mouse weighed 100 pounds instead of less than an ounce, it would be more easily found and killed. The yet smaller size of insects makes them even more difficult to cope with.

Of much greater importance than their small size is the fecundity of these pests. A female deer produces no offspring until three years old and then only one or two a year. The other large animals produce young at about the same rate. But a female rat begins to bear young when six or eight months old and may produce 50 or even more in a single year. A house-fly, under the most favorable conditions, may lay eggs within two weeks of the time the egg was laid from which she herself hatched.

A single pair of flies, warmed to activity in April, have within themselves the potentiality of producing before October (if every egg laid by them and their descendants should hatch into a maggot that would mature into a fly) at their normal rate of increase under favorable conditions, about one hundred trillions of flies, at a conservative estimate, or fifteen millions of tons, by weight.

Of course many flies fail to reach maturity and only a small percentage of the eggs laid ever hatch. This statement has been introduced here merely to show how ineffectual is our warfare against animals procreating their kind at such a rapid rate, as contrasted with the effect of slaughtering a few slow breeding animals. Yet many of the microscopic organisms, both harmless and disease-producing kinds, multiply infinitely faster than the house-fly.

Down to the present generation, a rapid rate of reproduction has been the surest means possessed by any animal species of withstanding the enmity of man. Now scientific knowledge is beginning to triumph over both fecundity and small size. Mosquitoes have been exterminated by the wholesale in the canal zone. Europe, Asia, Africa and Australia have been successfully ransacked to find natural enemies that will hold in check scale insects, and codling and gipsy moths. A partially successful attempt has been made to inoculate rats with a disease that will kill them as cholera once killed men. War is being successfully waged on the germs of tuberculosis, yellow fever and many other diseases, and men best qualified to judge look confidently forward to a day when not one of these infinitesimally small but infinitely baneful organisms shall exist among civilized peoples.

Mental Traits

Under this head we may group several more or less distinct kinds of traits. First, there is the gregarious instinct, the tendency to herd together so noticeable in many animals. "In union there is strength" seems to be a motto in the animal as well as the political world. By banding together into great herds the bison became invincible to all foes save man. But with the advent of civilized man, armed with breech-loading rifles, the herding instinct of the animal only made its slaughter the more easy. The same is true, to a greater or less extent, of many other animals. Colonel Roosevelt says that, "the elk is the most gregarious of the deer family," and it was also the first of its family to disappear before the advance of civilization in almost every section of the country.

In the early seventies, passenger pigeons occupied a vast breeding ground in Michigan. It is said that in many square miles of this thickly wooded area, there was not a tree without a brooding pigeon on its nest at the proper season. Pot hunters found the birds, killed them with hands and sticks and guns, packed them in barrels and shipped them to market by the ton. Recently, in an effort to save this fine bird from extermination, a prize of one hundred dollars has been offered for the first person reporting a pair of breeding passenger pigeons.

A couple of decades before the passenger pigeon's extermination, flocks of hundreds of Carolina paroquets used to swoop down on the apple orchards of Kentucky and southern Indiana. Naturally the farmers took their guns and wreaked vengeance on the birds, and to-day the Carolina paroquet is all but extinct. And it has long been driven from the region I have just mentioned.

The economic factor was an important one in the extermination of these birds, but the rapidity of their extermination was due to the fact that they flocked together and were killed by the wholesale.

Beasts of prey are more courageous than weaker animals and all of the larger ones are gone from thickly settled communities. The rabbit is notorious for its timidity and still abounds everywhere outside of city limits. True, fecundity and small size play an important part in the preservation of the rabbit, but suppose that possessing these characteristics, the instinct of self-defense were stronger than the instinct to flee? The inevitable result would be the destruction of the race.

No mental trait has been of greater value to an animal species warred upon by man than timidity. The trait next in order of value is cunning.

The fox has always been justly considered as a type of the cunning animal, but the trait has not been equally developed in all kinds of foxes. In eastern North America there are two very distinct races, the gray fox and the red, cross and silver foxes being mere varieties of the latter. It is highly probable that the American red fox is descended from animals brought from England by gentlemen emigrating from that country during the eighteenth century, although this fact has not been clearly established. It is certain, at least, that it was either rare or absent in Ohio, Indiana and Illinois during the days when these states were frontier regions, and at that time the native gray species was abundant. Now the gray fox is extinct except in the rougher and more wooded districts, while his red relative is a pest in even the most densely settled valleys. The two species are nearly equal in size, fecundity, value of fur and destructiveness to poultry. They eat the same food, they live in the same kind of places, with the exception that the gray species seldom makes its den in the open fields, while the red often does. The vital point of difference seems to be in their cunning. The red fox, if not the sly renard of Europe, is certainly a close counterpart in cunning, while its gray cousin is lacking in this respect. In these two species, at least, the difference between survival and extermination depends upon cunning.

Miscellaneous Peculiarities

There remain to be considered certain characteristics which can not be very accurately designated by any well-understood and precise term. I refer to what is sometimes called by biologists a high degree of specialization, and more particularly specialization in the direction of bizarre and conspicuous features.

The porcupine is a good example. This animal is of absolutely no economic importance to civilized man. It lives in the forests and eats little save twigs and bark. Its flesh was eaten to some extent by Indians and its quills were prized by them as ornaments, but neither flesh nor armature are valued by whites. It might be supposed that a few porcupines could find sufficient food and shelter in any small wood lot and that they would remain there unmolested because of their inoffensive habits. Yet few species have disappeared more rapidly before the advance of civilization.

The animal had few natural enemies because of the efficient protection of its spiny armature, consequently it had no fear and was a slow breeder. Its spines, however, afford no protection from man, and there can be no doubt that more porcupines have been killed from curiosity excited by the peculiar appearance of the animals and mere wantonness than from any other reason.

One species of armadillo is found in the Unites States chiefly in Texas. It is an animal with a head and body about a foot in length and a tapering tail of equal length. Its body is covered with an armor of bony plates, quite solidly joined together in most places, but with overlapping joints in the middle. When attacked it curls up, covering the poorly protected belly, throat and nose with its tail, and hence becoming invulnerable to teeth and claws. It is harmless in habit, living chiefly on insects. Its peculiar appearance frequently leads people to kill it from no motive except curiosity and wanton love of slaughter. Recently a tourist trade has grown up in the armor, which is made into a basket, the tip of the tail being brought forward to the neck and fastened there to form the basket handle. Thus an economic relation is growing out of the bizarre appearance of the animal and its extermination seems to be only a matter of a few years, unless it receives better protection.

Horned toads, lizards and, to some extent, tortoises and snakes are being slowly exterminated because their appearance arouses the desire to kill and not because of any economic motive. A few comparatively harmless species of insects, namely, the walking stick or devil's darning needle, the praying mantis or rear-horse, and the rhinoceros beetle have been nearly exterminated in some parts of the country merely because their unusual appearance arouses an interest in them and their life is forfeited therefor.

We might also include in this category the snowy heron, the roseate spoonbill and other birds that have been slaughtered for their plumage. Although the economic value is here the direct motive for the slaughter, this value grows out of unusual (and beautiful) modification of the plumage.

The preceding paragraphs are necessarily sketchy, because the subject is too large to treat in detail and it is now desirable to gather up the threads.

Briefly, the general tendency of the North American fauna is toward mediocrity. Large species are giving way to small; bizarre species to commonplace. Marsh-loving and forest-loving animals disappear with the advance of civilization, and grass-loving species that are able to exist in fence rows and pastures survive. Animals that yield products of value vanish before the hand of man; likewise his enemies are destroyed unless protected by small size and great fecundity. Courage and the social instinct are at a discount and cunning and timidity at a premium.

Finally man is beginning (and only beginning) to shape the destiny of his God-given dominion "over the beasts of the field and the fowls of the air." To make this dominion an intelligent reality is the aim of present-day biological science.

THE SIZE OF ORGANISMS AND OF THEIR CONSTITUENT PARTS IN RELATION TO LONGEVITY, SENESCENCE AND REJUVENESCENCE*

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I. Body Size

BODY size is one of the most variable properties of organism; the smallest living things are probably invisible to the highest powers of the microscope, the largest are gigantic beasts weighing many tons. Within the same class, and in animals equally complex in structure, variations in size are enormous, as, for example, in the elephant and the mouse. Within the same species, where structural differences are insignificant, size differences may be very great. In some species there are great differences of size between males and females; in extreme cases males may be minute and rudimentary forms, without mouths and alimentary canals, and capable of living for only a few hours, as in certain rotifers, worms and arthropods, whereas the females are relatively large and perfect individuals capable of an extended existence.

In *Crepidula* a genus of marine gasteropod which I have studied and to which I must particularly direct your attention, I have found[1] great differences of body size in the mature individuals of different species and also in different individuals of the same species. The volume of the average adult male of *C. fornicata* is 125 times that of the average male of *C. convexa;* the volume of the female of the former species in 32 times that of the latter. In these gasteropods the males are always much smaller than the females; the volume of the average female of *C. plana* is about 15 times that of the average male. All mature animals of this genus are sedentary, and many of them live in or on dead shells which are the homes of hermit crabs. In the species *C. plana* I have found an interesting class of dwarfs; the animals of usual size live in large shells inhabited by a species of large hermit crabs (*Pagurus bernhardus*); the dwarfs live in small shells occupied by a species of little hermits (*Pagurus longicarpus*). The dwarfs are sexually mature and, unless forcibly removed, live their whole life long in the small shells, where they attain an average size only one thirteenth that of the normal forms but if the dwarfs are forcibly taken out of the

* Lecture before the Harvey Society, New York, March 7, 1913.

[1] Conklin, "Body Size and Cell Size," *Jour. Morph.*, 12, 1912.

small shells and put into larger ones they may grow up to be as large as animals of typical size. These dwarfs are, therefore, only a physiological variety, produced by environmental conditions.

What are the causes of such differences in size of animals of the same species? What explanation can be offered for the enormous difference in size between an elephant and a mouse? What are the factors generally involved in determining size?

1. There is plainly an inherited factor in all specific differences of this kind. Every species of animal and plant has a more or less characteristic body size which may be said to constitute the norm of that species. This norm may be altered to a certain extent by environmental conditions, but such possible modifications are relatively slight; no amount of environmental influence could ever make a mouse grow to the size of an elephant. The limits of body size of a race or species are as certainly inherited as are any other characteristics; their causes, whatever they may be, are intrinsic in the constitution of the germinal protoplasm.

What is the nature of this inherited factor which determines the possible size of organisms? Undoubtedly it is found in the power of growth as contrasted with limitations to growth, with the rate and duration of assimilation as contrasted with dissimilation. Increase in size may be due to mere imbibition of water, or to an actual increase in the quantity of protoplasm, and secondarily of formed products, in the body. In this discussion the latter process alone will be termed growth. As long as assimilation exceeds dissimilation organisms grow, when the one balances the other they remain unchanged in size, when dissimilation exceeds assimilation they dwindle. The large-sized *Crepidulæ* continue to grow for a much longer time than the small-sized ones. A mouse achieves its full growth after 60 days and may live approximately 60 months; an elephant continues to grow for about 24 years and may live approximately 150 years.

What it is which keeps up this process of growth so much longer in one species than in another we do not know—and as so often happens, it is precisely this which we most desire to know, for length of life as well as size of body depends primarily upon the rate and duration of assimilation. It may be that there is some peculiar secretion or enzyme which stimulates growth and varying quantities of which cause one species to continue to live and grow for a much longer time than another species; it may be that some substance is formed in the course of development which limits growth and that it appears earlier in some species than in others. Since assimilation and dissimilation are chemical processes it is very probable that the factors which determine rate and duration of growth, and consequently body size and length of life, are of a chemical nature. This is a subject upon which there has been much speculation and but little work and to which experimental investigation might well be directed with promise of important results.

2. Another supposed factor which is not precisely hereditary nor yet strictly environmental is the size of the germ cells, of the "Ausgangszellen," from which an animal develops. Morgan[2] and Chambers[3] found that small eggs of the frog give rise to smaller tadpoles and to smaller frogs than do large eggs. Popoff[4] maintains that spermatozoa as well as ova vary in size, owing to slight inequalities of division during the genesis of these cells, and he supposes that when a large egg is fertilized by a large spermatozoon a large individual results, whereas if the sex cells are smaller than usual the individual developing from them will also be smaller. In favor of this hypothesis may be cited the fact that small eggs of *Rotifera, Phylloxera* and *Dinophilus* give rise to small and rudimentary males, whereas the larger eggs give rise to relatively large females. Within the same species, where the mode of development is the same for all individuals, egg size may be a factor in determining body size, but it is a relatively unimportant factor, since the size of an animal depends not merely upon its initial size, but chiefly upon the rate and duration of its growth. In many cases the smaller egg continues to grow for a longer period than does the larger one and in the end gives rise to a larger adult. This is strikingly shown in different species of *Crepidula,* where species with small eggs give rise to large animals and those with large eggs give rise to small animals. The large eggs produce large embryos, and the small eggs small embryos, but the latter continue to grow for a much longer period than the former and in the end give rise to animals of much larger body size than those which come from the large eggs. An egg of *C. fornicata* is about one quarter the volume of one of *C. convexa,* but the adult female of the former species is about 32 times the volume of one of the latter species, while the males of the former species are 125 times the volume of those of the latter species. Other cases of a similar sort are known and they show that in different species egg size can not be correlated with body size, and even within the same species it is a relatively unimportant factor in determining size.

3. It is well known that many extrinsic factors influence the character, rate and duration of metabolism, and consequently the size of organisms. Among these extrinsic factors I shall mention only a few which are known to be important, viz., (*a*) quantity and quality of food, (*b*) secretions of certain glands, particularly the sex glands, thymus, thyroid and hypophysis, (*c*) various chemical substances, such

[2] Morgan, "Relation between Normal and Abnormal Development, etc.," *Arch. Entw. Mech.*, 18, 1904.

[3] Chambers, "Einfluss der Eigrösse, etc.," *Arch. mik. Anat.*, 72, 1908.

[4] Popoff, "Experimentelle Zellenstudien," *Arch. Zellforschung,* 1, 1908.

as ether, alcohol, tobacco, lecithin, etc., (*d*) temperature, (*e*) oxygen, (*f*) presence or absence of waste products, (*g*) conditions of normal or abnormal stimulation and irritability. These extrinsic factors which influence growth have been studied by many investigators, but owing to lack of time I shall pass over all of them except the last named. In the case of the dwarf *Crepidulæ* which are found in the small shells with the small hermit crabs there is practically no evidence that any of the other factors except the last named, are involved in this dwarfing. These animals live in open shells on sandy sea beaches along with the giant forms; so far as I can determine, the food supply is superabundant, while the conditions of temperature, aeration and freedom from waste products are identically the same for dwarfs and giants. The only difference which I have been able to detect is the size of the shells to which the animals are attached; those which are attached to the small shells of *Nassa* or *Litorina* live and die as dwarfs, reaching only about one thirteenth the volume of those which are attached to the larger shells of *Natica;* however, if they are removed from the smaller shells and placed on the larger ones they may grow to typical size. The dwarfs, however, are continually hampered by their limited quarters; they are unable fully to expand the foot or the mantle, and they are more frequently irritated by the movements of the hermit crabs than are those in the larger shells. Under these circumstances they probably take less food than those in larger quarters, and although they become perfectly differentiated and sexually mature they are dwarfed in size. Similarly I have found that *Paramecium* confined in capillary tubes never grows nor divides, though it may live indefinitely, and although precautions may be taken to change the medium frequently and thus to remove waste products and to supply abundant food and oxygen. In such tubes *Paramecium* is continually irritated and presumably takes less food than when in unconfined spaces.

II. Body Size, Cell Size and Cell Number

Is the size of an organism due to the size of its constitutent parts, or to the number of those parts, or to both of these causes combined? Evidently different organisms differ in this regard. In many plants and lower animals the number of constituent parts is directly correlated with the body size; branches and leaves, segments and organs may increase in number indefinitely with the growth of the organism. In tapeworms and many annelids the number of segments, with their characteristic organs, increases throughout life; but in more highly differentiated forms the number of body segments and organs is constant, and does not increase in number after embryonic stages. In spite of the information occasionally conveyed by examination papers, the number of bones or other organs in the human body does not depend upon the size of the man.

In animals in which the number of organs is constant the constituent parts of such organs may vary in number with the size of the organs. Thus in a large *Crepidula plana* the gill is composed of more than two hundred large filaments, in a dwarf it consists of only fifty or sixty small ones. The liver, sex glands and salivary glands are composed of a larger number of lobules in large animals than in small ones, and the size of each lobule is also larger. Evidently the number of such body parts, whether segments, organs, filaments or lobules, depends upon the power of growth and subdivision of each of these parts. In general the more complex any part becomes the less capable it is of subdivision, and so in all highly differentiated animals we find the body parts and organs are constant in number, though variable in size; whereas in lower animals the number of body parts as well as their individual size may vary with the size of the body as a whole.

Cells are generally recognized to be the ultimate independent units of organic structure and function; the causes of growth and differentiation, of assimilation and dissimilation, of longevity, senescence and rejuvenescence are to be looked for in cells. What is the relation of body size to cell size and cell number? A large number of investigators have studied this problem in a wide range of animals and plants, and with apparently conflicting results; nevertheless enough is now known I think to permit a general answer to this question. Just as in the case of body parts and organs, so also with cells, complexity of differentiation and power of division are generally in inverse ratio. In many animals and plants certain types of cells continue to divide throughout life, where other types cease to divide at an early age. In both plants and animals those cells which continue to divide throughout the growing period become more numerous in large organisms than in small ones, but not individually larger; on the other hand cells which cease to divide at an early stage in the life cycle become individually larger in large animals than in small ones, though in closely related forms their number may remain the same. In short, the size of cells is directly proportional to the rate and duration of growth and inversely proportional to the rate of division. It is well known that muscle cells and nerve cells cease to divide at a relatively early age, whereas epithelial and gland cells, mesenchyme, blood and sex cells continue to divide for a longer period, if not throughout life; accordingly, one would expect to find that muscle cells and nerve cells are larger in giants than in dwarfs, but that the other types of cells named would differ in number but not in size—and this is the general result reached by most of the investigators who have worked on this subject (Donaldson, Levi, Boveri, Conklin,[5] *et al.*). In the most highly differentiated cells (*e. g.*, muscle, nerve) growth takes place independently of cell division; in less highly differentiated cells (*e. g.*, epithelium, mesenchyme) the two processes go hand in hand.

It is an important fact that growth in size and growth in complexity are separable processes, for although they are usually coincident during embryonic development they are not causally united. Just as growth in body size may, or may not, be accompanied by growth in complexity, so cell division may, or may not, be accompanied by differentiation. Cell divisions may thus be classified as differential and non-differential; the former are associated with growth in complexity as well as in size, the latter with growth in size only; the former are relatively constant in number for a given species, the latter vary in number with the size of the individual. The earlier cleavages of the egg are more generally differential than are the later ones, and within the same genus and even in related genera and phyla the number and character of differential cleavages is very constant. Thus in all annelids and mollusks, with the exception of cephalopods, the ectoderm comes from three quartets of cells which are cut off, one after another, at the animal pole of the egg, and in all cases each of these quartets gives rise to homologous regions of the larvæ of the different forms; the left posterior member of the fourth quartet (4*d*) is the mesentoblast and in all annelids and mollusks (except cephalopods) it gives rise to the mesodermal bands and to the posterior part of the intestine; and in general homologous portions of larval or adult animals come from homologous portions of the eggs of these animals through the medium of homologous differential cleavages.

On the other hand, non-differential cleavages are relatively inconstant in number, position and character; they vary greatly in number in different species, or even in different individuals of the same species, depending upon the size of the egg or embryo. Thus in different species of the genus *Crepidula* the differential cleavages are almost precisely the same in all, though the relative volumes of the eggs of different species vary from 1 to 27, but the non-differential cleavages are much more numerous in the large eggs than in the small ones. It is the fact that the earlier cleavages of eggs are so generally differential that makes possible the study of cell lineage; if such cleavages were generally non-differential they would be relatively inconstant and lacking in significance.

In animals with determinate cleavage of the egg the number and nature of the cells at any given stage of differentiation is, under normal conditions, absolutely constant for each species, and it may be a constant number even for different species of a genus, especially if the eggs

[5] Conklin, "The Organization and Cell Lineage of the Ascidian Egg," *Jour. Acad. Nat. Sci. Phila.*, 13, 1905.

of the different species do not differ greatly in size. In various ascidians (*Styela, Ciona, Molgula, Phallusia, Ascidia*) there is a close correspondence in the character and number of the cleavage cells present at corresponding stages of development, even up to advanced stages. For example in all these genera there are 118 cells present when the cup-shaped gastrula is first formed and the prospective fate of each of these cells is indicated herewith: 10 will give rise to endoderm cells, 12 to muscle cells, 16 to mesenchyme cells, 8 to chorda cells, 8 to neural plate cells, 64 to ectodermal epithelium.

At the stage when the gastrula begins to elongate there are 218 cells distributed as follows: 26 endoderm cells, 12 muscle cells, 20 mesenchyme cells, 16 chorda cells, 40 neural plate cells, 104 ectodermal epithelial cells.

Each of these cells is characteristic in position, structure, size and potency, and this is true of all species and genera of simple ascidians hitherto studied with respect to this matter.

In a number of species of small body size Martini[6,7,8] has determined that there is a high degree of constancy in the number of cells in the adult body. In the appendicularian *Fritellaria pellucida* the number of cells is constant in the following organs: 28 flattened epithelial cells of body, 446 oikoplasts (columnar epithelial cells of body), 10 large gland cells in the tail, 7 flattened epithelial cells of the pharynx, 10 large cells of the endostyle, 24 small cells of the endostyle, 4 branchial gland cells, 7 branchial cells, 6 ciliated funnel cells, 19 epithelial cells in the stomach, 10 epithelial cells in the pyloris, 17 epithelial cells in the small intestine, 12 epithelial cells in the large intestine, 6 or 7 epithelial cells in the rectum, 39 cells in the brain, 25 cells in the chief caudal ganglion, 23 cells in the remaining nerve cord, 8 nuclei in heart and pericardium, 20 muscle cells, 12 large chorda cells, 4 small chorda cells.

In different individuals of this species there is a high degree of constancy in the number of these cells, the only variation being in the occasional presence or absence of a single subdivision of a cell.

Also in the rotifer *Hydatina senta* he finds that there are all together just 959 cells, or rather nuclei, in the entire body of the adult, and that each organ consists of a perfectly characteristic number of cells. Even in different species of rotifers the number of cells in many homologous organs is the same; thus there are generally 6 cells in the anterior part

[6] Martini, "Die Konstanz histologische Elemente bei Nematoden, etc.," *Verh. Anat. Gesell.*, 22, 1908.

[7] "Darwinismus und Zellkonstanz," *Sitz. u. Abh. naturforsch. Gesell. Rostock*, 1, 1909.

[8] "Studien über die Konstanz histologischer Elemente," I., II., III., *Zeit. wiss. Zool.*, 92, 94, 1909; 102, 1912.

of the œsophagus, 6 pairs of cells in the excretory tubules, and 13 cells in the cingulum, one of which is on the dorsal mid line.

In the nematode *Ascaris megalocephala* Goldschmidt[9] found 162 cells in the nervous system, while Martini[6] finds 65 muscle cells in *Oxyuris,* and 87 muscle cells in *Sclerostoma,* the latter being derived from 65 cells of an earlier stage.

A similar constancy of cell number has been found by Woltereck[10] in *Polygordius* larvæ, by Apathy in the central nervous system of *Hirudinea,* by Gaule and Donaldson[11] in spinal ganglia of frogs, and by many investigators in small but highly differentiated parts, such as the ommatidia of compound eyes, the lens fibers of vertebrate eyes, the nurse cells of certain arthropod and annelid ova, etc. Such cases of cell constancy are, as Martini remarks, "the crowning fact of determinate development." In all such cases the definite number of cells in the entire body or in a particular organ must be determined by a definite number of cell divisions which proceed from the egg, or from the protoblast of the organ, and this limitation in the number of cell divisions must in some way be determined by heredity. Since increase of differentiation is associated with decrease of cell division, the latter being stopped altogether when differentiation has reached a certain stage, it seems probable that all cases of cell constancy are due to constancy of differentiation.

Where the number of cells in an organ or in an animal is very large it is not possible to prove that the cell number is constant, but in many cases where cell division ceases in embryonic stages the cell number is constant. In such cases cell division does not continue after differentiation is complete, though cell growth does. To all such cases in which there is cell constancy Martini gives the name "Eutelie."

On the other hand, there are many animals in which the number of cells in any particular organ is not constant but is proportional to the size of the organ. In *Crepidula* the number of egg cells within the ovary and the number laid in any season varies with the size of the animal, but the size of individual eggs remains constant for each species; the same is also true of epithelial cells, gland cells and blood cells. The divisions by which such cells are formed are in general non-differential, and since both growth and division in such cases continue throughout life the size of any given type of cell is fairly uniform whatever the body size may be. In differential cell divisions, or in highly differentiated

[9] Goldschmidt, "Das Nervensystem von Ascaris, etc.," *Zeit. wiss. Zool.,* 90, 1908.

[10] Woltereck, "Beiträge zur praktischen Analyse der Polygordiusentwicklung," *Arch. Entw. Mech.,* 18, 1904.

[11] Donaldson, "The Growth of the Brain," Scribners, New York, 1895.

cells which do not continue to divide throughout life, the size of cells varies directly with the body size and with the infrequency of division.

III. Cell Size and Nuclear Size

In a series of recent papers Richard Hertwig[12, 13] and several of his pupils have maintained that there is a definite ratio between the size of the nucleus and the size of the cell; this is the "Kernplasmarelation," or the nucleus-plasma ratio. When this ratio is altered by the greater growth of the nucleus, Hertwig thinks that it leads to a "tension," which brings about division, and thus the normal nucleus-plasma ratio is restored. This ratio is supposed to be a constant one under normal conditions, and if at any time it is altered it is capable of self regulation.

On the other hand, I[14] have found that this ratio varies greatly in different cells of an animal, and indeed within the same cell at different stages of the division cycle, that it may be experimentally altered, and that it is a result, rather than a cause, of the frequency of cell division.

Within the same cell the size of the nucleus varies greatly at different stages of the division cycle, while the volume of the cell as a whole remains relatively constant. The nucleus is smallest during the anaphase, or later stages of division, when it consists of a compact plate of condensed chromosomes; it is largest immediately before the nuclear membrane dissolves at the prophase of the next division. In the cleavage of the egg of *Crepidula plana* the nucleus-plasma ratio in identically the same cell varies from approximately 1:6 when the nucleus is largest, to 1:286 when it is smallest; that is, the volume of the nucleus increases nearly 50 times during the resting period between the previous anaphase and the subsequent prophase; during this same time the volume of the cell remains practically unchanged.

Even when measured at the same phase of the division cycle the nucleus-plasma ratio differs greatly in different cleavage cells; at maximum nuclear size the volume of the nucleus of certain cells of *Crepidula* (4*A*–4*C*) may be 3 times that of the protoplasm, whereas in other cells (1*A*–1*D*) the volume of the protoplasm may be 14.5 times that of the nucleus. At minimum nuclear size the nucleus-plasma ratio may vary from 1:29 in the cells $1a^2$–$1d^2$, to 1:285.5 in the cells 1*A*–1*D*.

The growth of the nucleus between successive divisions is due to the absorption from the cell body of a particular kind of cell substance, which constitutes the achromatin of the nucleus; at the beginning of this growth the nucleus is composed of compact chromosomes, at its

[12] Hertwig, R., "Ueber Korrelation von Zell- und Kerngrösse, etc.," *Biol. Centralb.*, 22, 1903.

[13] Hertwig, R., "Ueber neue Probleme der Zellenlehre," *Archiv Zellfors.*, 1908.

[14] Conklin, "Cell Size and Nuclear Size," *Jour. Exp. Zool.*, 12, 1912.

end it consists of a large vesicle of achromatic substance in which the chromatin usually exists as scattered granules. At the next division some of these granules form chromosomes and all the rest of the nuclear content is liberated into the cell body, to be again absorbed by the daughter nuclei during the succeeding rest period. There is thus a sort of diastole and systole of the nuclear vesicle during every division cycle of a cell, achromatin being taken up by the nucleus during its growth and liberated again into the cell body during its division.

In different cleavage cells of *Crepidula plana,* when the yolk is eliminated from consideration, the nucleus-plasma ratio varies from 1:0.37 to 1:14.5; that is, the volume of the actual protoplasm in certain cells may be only one third the volume of the nucleus, or in other cells it may be fourteen times that volume, depending largely upon the length of the resting period.

In general the size of a nucleus is directly proportional to the volume of the general protoplasm in the cell, to the length of the resting period, and in cases of abnormal or irregular distribution of chromosomes, to the number and volume of the initial chromosomes which go to form the nucleus. The inciting cause of cell division is not to be found in departures from a normal nucleus-plasma ratio, which is a result rather than a cause of the rate of cell division, but rather in the coincidence of certain metabolic phases in nucleus, centrosome and protoplasm.

If the growth period of the nucleus is very long, the greater part of the protoplasm may be taken into the nucleus, as in those cleavage cells in which the nuclear volume is about three times as great as that of the protoplasm outside of the nucleus; if the growth period of the nucleus is short, the nucleus remains correspondingly small. If nuclear division is prevented by hypertonic solutions or by decreased oxygen tension, the nuclei may grow to an enormous size until they contain the greater part of the cell protoplasm.[15]

In certain stages of the division cycle it is possible by the use of hypertonic solutions to prevent the daughter chromosomes from absorbing achromatin, and in such cases these chromosomes form small, densely chromatic nuclei, while the achromatin may be gathered into one or many vesicles. In other cases, the chromatin may be caused to contract and to squeeze out the achromatin. The latter case is similar to that which takes place normally in the formation of a spermatozoon from a spermatid, where there is a condensation of the chromatin of the spermatid nucleus and a squeezing out of the achromatin; this diminution of the nucleus is coincident with the transformation of the protoplasm of the spermatid into differentiation products. A similar thing happens in superficial epithelial cells which are undergoing keratiniza-

[15] Conklin, "Experimental Studies on Nuclear and Cell Division," *Jour. Acad. Nat. Sci. Phila.,* 15, 1912.

tion; up to a certain stage, the nuclei of such cells shrink in size and become more densely chromatic in proportion as the cell protoplasm is converted into metaplasm. The same thing is true of gland cells, muscle cells, fiber cells and fat cells in which the general protoplasm is progressively being changed into differentiation products, and coincidently the individual nuclei shrink in size and become more densely chromatic.

In no case do metaplasmic substances or differentiated structures of the cell enter into the nucleus during its growth, and the relative quantities of general protoplasm and of differentiated products in a cell can be determined by the size to which the nucleus will grow during interkinesis, under given conditions of time, temperature, etc. By subjecting eggs to centrifugal force, the quantities of protoplasm and yolk in the cleavage cells may be greatly changed, and under such circumstances the size of a nucleus is always proportional to the volume of the protoplasm in which it lies; the heavier yolk which segregates at the peripheral pole, and the lighter watery or oily substance which gathers at the central pole of the centrifuged egg do not contribute to nuclear growth, only the clear protoplasm which lies in the middle zone enters the nucleus or contributes to its growth. In muscle cells with small nuclei, the quantity of general protoplasm (sarcoplasm) which may enter into the nucleus or contribute to its growth is small; in nerve cells, it is evidently larger, since the nuclei of such cells are relatively large, but the substance which may enter the nucleus of a nerve cell is by no means as great in quantity as in germ cells and blastomeres, thus indicating that much of the substance of a nerve cell is too highly differentiated to enter into the nucleus. In epithelial and gland cells, the size of nuclei is limited not only by the presence of metabolic products in the cells, but also by the occurrence of cell division and the consequent limitation of the growing period of the nucleus.

The following table gives the cell diameter and nuclear diameter at maximum size, the corresponding nuclear volume, the cell volume less the nuclear volume, and the nucleus-cell ratio, in a number of different kinds of cells in adult individuals of *Crepidula plana:*

The nucleus-cell ratio of these cells varies from 1:1.3 to 1:88.6, depending primarily upon the quantity of formed substance in the cells. The nuclei are relatively largest in germ cells before the formation of yolk, and in embryonic cells in which there is relatively little formed substance; in such cases a relatively great part of the protoplasm may enter the nucleus. The nuclei are relatively smallest in those cells in which the protoplasm has been most completely transformed into products of metabolism or differentiation, such as gland cells filled with secretion, red blood cells of mammals in which the nuclei completely disappear, egg cells filled with yolk, and spermatozoa in which most of the protoplasm has been transformed into the contractile substance of the flagellum.

I have not been able to measure the volume of muscle cells in *Crepidula,* but such measurements have been made by Eycleshymer[16] for the striated muscle cells of *Necturus.* From the measurements given by Eycleshymer, I have calculated the nucleus-plasma ratio in the usual manner, *i. e.,* by determining the ratio of the nuclear volume to the cell volume less the nuclear volume; and I find that in the 7 mm. and 8 mm. embryos this ratio is about 1 :11, whereas in the 23 cm. adult it is about 1 :73. The increase of cell substance is therefore less than seven times, instead of twenty or thirty times, that of the nucleus, as he states.

Ratio of Nuclear Volume to Cell Volume in Adult Individuals of *Crepidula plana*

Kinds of Cells	Maximum Diameter of Cell μ	Maximum Diameter of Nucleus μ	Volume of Nucleus Cu. μ	Volume of Cell Less Volume of Nucleus Cu. μ	Nucleus-Cell Ratio
Spermatocytes I	8	6	113	155	1: 1.37
Spermatocytes II	7	5	64.4	114.6	1: 1.7
Spermatids (chromatin condensed)	3	2	4.18	9.94	1: 2.38
Oocytes I (before yolk formation)	10	6	113	407	1: 3.6
Large ganglion cells (not including any outgrowths)	17×17×23	12	905	5724	1: 6.3
Ectodermal epithelium (of foot)	6× 6×15	5	65.4	474.6	1: 7.1
Epithelium of mantle (near anus)	5× 5×15	4	33	342	1:10.3
Intestinal epithelium	11×11×12	6	113	1339	1:11.8
Gastric epithelium	10×10×36	8	268	3332	1:12.4
Branchial epithelium	7× 7× 9	4	33	408	1:12.3
Liver cells (without secretion products)	14×14×30	9	382	5498	1:14.4
Liver cells (with secretion products)	15×15×45	6*	113	10012	1:88.6
Oocytes I (before maturation and with maximum quantity of yolk)	150	42	32409	1722591	1:53

It is important to note that Eycleshymer found that as the fibrillæ are progressively formed out of the protoplasm of the cell, the nuclei are crowded out of the center of the cell toward its periphery; that the nuclei become more densely chromatic, and especially so on the side of the nucleus toward the fibrillæ; and that possibly the nuclei may disintegrate and their chromatin go to form the dark bands of the striated

[16] Eycleshymer, "The Cytoplasmic and Nuclear Changes in the Striated Muscle Cells of *Necturus,*" *Am. Jour. Anat.,* 3, 1904.

* Nucleus shrunken and irregular in shape.

muscle fiber. These facts seem to me to justify the conclusion which I reached in a former paper:[14]

> It is probable that the contractile substance which makes up the larger part of the muscle cell does not contribute to the growth of the nucleus as does the protoplasm of embryonic cells—that so far as the growth of the nucleus is concerned it acts as does yolk, oil, membranes, fibers or other products of metabolism and differentiation. If only the sarcoplasm of the muscle cell and not its contractile substance is able to contribute to the growth of the nucleus, the small volume of the nuclei as compared with the entire cell would find a ready explanation. There can be no doubt that the plasma is the chief seat of differentiation, as Minot has emphasized, and that highly differentiated cells, such as muscle, nerve, and some kinds of connective tissue, have a larger amount of plasma *and its products*, relative to the nucleus, than have embryonic cells. In the case of fiber cells, fat cells and probably muscle cells, the cell body becomes filled with the products of differentiation and metabolism, which like the yolk in egg cells, or the secretion products in liver cells can not enter the nucleus and consequently do not influence its size. In such tissue cells the cell body is relatively much greater as compared with the nucleus, than in purely protoplasmic cells, but I have been unable to find any evidence that the ratio of protoplasm (using this term in its usual sense) to the nucleus is greater in tissue cells of *Crepidula* than in the blastomeres.

Just as the size of a nucleus in any given species is proportional to the volume of the general protoplasm, so the volume of its chromosomes is proportional to the volume of the nucleus. The number of chromosomes and their relative sizes are characteristic for each species, but the absolute size of chromosomes depends upon the size of the nucleus from which they come. Throughout the period of cleavage, as the cells and nuclei grow smaller, the chromosomes also diminish in size. The view of Boveri[17] that the chromosomes divide when they have grown to their original size before division, and that thereby a definite specific size of the chromosomes is maintained, finds no confirmation in the work of Erdmann,[18, 19] Schleip[20] or myself; while the view of Koehler[21] that the autonomy of the chromosomes may be extended to their growth, which is supposed to be independent of that of other cell constituents, is flatly contradicted by the facts.

During the cleavage stages at least, neither the nuclei as a whole nor the chromosomes double in volume at each successive division as is so often assumed. The total volume of the nuclei at the 70-cell stage of *Crepidula plana* is only 2.25 times their volume at the 2-cell stage. The

[17] Boveri, Zellenstudien V., Jena, 1905.

[18] Erdmann, ''Experimentelle Untersuchungen der Massenverhältnisse, etc.,'' *Arch. Zellforsch.*, 2, 1908.

[19] Erdmann, ''Qualitative Analyse der Zellbestandteile, etc.,'' *Ergeb. Anat. Entw.*, 20, 1912.

[20] Schleip, ''Das Verhalten des Chromatins, etc.,'' *Arch. Zellforsch.*, 7, 1911.

[21] Koehler, ''Ueber die Abhängigkeit der Kernplasmarelation, etc.,'' *Arch. Zellforsch.*, 8, 1912.

volume of the protoplasm more than doubles, at the expense of the yolk, between the 1-cell and the 24-cell stages, while the total nuclear volume increases less than 1.5 times during this period. Jennings[22] has shown that the *rate* of growth is numerically greater than I had stated if one compares any stage with its immediately preceding stage, but of course this criticism does not apply to the total *actual* growth of nuclear material during any given period of development. It is often said that there is a "colossal increase of nuclear mass" but no increase in the protoplasm during the cleavage stages of the egg; and correspondingly there is said to be a great increase in the ratio of nucleus to plasma in the cleavage period. Upon this supposed increase in the nuclear material as compared with the plasma, Minot and Hertwig have based their hypotheses that the cleavage of the egg represents a period of rejuvenescence. However, in *Crepidula* and *Fulgur* among the gastropods and in *Styela* among ascidians there is no great change in the nucleus-plasma ratio during cleavage, and I believe that this will be found to be generally true for other animals. On the other hand, there is a considerable increase in the plasma at the expense of the yolk, during the cleavage period in these animals, and in this fact, rather than in an increase of nuclear substance, is to be found the cause of such rejuvenescence as may occur in these stages.

IV. Longevity, Senescence and Rejuvenescence

Apart from accidental causes of death, longevity is determined by the duration of the excess of anabolism over katabolism. If destructive metabolic changes gain ascendency over constructive ones at an early period the organism is short lived; if constructive processes are indefinitely in the ascendent the organism is potentially immortal. Such a condition is shown in *Paramecium* where Woodruff[23] has reared more than 3,000 generations without conjugation and without loss of vitality. These and other similar experiments have demonstrated the essential truth of Weismann's doctrine that Protozoa are potentially immortal. Woodruff found that the most important factors for maintaining vigor are proper food and freedom from the poisonous effects of waste products. In higher animals there is no doubt that both of these environmental factors are important, but there are also other important factors which influence length of life which are not entirely environmental.

Duration of assimilation conditions not merely body size, but also length of life. Very large animals are long lived and small ones are

[22] Jennings, "Nuclear Growth during Early Development," *Am. Nat.*, 46, 1912.

[23] Woodruff, "Dreitausend und dreihundert Generationen von Paramecium, etc.," *Biol. Centralb.*, 33, 1913.

apt to be short lived, though the latter is by no means universally true —length of life being conditioned by *duration* of the ascendency of assimilation over dissimilation, whereas size is conditioned also by *rate* of assimilation as contrasted with dissimilation.

Weismann has pointed out a relation between longevity and the rate of reproduction—animals in which there is a slow rate of reproduction being in general long lived, while those in which the rate of reproduction is rapid are generally short lived. Numerous exceptions to this rule may be cited, though in many cases it is undoubtedly true; but Weismann has not proved that length of life is the result of slow reproduction. It may well be that both length of life and rate of reproduction are dependent upon the duration and rate of assimilation and dissimilation in somatic and germinal cells.

There is also an undoubted relation between longevity and adaptability, or the power of regulation. If life is continuous adjustment of internal conditions to external conditions, length of life may be said to depend upon the duration and perfection of such adjustment. The power of regulation is much less perfect in some animals than in others, and at certain stages of the life cycle than at other stages. But in all animals this power is greatest where the relative proportion of protoplasm to metaplasm, or differentiation products, is greatest, and where the protoplasm is most labile. In Protozoa this power of regulation is shown at every division and it suffers no abatement in successive generations; in Metazoa generally the power of regulation is greatest in early stages of development and in tissues in which protoplasm is abundant, and it diminishes as life advances and as the products of differentiation more and more replace the protoplasm. In the fission of a *Paramecium* there is a certain amount of dedifferentiation preceding division and of redifferentiation succeeding it, and as a result of this the two halves of the original *Paramecium* become alike; furthermore, in successive generations, there is no accumulation of the products of differentiation. In the division of the eggs of Metazoa the cleavage cells sooner or later become unlike, owing to the differentiations present in the mother cell and the failure of complete regulation in the daughter cells. This progressive differentiation is accompanied by a progressive loss of the power of regulation, and when the general protoplasm is so completely transformed into differentiation products that the power of regulation is completely lost, the organism as a whole must lose the power of adjustment to external conditions, and hence of indefinitely continued life.

Many different hypotheses have been advanced to account for the running down of the vital machine. That death is not a necessary corollary of life is evidenced by the potential immortality of Protozoa and of the germ cells of Metazoa. Senescence, like all other processes occurring in organisms, is primarily a cellular phenomenon. The decline and degeneration of cells begins in the earliest stages of individual development; in many cases large numbers of germ cells regularly undergo degeneration, apparently as the result of intrinsic rather than of extrinsic causes. The polar bodies which are formed during the maturation of the egg are at the same time the smallest and the shortest lived cells in the entire life cycle; they rarely last beyond the cleavage period and do not grow at all. Evidently their degeneration is due to lack of the power of assimilation, rather than to the accumulation of waste products, or to the increase of formed material. This lack of the power of constructive metabolism is evidently not due to lack of chromatin, for at the time of their formation they contain as much chromatin as the egg cell itself; they usually contain very little protoplasm, but even when the quantity of protoplasm in them is very greatly increased, through the effects of pressure or centrifugal force at the time of their formation, they still lack the power of assimilation and differentiation. Such a large polar body resembles an unfertilized egg, and like it is incapable of development unless stimulated by the entrance of a spermatozoon or by some artificial means.

In many cases certain cleavage cells run through their development quickly and then degenerate and disappear, while other neighboring cells live as long as the organism itself. Many larval or fetal organs have a very short life; the cells of which they are composed grow and divide rapidly for a time and then dissimilation exceeds assimilation and they dwindle and disappear. Throughout the mature life of any metazoan many cells are continually growing old and dying, while others take their places. Even in the oldest organisms certain types of cells are still young enough to grow and divide, and there is no reason to doubt that such cells are potentially immortal and, if saved from the general death of the organism by isolation, might live indefinitely. Cells which continue to grow and divide throughout life apparently never grow old. It is customary to speak of the germ plasm as potentially immortal, but it is not generally recognized that other kinds of plasm may also be immortal. Indeed all kinds of protoplasm may be regarded as potentially immortal, except when processes of constructive metabolism are prevented in one way or another. In most cases the power of cell division is lost before that of growth, and the presence or absence of cell division is therefore indicative of youthful or of senile conditions in the cells concerned. Measured by this standard, certain cells grow old at a very early stage in the life cycle, whereas others remain young until overwhelmed by the general death of the organism. Senescence then is not a uniform process for the entire organism; it begins in certain cells at a very early stage of development, while it may not appear at all in other cells.

The possible causes of senescence and rejuvenescence may be classified as structural and functional, though these two should not be regarded as mutually exclusive. Indeed it is practically certain that both structure and function are involved in these processes as in most other vital phenomena. However, different students of this subject have placed emphasis more or less exclusively upon either the structural or the functional causes of senescence and rejuvenescence.

Under the structural causes may be cited Minot's hypothesis that senescence is caused by an increase in the amount of protoplasm as compared with the nucleus. In 1890 he[24] summarized his views on this subject in the following words:

> We have then to state, as the general result of the studies which we have just made, that the most characteristic peculiarity of advancing age, of increasing development, is the growth of protoplasm; the possession of a large relative quantity of protoplasm is a sign of age. . . . We see that there is a certain antithesis, we might almost say a struggle for supremacy, between the nucleus and protoplasm.

In several subsequent papers and books,[25] Minot has developed this idea at length. In his book on "Age, Growth and Death,"[26] he concludes that

> Rejuvenescence depends on the increase of the nuclei, senescence depends on the increase of the protoplasm and on the differentiation of the cells.

R. Hertwig's[28] views are apparently diametrically opposed to those of Minot. He finds that senescence or rather "depression" and "physiological degeneration," in *Actinospherium* and Infusoria are accompanied by an enormous growth of the nucleus. He regards the immature egg cell with its great nucleus as in a condition of depression similar to that found in the protozoa named. By the processes of maturation and fertilization this nuclear material is greatly reduced and thus the cells are brought back to a normal condition.

As opposed to the hypotheses of Minot and Hertwig, it may be pointed out that the larger part of a resting nucleus is composed of achromatin which has been absorbed from the cell body, and that the size of a nucleus depends chiefly upon the quantity of general protoplasm in a cell and upon the length of the resting period during which the nucleus is absorbing this protoplasm. So far from there being an antithesis between nucleus and general protoplasm, we find that the general protoplasm is common to both; small nuclei occur only in cells

[24] Minot, "On Certain Phenomena of Growing Old," *Proc. Am. Ass'n Adv. Sci.*, 29, 1890.

[25] Minot, "Ueber Vererbung und Verjüngung," *Biol. Centralb.*, 15, 1895.

[26] Minot, "Age, Growth and Death," Putnams, New York, 1908.

[28] Hertwig, R., "Ueber die Kernkonjugation der Infusorien," *Abh. Bayer. Akad. Wiss.*, II. Kl., 17, 1889.

with a small amount of such protoplasm, while large nuclei occur only in cells with a large amount. It is not the increase in the general protoplasm which causes the nuclei to become relatively small, but rather the increase in the differentiation products and the corresponding decrease in the general protoplasm.

In most respects I am in hearty accord with Minot's latest formulation of the causes of senescence.[27] In this work he particularly emphasizes the effect of differentiation in causing senescence. Indeed he concludes, "dass die Differenzierung als die wesentliche Ursache des Altwerdens zu betrachten ist." Nevertheless, he still holds that the greater growth of the protoplasm, relative to the nucleus, is the essential basis of differentiation; and that we may distinguish in development an earlier and shorter period, which is characterized by the preponderating growth of the nucleus, from a second and longer one characterized by growth and differentiation of the protoplasm—the former being the period of rejuvenescence, the latter the period of senescence. In *Crepidula,* as I have shown,[14] the growth of nuclear material during early cleavage is not greater than that of the protoplasm, and in general the size of a nucleus is directly proportional to the quantity of general protoplasm and to the length of the resting period, because general protoplasm is absorbed by the nucleus during interkinesis, whereas products of differentiation do not enter the nucleus. A causal explanation is thus given of the relation between nuclear size and cell size at different stages of development; and in the fact that differentiation products can not enter the nucleus we have, I believe, a causal explanation of the relation between differentiation and senescence.

The principal objection to Minot's formulation of the cause of senescence is that it overemphasizes the antithesis between nucleus and protoplasm and does not with sufficient clearness distinguish between the general protoplasm and its differentiation products. It is undoubtedly true that with advancing age and differentiation there is an increase of cellular as compared with nuclear substance, but the significant thing here is the fact that this cellular increase is not so much in the protoplasm as in the products which are formed from it and which can not enter into the nucleus.

By all odds the most important structural peculiarity of senescence is the increase of metaplasm or differentiation products at the expense of the general protoplasm. This change of general protoplasm into products of differentiation and of metabolism is an essential feature of embryonic differentiation and it continues in many types of cells until the entire cell is almost filled with such products. Since nuclei depend upon the general protoplasm for their growth, they also become small in such cells. If this process of the transformation of protoplasm into

[27] Minot, "Moderne Probleme der Biologie," Fischer, Jena, 1913.

differentiation products continues long enough it necessarily leads to the death of the cell, since the continued life of the cell depends upon the interaction between the general protoplasm and the nucleus. In cells laden with the products of differentiation, the power of regulation is first lost, then the power of division, and finally the power of assimilation; and this is normally followed by the senescence and death of the cells.

In some cases the progressive transformation of protoplasm into metaplasm may be reversed; in some manner the formed material is dissolved and converted into general protoplasm, the protoplasm and nuclei increase in size, the cells begin to divide and may become capable of regulation. In short, this reversal of the differentiation process leads to the rejuvenescence of senile cells. Minot[27] holds that differentiated cells do not become undifferentiated—but at least it must be admitted they may lose their products of differentiation and metabolism; gland cells lose their secretion granules, egg cells their yolk, spermatozoa within the egg their flagella, injured muscle cells their fibrillæ, etc. In such cases differentiation products are either eliminated from the cell or are transformed into a more labile and more general form of protoplasm, though the latter is probably not undifferentiated. I have used the term *dedifferentiation* for this process.

Among functional causes of senescence may be mentioned the well-known opinion of Metschnikoff, that the organism is slowly poisoned by its own waste products. Metschnikoff especially emphasizes the effects of intestinal fermentation and putrefaction in producing old age. Zoologists are familiar with the fact that, in certain Polyzoa and Tunicata which lack kidneys or efficient means of eliminating urea, or other nitrogenous waste, the tissues gradually become laden with such waste substances and the animal becomes senile and finally dies, but before this happens it may give off one or more buds which are relatively free from these waste products and which continue the life of the colony. It is a general phenomenon both in plants and animals that buds are composed of protoplasm which is not laden with products of differentiation or metabolism, and hence they exhibit youthful characteristics although the body from which they come may be senile.

Another functional cause of senescence is to be found in a decrease in the power of constructive metabolism. This factor has been recently advocated by Child[29] in a very valuable paper, in which he concludes that anything which decreases the rate of metabolism, such as "decrease in permeability, increase in density, accumulation of relatively inactive substances, etc.," will lead to senescence. On the other hand, "Rejuvenescence consists physiologically in an increase in the rate of

[29] Child, "A Study of Senescence and Rejuvenescence, etc.," *Arch. Entw. Mech.*, 31, 1911.

metabolism and is brought about in nature by the removal in one way or another of structural obstacles to metabolism."

It is well known that constructive metabolism can not take place in the absence of a nucleus, and I have elsewhere[14] shown that the interchange between the nucleus and the protoplasm is a condition of assimilation. I have likewise shown that only the general protoplasm can enter the nucleus and that the products of differentiation are excluded from it. The progressive increase of such products and corresponding decrease in the general protoplasm lessen this interchange between nucleus and cell body and thus decrease the power of constructive metabolism.

In conclusion it may be said that there are several factors which produce senescence, but that the chief of these is the progressive differentiation of the protoplasm. As Minot has well said "Old age and death are the price which we pay for our differentiation." If we could find means by which this progressive differentiation could be stopped or reversed when it has gone too far, we might hope to attain potential immortality. That the possibility of this is not a mere delusion is shown by the fact that there are many animals which either in whole or in part are capable of rejuvenescence. In Protozoa the dedifferentiation which usually precedes or accompanies division is a process of rejuvenescence, and where such dedifferentiation and division are long delayed even protozoans show signs of old age. The same is true of germ cells; the mature egg and sperm are senile cells not because the one has a very large nucleus and the other a very small one, but because both are loaded with products of differentiation which interfere with constructive metabolism. When the sperm enters the egg and either leaves behind its old cell body or dissolves it, and its nucleus gets a new protoplasmic body, it is rejuvenated; likewise when the egg begins to dissolve the yolk and other products of differentiation with which it has been loaded it begins to live anew.

Similarly any adult animal or plant which is capable of dedifferentiation is also capable of renewing its youth. It has long been known that encystment and accompanying loss of differentiation lead to rejuvenescence. Jacobs,[30] working under my direction, found that when the rotifer, *Philodina*, becomes senescent, it may be rejuvenated if it is completely dried up and afterwards put back into water; in this treatment it evidently undergoes dedifferentiation.

Child[29] found that after planarians in a condition of apparent extreme senility had been starved for some time, they afterward became young within a few hours or days. Evidently the starving served to use up a part of the structural substance which prevented rapid metabolism.

[30] Jacobs, "The Effects of Desiccation on the Rotifer *Philodina roseola*, *Jour. Exp. Zool.*, 6, 1909.

Similar conditions of renewed vigor are shown by many animals after long hibernation. The great breeding activity of many animals, such as frogs, so soon after their winter sleep, may find a physiological explanation in this using up of metabolic products during hibernation and the subsequent increase in vitality.

In similar manner it is known that the new tissue which is formed in regeneration comes from undifferentiated (epithelial or lymphoid) or from dedifferentiated cells (*e. g.*, muscle cells of amphibia, etc.). In the latter case also there is a rejuvenescence, due to the loss of differentiation products. In this case dedifferentiation is evidently due, in the first instance, to the injury. It is at least possible that the failure to regenerate lost parts, which many animals show, is due to the inability of the cells to undergo dedifferentiation and subsequent rejuvenation.

In conclusion, we find that the life of a cell is dependent upon the continued interaction of nucleus and protoplasm; that as the protoplasm is transformed into products of differentiation this interaction of nucleus and protoplasm is reduced and constructive metabolism is diminished; that when the quantity of protoplasm present has been reduced beyond a certain point, either by its transformation into metaplasm, or by other means, constructive processes fail to compensate for destructive ones, and the cell grows old and finally dies. On the other hand, processes which lead to the increase of the general protoplasm in a cell, either by the growth of the protoplasm already present or by the conversion of metaplasm into protoplasm, lead also to the growth of the nucleus, to increased interchange between nucleus and protoplasm, and hence to increased powers of assimilation, cell division and regulation. Anything which decreases the interchange between nucleus and protoplasm leads to senility; anything which decreases this interchange renews youth.

BERNOULLI'S PRINCIPLE AND ITS APPLICATION TO EXPLAIN THE CURVING OF A BASEBALL

By S. LEROY WN, Ph.D.,

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WHEN a liquid or a gas is flowing through a horizontal pipe and encounters a constriction in the pipe, there is a higher velocity of the fluid and a lower pressure in the constriction than in the larger section of the pipe. At first thought, this is contrary to what one would expect, for the crowding of the fluid into a smaller section would apparently raise the pressure. Closer analysis, however, shows that places in the pipe where the velocity of the fluid is greater must be places of lower pressure and at places where the velocity of the fluid is less, the pressure must be greater.

Consider a definite mass of water as *m* in Fig. 1. When this piece of water moves from position *A* to position *B*, its velocity is increased

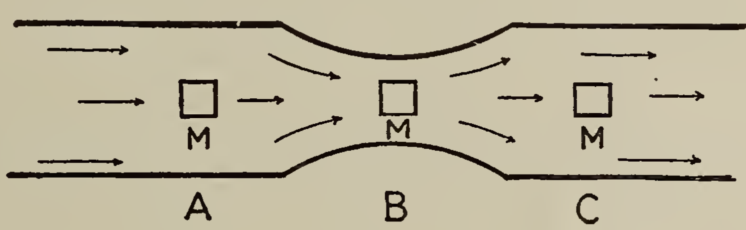

Fig. 1.

since the velocity of the water in the smaller section of the pipe must be larger than in the larger section if the same amount of water per second which flows through the larger section is to go through the smaller section. Since the velocity of this mass of water is increased (mass *m* is accelerated) there must be an unbalanced force acting on it. This unbalanced force is furnished by a higher pressure at position *A* than at position *B*. That is, the pressure behind the moving mass *m* is greater than in front of it and, consequently, the velocity is increased. As the piece of water leaves the neck in the pipe, the pressure in front of it is greater than the pressure behind it and it slows down to the lower velocity in the larger section of the pipe.

The generalization of the above described phenomenon is, that places in a fluid where the velocity is relatively greater are places of lower pressure and places where the velocity of the fluid is relatively smaller are places of higher pressure.[1] This generalization (first established by John Bernoulli) is called Bernoulli's principle and its application to explain many paradoxical results is interesting.

Fig. 2 shows how the weight of a marble may be held up by blowing through the tube. The high velocity of the air over the top of the marble causes a lower pressure than there is under the marble where the air has a comparatively low velocity and this difference in pressure exerts an upward force which is sufficient to balance the weight of the marble.

A light ball may be held in midair by a stream of air flowing just above it, as shown in Fig. 3. Just above the ball is a region of high

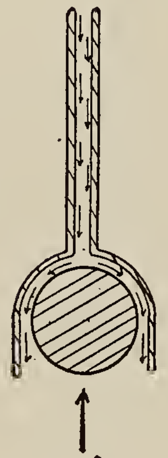

FIG. 2.

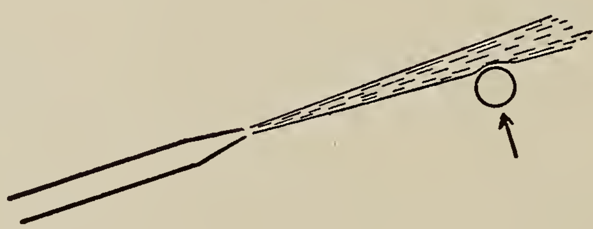

FIG. 3.

velocity and low pressure, while under the ball is a low velocity and high pressure region and therefore the force of gravity on the ball is balanced by the difference in pressure.

The difference between the higher pressure in the larger section and the lower pressure (higher velocity of water) in the smaller section of a water pipe is indicated by the manometer in Fig. 4. The pressure in the larger section of the pipe is greater than the pressure in the smaller section by an amount equal to the pressure exerted by a column of mercury h high. If the areas of the larger and smaller sections are known, the rate at which the water is flowing through the pipe (cubic feet per second or gallons per second) can be determined from the difference in pressure which is indicated by the manometer. This method of measuring rates of discharge is used in the Venturi water meter, which is not essentially different from the arrangement shown in Fig. 4.

[1] When a fluid flows from a region of low velocity to a region of high velocity the pressure decreases but the reverse, that when a fluid flows from a region of high velocity to a region of low velocity the pressure increases, is not always true. For example, the friction of the water against the sides of the tube in Fig. 1 might be sufficient to decrease the velocity of the water as it flows out of the neck without the pressure increasing.

A baseball moving through the air is the same as air moving past the baseball as far as the forces which the air exert on the ball are concerned. A ball thrown straight (without rotating) through the air can

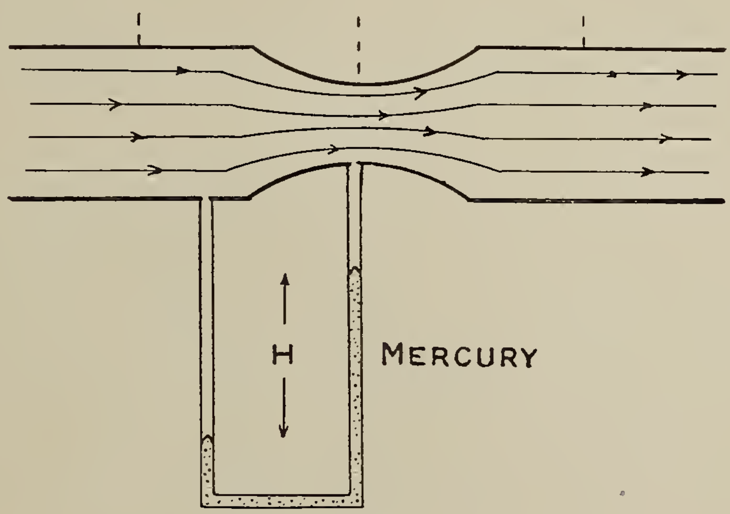

FIG. 4.

be pictured as air moving past the ball with the same velocity on all sides of the ball which is shown by the equal density of stream lines above and below the ball in Fig. 5. According to Bernoulli's principle,

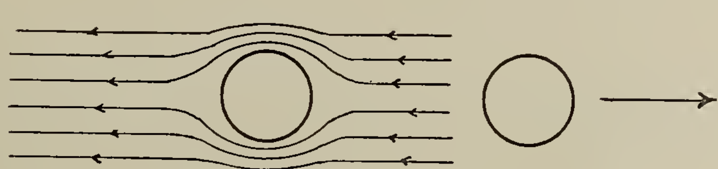

FIG. 5.

there are equal pressures (equal velocities) of the air on all sides of the ball and it does not curve.

If the ball is rotating as it moves through the air, its spin will increase the velocity of the air past the ball on one side and retard the velocity of the air past the ball on the opposite side as is indicated in Fig. 6 by many stream lines on one side and few on the other. The higher pressure (low velocity) on the one side pushes the ball toward the low pressure (high velocity) region and it curves as shown by the heavy arrow in Fig. 6. If the ball had been rotating in an opposite

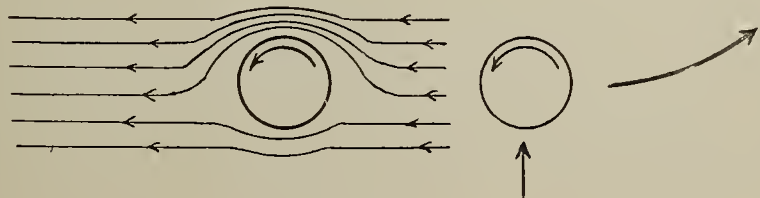

FIG. 6.

direction, the low pressure region would have been on the other side of the ball and it would have curved in the opposite direction.

In order to show this difference in pressure on the sides of a rotating ball as it is thrown through the air, or in practise as the air is driven past the ball, the author has devised the following demonstration. The air is driven past the ball by a centrifugal blower and the pressures on two opposite sides of the ball are indicated by manometers as shown in Fig. 7.

When the ball is not rotating, the velocity of the air on the two sides of the ball is the same (shown by equal density of stream lines in top view section of Fig. 8) and the manometers indicate equal pressures on the two sides of the ball (end view of Fig. 8). This is equivalent to the ball going through the air without rotating and without curving to either side as shown by the heavy arrow. However, the pressure on either side of the ball is less than the pressure in the still air outside the tube which directs the air past the ball; that is, the high velocity regions near the ball are low-pressure regions.

When the ball is rotating as shown in Fig. 9 the friction against the surface of the ball accelerates the flow of air past it on one side and retards the air stream on the other side; that is, the stream lines are more dense on one side (shown in top view of Fig. 9) and the manometers indicate unequal pressures on the two sides of the ball (shown

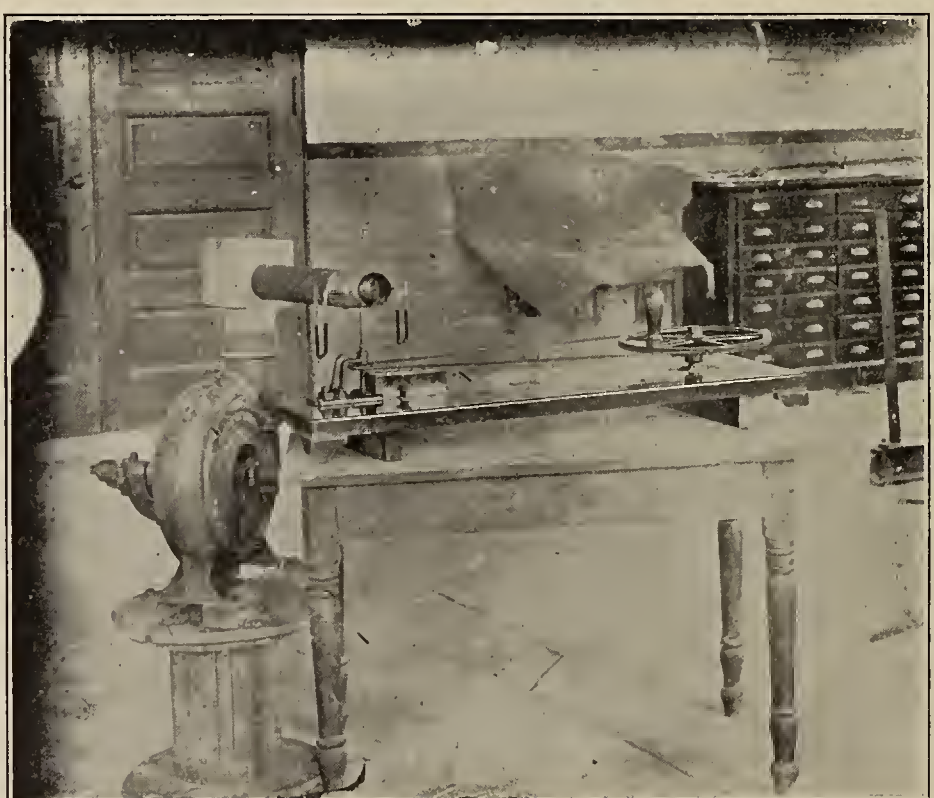

Fig. 7.

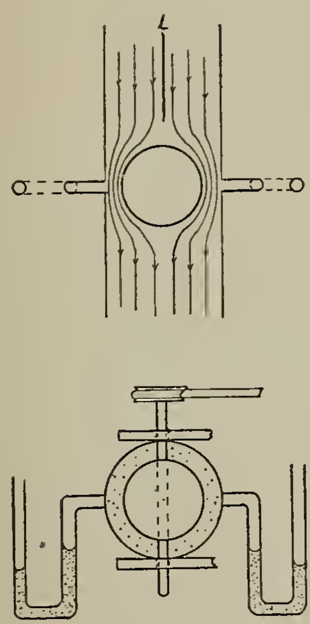

Fig. 8.

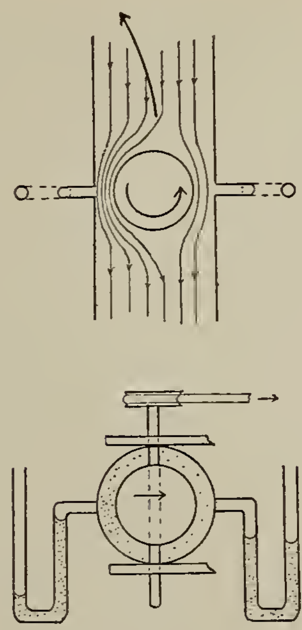

Fig. 9.

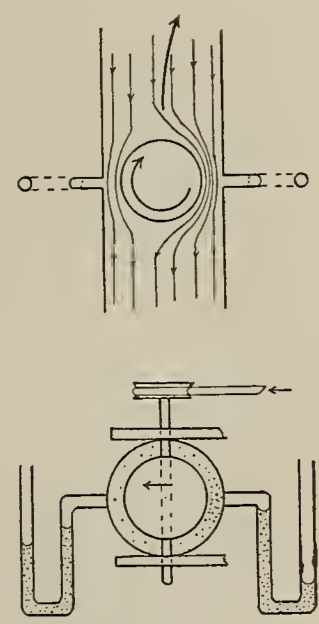

Fig. 10.

in end view of Fig. 9). This is equivalent to the ball going through the air with a rotary motion and the difference in pressure on the two sides curves it as shown by the heavy arrow.

If the rotation of the ball is reversed, the lower-pressure region (higher velocity region) is on the other side of the ball. This is equivalent to the ball going through the air with a rotary motion as shown in Fig. 10 and the difference in pressure on the two sides of it causes it to curve as shown by the heavy arrow.

Main Building of the Bureau of Science at Manila

THE PROGRESS OF SCIENCE

THE BUREAU OF SCIENCE OF THE PHILIPPINE ISLANDS

THE annual report of the acting director of the Bureau of Science, maintained under the government of the Philippine Islands, for the year ending with July, 1912, has just reached this country, and bears witness to the accomplishment of a considerable amount of scientific work. It might be better if the native peoples were permitted to follow their natural lines of development, but scientific investigation and the common schools are probably better for them than the rule of the Spanish friars. In any case, the serious efforts made by the Bureau of Science to investigate the natural history and natural resources of the islands and the tropical diseases that occur there will be of value to the world at large. Government and investigations in a tropical country, however, can be carried forward only at a heavy cost, and we should probably adopt the English policy of paying large salaries and permitting early retirement on a pension.

The present report gives evidence of the difficulty of maintaining a scientific staff. Dr. Paul C. Freer, director of the Bureau of Science from the time of its organization as the Bureau of Government Laboratories in the year 1901, dean of the college of medicine, and professor of chemistry in the University of the Philippines, died last year. The important work that he accomplished in advancing science and education was thus paid for at a heavy price. Several others of the most active workers in the bureau have returned to the United States, and just now Dr. Richard P. Strong, chief of the biological laboratory, has accepted a chair of tropical medicine in the Harvard Medical School.

During the year a new wing was added to the laboratory building, as shown in the foreground of the accompanying illustration. The division of mines, the sections of fisheries and ornithology, the entomological section and laboratories and the library were moved into it. The room in the main building vacated by the library now contains the herbarium, and other rooms left vacant by the readjustments are occupied by laboratories and for clerical work.

The amount of research work accomplished by the bureau is born witness to by *The Philippine Journal of Science,* established by Dr. Freer. It is published in four sections—one devoted to the chemical and geological sciences and to the industries, one to tropical medicine, one to botany and one to general biology, ethnology and anthropology. During the year under review, there were published in these sections of the journal about one hundred articles, most of them by members of the staff of the Bureau of Science. Among the work published or to be published in the *Journal* may be noted the proceedings of the International Plague Conference at Mukden in 1911, of which Dr. Strong and Dr. Teague were members. Experiments have been carried on in several directions, including work on beri-beri, surra and entamœbic dysentery. In the botanical section additions have been made to the herbarium which now numbers over 100,000 specimens, but apparently no very great amount of field work has been done. The division of entomology has done economic work in promoting silk culture and has carried on campaigns to exterminate the mosquito and other disease-bearing insects. The section of fisheries has studied shells used in the manufacture of buttons, tortoise shells, the shark-fin industry and the manufacture of leather from the skins of marine animals. Something, but apparently not much, has been accomplished in stocking the streams with game fish and in the

SIR JONATHAN HUTCHINSON,

the distinguished London surgeon and author who has died at the age of eighty-five years.

study of the deep-sea fisheries. An aquarium has been built in the bastion in front of the Real Gate of the city. The chemical laboratory like the biological laboratory is largely occupied with routine work, there having been made last year over 10,000 analyses and tests. The investigations include the study of Philippine soils, coal and Portland cement. A sugar laboratory has been opened at Iloilo, and it is recommended that there be established an experiment station in that region, where sugar cane of various kinds can be tested. The division of mines has, like the other departments, been largely occupied with routine work. Investigations have been made of the black sands, of the ore deposits, including gold veins, and of the raw materials for cement. The division of ethnology has continued the study of the Iloco people and the museum has been developed.

It is three years since the bureau has had an increase in appropriations in spite of the fact that demands upon it have increased in every direction. The need is urged of a new testing laboratory, of enlarging the soil surveys, of the study of animal diseases and of insects injurious to agricultural products, of enlarging the library and of developing the scope of the work on the fish and fisheries of the islands.

DISTRIBUTION AND CAUSE OF PELLAGRA

Dr. Louis W. Sambon, of the London School of Tropical Medicine, who is about to visit the United States in response to an invitation to join the Pellagra Commission which is working in South Carolina, contributes to the last number of *The British Medical Journal* an article giving an account of several cases in Great Britain and of his theory of the natural history of the disease. Pellagra has been recognized for two centuries, but until recently was supposed to be confined to the peasantry in parts of Italy and other regions adjacent to the Mediterranean. The symptoms are first a red smarting rash—whence the name of the disease—headache, giddiness and diarrhœa. It appears in the spring, declining towards autumn, and is likely to recur with increased intensity the following spring. Death frequently follows, or a complete disorganization of the nervous system, leading to imbecility and a mummified condition of body.

The theory of Lombroso that pellagra is caused by eating moldy maize was widely accepted, until Dr. Sambon at a meeting of the British Association

Professor William Morris Fontaine,
for thirty-one years professor of natural history and geology in the University of Virginia, who has died at the age of seventy-eight years.

in 1905 suggested that it was probably of protozoal origin, and was communicated by sand flies, as sleeping-sickness is by the tsetse fly or malaria and yellow fever by mosquitoes. Since that time Dr. Sambon has made careful studies in Italy and elsewhere, and his views are accepted by a number of leading authorities. He calls attention to the analogy with malaria, especially in its seasonal occurrence. While Dr. Sambon has been able to produce no experimental evidence of the causes of the disease, Dr. W. H. Harris, of Tulane University, has recently published in *The Journal* of the American Medical Association a note on experimental production of pellagra in monkeys. These monkeys were injected with filtrates, made through a Berkefeld filter, obtained from cases of pellagra shortly after death, and all showed the typical symptoms of the disease.

As recently as 1906 Sir William Osler in the sixth edition of his "Principles of Medicine" stated that the disease has not been observed in the United States. In the following year, Dr. G. H. Searcy in Alabama and Dr. J. W. Babcock and J. J. Watson in South Carolina recognized the disease. Their reports were received with skepticism and even with ridicule, but now pellagra is known to exist in no fewer than thirty-three states and there are probably at present 30,000 cases. It is strange that pellagra and the hookworm disease, both of which are so prevalent and so disastrous in our southern states, should have remained until recently unrecognized. Both diseases are preventable, and we may look forward to a great advance in health and social efficiency when they have been brought under control in the south. We should be grateful to the General Education Board for the work that it has accomplished in this direction, but the national government, the states and the municipalities should now take up the suppression of preventable diseases with all the resources at their command.

SCIENTIFIC ITEMS

We record with regret the death of Dr Horace Jayne, formerly professor of vertebrate morphology in the University of Pennsylvania; of Professor N. H. Alcock, professor of physiology in McGill University, and of Dr. Philip Lutley Sclater, from 1859 to 1902 secretary to the Zoological Society of London, distinguished for his work on systematic zoology.

Dr. Joseph Swain, president of Swarthmore College, has been elected president of the National Educational Association; Dean Gardner C. Anthony, of Tufts College, president of the Society for the Promotion of Engineering Education, and Dean Victor C. Vaughan, of the University of Michigan, president of the American Medical Association.

In the article on "Ancient Man, his Environment and his Art," which appeared in the July number of The Popular Science Monthly, Fig. 4 is from a photograph by Professor V. Commont, and Figs. 7–10 are from photographs by Count Bégouen.

The editor has received a letter from Professor Karl Pearson, the Francis Galton Eugenics Laboratory, University of London, under date of June 9, in which he says:

> The following paragraph occurs in your June issue in a paper by Professor H. E. Jordan: "We are now in possession of facts, thanks mainly to the labors of Professor Karl Pearson and his collaborators at the Galton Eugenics Laboratory, and to Professor Davenport and his staff of assistants at the Eugenics Record Office, showing that the inheritance of several scores of human physical and mental traits are in close conformity with Mendelian formulæ" (p. 580). Such a statement will astonish those who are acquainted with the work done here, and I feel bound at once to state that, as far as my experience reaches, I find no physical or mental trait with which we have dealt here to be "in close accordance with Mendelian formulæ." The almost amusing aspect of the matter is, that the one paper in which I have dealt with the mulatto was an endeavor to show that Mendelian formulæ did not hold for him.

The Popular Science Monthly

Entered in the Post Office in Lancaster, Pa., as second-class matter.

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PRESS OF THE NEW ERA PRINTING COMPANY

6413

Vol. LXXXIII, No. 3 SEPTEMBER 1913

THE POPULAR SCIENCE MONTHLY

EDITED BY J. McKEEN CATTELL

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THE SCIENCE PRESS

LANCASTER, PA. GARRISON, N. Y.

NEW YORK: Sub-Station 84

Single Number, 30 Cents Yearly Subscription, $3.00

THE

POPULAR SCIENCE

MONTHLY.

SEPTEMBER, 1913

THE NITRATE FIELDS OF CHILE

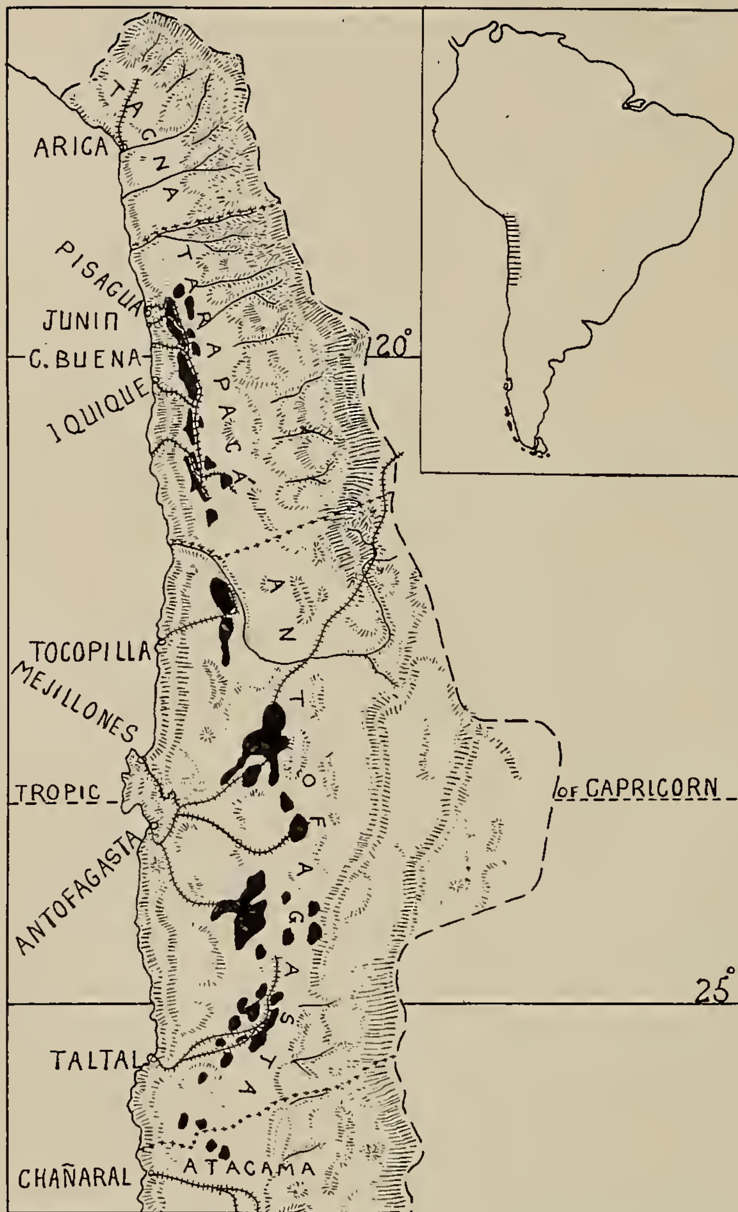
By Dr. WALTER S. TOWER

DEPARTMENT OF GEOGRAPHY, UNIVERSITY OF CHICAGO

THE importance of Chilean nitrate depends on a curious whim of nature. Nitrogen is needed by all plants and animals, and though the atmosphere is nearly four-fifths nitrogen, few plants and no animals can draw directly on that universal supply. Animals secure their nitrogen through the medium of plants, and most plants must get it from the soil. Some cultivated crops rapidly use up the soil nitrogen and in such cases the easiest way to maintain productivity is by applying fertilizers. Nitrogenous fertilizers once were made largely from guano, fish scrap, slaughter-house refuse, etc., but their manufacture now depends mainly on natural nitrates. These occur in many parts of the world, but they have been found in large amounts only in the northern provinces of Chile.

For Chile itself no other thing has been more important than nitrate in affecting national progress. By some, nitrate has been regarded as a curse; by others, as a national blessing; and spirited arguments over its political aspects may be heard in all parts of Chile, for the question is one of those which time does not settle. Nitrate has led to costly wars which established the prestige of Chile as the leading nation on the west coast of South America. It has lured tens of thousands of people into dreary deserts, and caused busy ports to develop where harbors are such only in name. It has created a great commerce for the country, made fortunes for the people, and provided great revenues for the nation to spend for army, navy and the general welfare. But along with these things, it has turned men and money from more stable forms of industry, and laid the country open to criticism, perhaps unjustly, for its extravagance.

Chile saltpeter, nitrate, or *salitre* as it is called, is when pure a glis-



Sketch map of northern Chile, showing approximate location of nitrate lands (black areas). Cross-lined area on small map of South America shows location of nitrates province.

tening white compound, salty and bitter to the taste, like some sea plants, and capable of absorbing a great amount of moisture. Chemically the substance is sodium nitrate ($NaNo_3$). Pure nitrate is found only in small quantities or "pockets." Commonly it is mixed with earthy materials and various saline compounds, as common salt, Glauber's salt and borax. A small amount of iodine compounds also are present in most cases. This impure raw material is known as *caliche* to the nitrate miner.

Caliche, unlike many raw forms of minerals, is easy to get at, for it lies on or near the surface. In some places, the caliche is covered with 25 or 30 feet of fine dust (*chuca*) and coarser rock waste (*costra*) which must be thrown aside by the miner. In such places, an area which has been worked looks as though it had been badly furrowed by gigantic ploughshares. In other places, there is almost no overlying material to remove. The layer of caliche may be as much as six feet thick, but for the most part it varies between one and three feet. The beds in some sections are fairly continuous over large areas; in others they are of very limited extent. Some caliche contains more than 70 per cent. of nitrate, but 50 to 60 per cent. is considered high; the average is nearer 20 to 30 per cent., and even as low as 15 per cent. is worked profitably. Hence the conditions of production, costs of operation and profits to be made vary widely from place to place. With few exceptions, however, it is true that the costs of operation are low as compared with many other mining industries, while the profits are large.

The main nitrate fields lie in two provinces, Tarapacá and Antofagasta, between latitudes 19° S. and 27° S. Other deposits doubtless will be found farther south in Atacama, and there are said to be small nitrate areas in Tacna, the most northerly province of Chile. The total area of these four provinces (105,000 square miles) is about equal to that of Colorado and its population (316,000) gives about two per square mile. Most of the people depend directly or indirectly on the nitrate industry. Chileans are the most numerous, but there are also many Bolivians and Peruvians, with smaller numbers of people from half the nations of the world. Only small parts, probably much less than 10 per cent., of the provinces named are workable nitrate lands. These limited areas, together with the seaport cities, contain the mass of the population, while many thousands of square miles contain not a living soul nor any other living thing.

The nitrate beds lie in a belt, commonly less than ten miles wide, about 500 miles long north and south, and 15 to 100 or more miles back from the coast. This short distance from the coast is important in making shipment cheap. Along the coast there is a range of low mountains through which a few ravines offer routes for railroads into the interior. Between the Coast Mountains and the base of the towering Andes lies lower land, known as the *pampa,* which slopes westward from the Andes to the Coast Ranges. The nitrate deposits lie along the western side of the pampa, its lowest part, associated with what were once the bottoms of water-filled basins, either lakes or arms of the sea. Lines of flats, covered with dazzling white salt beds, or *salares,* extend over many square miles. Thus one salt field in Tarapacá covers an area of more than 100 square miles, and salt of remarkable purity (over 99 per cent. pure) is said to extend to depths of scores of feet. Round about these salares are the nitrate lands or *salitreras.* In many parts of the region there is a saying: "Where there is salt there is no caliche." Though this saying holds true generally, there are some places where the two deposits occur together. The presence of nitrate, however, is easily determined. In a manner much like that of using flint and steel

Crossing one of the great *salares* in the province of Antofagasta.

on tinder, particles of any supposed caliche are brought in contact with a strip of burning cotton wicking, or *mecha*. If nitrate is present, the particles ignite sharply, and with no further test an expert can tell approximately the percentage of nitrate present.

The nitrate is so readily soluble that the deposits could not exist even in a moderately rainy region, but there is little trouble on that score in northern Chile. The high Andes on one side and the cold Humboldt or Peruvian current on the other make Chile north of the 30th parallel one of the driest regions in the world. Some places have passed more than a decade without a drop of rain. Other places have a few minutes of scattering sprinkles almost every year. This is said to have been the case in parts of Antofagasta for many years prior to 1910, when there was a heavy shower, followed in 1911 by two days of steady downpour. These occurrences, with rain again in 1912, and, more wonderful still, snow where people living in the region for a generation never had seen snow, have led many residents to believe that "the climate is changing since Halley's comet went past." That water has flowed here at times in the past is shown by the dry gullies and channels. Numerous snow-fed rivers descend the western slopes of the Andes, but their waters soon are evaporated or lost in the dry sands of the pampa. For hundreds of miles along this coast not a perennial stream enters the ocean. If absolute desert exists in the world, it lies in the nitrate pampa.

In crossing this region one can not help feeling the utter helplessness of man in the face of such great expanses of waterless and lifeless wastes. All directions lead to sand, more sand, even to the border of the ocean itself. One fails at first to understand how men are willing to live there year after year; why those who go away generally come back again

A Rio seco, or "Dry River," in a *salar*.

to this apparently limitless desolation. But almost the first day's stay reveals part of the reason. The day is not unpleasant despite the heat and the intensity of the sunlight, for the extreme dryness makes temperatures of 90° or more quite comfortable, and the colors—the grays, yellows, violet—playing over the sands, help make up for the lack of living green. The nights are wonderful—cool, crisp, refreshing, with the brilliancy of sky that only deserts can have; while the moonlight gleaming from millions of salt crystals lights up the land with an effect of half day and renders into attractive forms the most prosaic objects.

Presumably dryness also was a factor in the formation of the nitrate beds. It seems certain from the kinds of rocks found there that the area between the Coast Ranges and the Andes once was occupied by a bay or long arm of the sea. Then the land began to rise, cutting off the bay and converting it into a lagoon, entered perhaps by every high tide. About its borders great flocks of birds congregated—as they do now along the neighboring ocean—to feed on the prolific life in the shallow, warm waters. Enormous deposits of bird guano accumulated about its shores as the years went on. Meanwhile, however, the land was rising higher and higher, water came into the lagoon only from the land, bringing with it soluble nitrates from the guano. But this supply of water was too small to keep up the level; and as the region became drier and drier, evaporation reduced the original sea to a string of lakes occupying isolated basins in the lower parts of the pampa. As evaporation went on, these waters became too salty for life to endure. With their food supply gone, the birds were forced to seek other haunts and the accumulation of guano stopped. Streams and occasional rains, perhaps more frequent then than now, washing away the guano, brought together in the lakes compounds of nitrogen and soda, and the formation of nitrate of soda was the result. Eventually these waters became saturated with the differ-

A typical sandy waste. The cross and arrow indicate one of the pipe-lines which carry water to the coast from the Andine streams.

ent salty compounds, and as evaporation still continued, the different salts began to deposit on the pampa, in the salitreras and salares, much as they are to-day. Then as a final step sand and rock fragments from neighboring hills covered the beds with their present capping of loose waste.

Other explanations of the origin of the nitrate have been advanced. One ascribes it to natural chemical processes accompanying decomposition of different minerals. Another suggests that the wonderful electrical discharges in the Andes are responsible, for the odor of nitric acid in the air is not uncommon after severe electrical storms, and electricity even now is being used to extract nitrogen from the air. But the enormous amounts of nitrate in Chile and the geological conditions of its occurrence fit in best with the idea of origin from guano, as stated above.

The fertilizing value of these nitrates is supposed to have been known to the Peruvian Incas, but not generally to have been taken advantage of by them. Tradition also says that Bolivian Indians at an early date came down from the plateau after nitrate to use on their crops, and it credits them, rather doubtfully, with having developed a primitive form of refining. Rich pieces of caliche, so the story runs, were boiled with water in great earthen pots, called *cachuchos,* after which the solution was allowed to cool and evaporate until crystallization of nitrate resulted. Fairly pure nitrate can be secured in this way. Some of the earliest manufacturers for commercial purposes are said to have followed almost the same method, and the principle is exactly like that of the modern process. Even the name "cachuchos" still persists, though the great steel or iron boiling tanks of to-day scarcely suggest "earthen pots."

Prior to the nineteenth century the outside world knew little or noth-

In a cutting which shows the layer of caliche with almost no overlying material. The tools shown are the only ones needed in mining caliche.

ing of these nitrates. Fertilizers were then quite unheard of in most places; industrial uses of nitric acid and its compounds were few; and for making explosives—then gunpowder was the only one—small, scattered deposits of true saltpeter provided the raw material.

Nearly a hundred years ago, it is said, a Scotchman living near Iquique spread over part of his garden some soil containing white crystals. That part of his garden flourished much more than the rest. Thereupon samples of the soil were sent to Scotland for experiments which revealed the nature of the substance and its fertilizing value; and thus, so the story goes, the foundation was laid for the great nitrate industry. A decade later, or about 1826, a Frenchman is credited with having established the first real nitrate works in the pampa back of Iquique. Soon after that an Englishman, a German and a Chilean are supposed to have followed suit, and the business began to grow slowly. A little more than 8,300 tons of nitrate are said to have been exported in 1830.

The nitrate fields then were divided among three countries. Peru owned Tacna and Tarapacá. Bolivia owned most of what is now Antofagasta, while Chile owned from Atacama southward. This last region was then not known to contain nitrate, and still is the least important part of the fields. Peruvians and Chileans became most active in the industry, perhaps because the fields were more easily reached from Peru and Chile than from the highlands of Bolivia. The Chileans turned their attention largely to the Bolivian province of Antofagasta, where their influence became so marked that it is said not more than one person in twenty was a Bolivian, and that one probably an officer in the army. Important concessions were granted by Bolivia to Chilean inter-

General view of an *oficina* and its surroundings. In the foreground is rich nitrate land. The white in the distance is a *salar*, where no caliche has been found.

ests, and in 1874, in return for the cancellation of a debt owed Chile, Bolivia agreed not to impose any export tax on nitrate for twenty-five years. Four years later, however, attempts were made to levy a tax of ten cents per 100 pounds on all nitrate exported. When the Chilean companies refused to pay the tax, the Bolivian authorities seized their property and declared that it would be sold. Chile was forced to step in to protect the interests of her citizens. Since Bolivia had entered some years earlier into a treaty with Peru against Chile, Peru also was dragged into the quarrel, the result of which was the beginning of war by Chile against both Peru and Bolivia in 1879.

It was an epoch-making conflict in which Chilean naval successes against Peru were largely responsible for the outcome. The treaty of peace, signed in 1883 found Bolivia driven out of her seacoast province, Peru deprived of her nitrate lands, and the Chilean boundary pushed more than four hundred miles northward. In some quarters the impression is common that the treaty provided for a return of the nitrate areas to Peru, if after ten years the people of the region should so vote. Such a provision was applied to the province of Tacna, and has been ignored by Chile, but Tarapacá, with its great nitrate resources, was handed over "forever and unconditionally" (perpetua é incondicionalmente). It was predicted then that possession of the nitrate lands would ruin Chile, as guano and nitrate were believed to have ruined Peru, but this gloomy forecast has not been verified.

Since the war, and especially in the last fifteen years, a number of things have led to great progress in the nitrate industry. Foreign capital, English, German, Belgian, French, Austrian, and some from this country, has been added to the large investments made by Chileans. Thus more than £20,000,000 of English capital alone is tied up in

Loading caliche to be taken to the *maquina*. Piles of caliche at the left. The "camp," or laborers' quarters, of a neighboring *oficina* lies in the right background.

this business. Methods of manufacture have been improved, and the scale of operations has been increased greatly. New railroads have been built and old ones extended, until now there are about 2,000 miles of railroads, most of which have no other use than to serve the nitrate trade. But perhaps most important of all has been the vigorous campaign to advertise the merits of nitrate as a fertilizer. Tests have proved that nitrates are about the most effective fertilizer known for such crops as vegetables, sugar beets, and some of the cereals. To help increase the demand for this use particularly, representatives are maintained in every important agricultural region by the Chilean Nitrate Committee, and advertisements which are a part of this propaganda appear in agricultural journals in all parts of the world. Importations by the United Kingdom, Germany and the United States have been and still are increasing rapidly, while smaller amounts go to widely scattered markets.

The exports of nitrates in 1830 are said to have been about 8,300 tons. At the time of the Peruvian War, fifty years later, the amount had increased to 226,000 tons yearly—or less than the amount that two establishments might turn out now. Since 1880 the exports have reached enormous proportions. The million-ton mark was passed in 1890; almost a million and a half tons were shipped in 1900; and in 1911 the exports were but little short of two and a half million tons. To take care of this greatly increased demand, plant after plant has been built, until now more than 100 are in operation, several of which can produce in a month more than the whole exportation amounted to in 1830. Lands which were offered for sale a dozen years ago could not now be bought for ten times the figure quoted then. Shares of stock

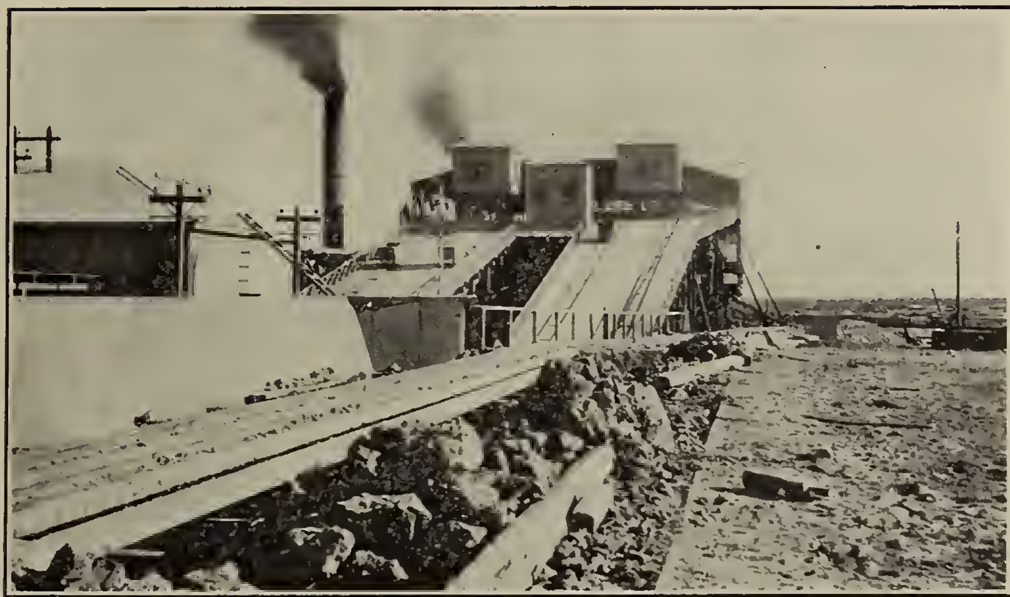
Dumping the caliche into the hoppers of the crushing machinery. Capacity of each car is about three tons.

of a par value of 25 pesos[1] not infrequently have paid annual dividends of 20 pesos, and stock dividends of 100 to 200 per cent. are not unknown. Under such conditions it is not strange that plants costing 5,000,000 pesos or more have paid for themselves in two or three years, and that nitrate shares are quoted at many times the amounts of paid-in capital which they represent. Thus in May, 1912, some quotations in Valparaiso were as follows:

Name of Company	Capital Paid in Per Share	Sales at
Agua Santa	10 pesos	340 pesos
Antofagasta	25 "	180 "
Boquete	5 "	130 "
Loa	1 "	67 "

Yet with all this enormous growth and prosperity, the process of production still is almost as simple as when the industry began. The first step is to make a hole about six to ten inches in diameter through the layer of caliche. Generally this is done with a chisel-edged, steel-pointed crowbar, or *barra,* the débris being removed from the hole with a home-made spoon-like affair, the *cuchara.* The bottom of the hole is enlarged so that a charge of powder may be put under the caliche. Most of the powder is made locally from nitrate, charcoal or coal dust and sulphur, for here it is so dry that the nitrate can not absorb enough water to make it unfit for powder. The explosion of the charge, the *tiro,* heaves up the caliche, commonly in blocks which must be broken

[1] Unless stated otherwise all money values are expressed in Chilean pesos, paper currency, at the rate of 1 peso equals about 21 cents in United States money.



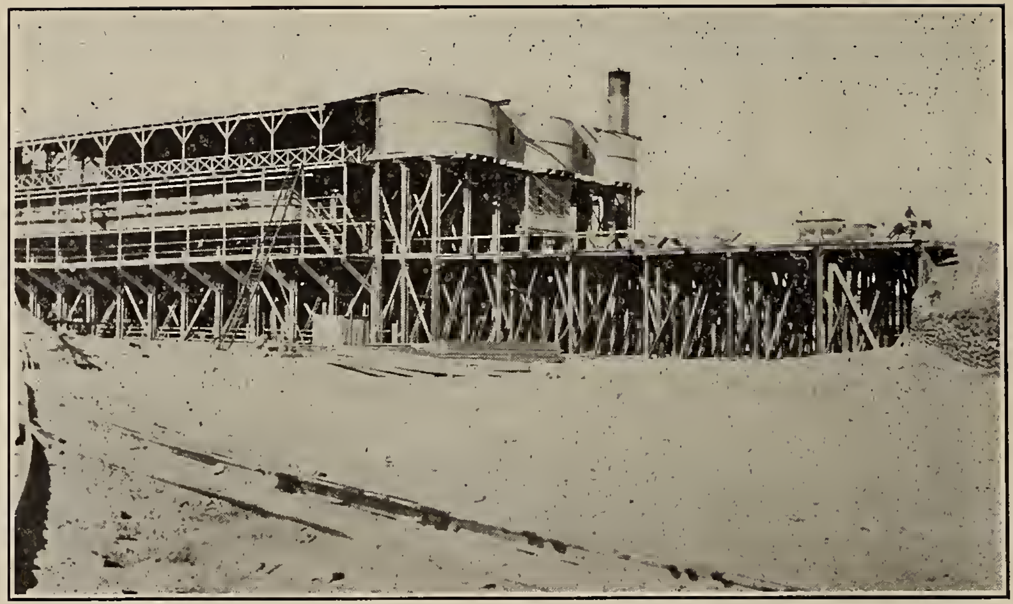
Cars of caliche, after crushing, going up the inclined planes to the *maquina*. Empty car comes down as full car goes up.

into smaller pieces with a heavy hammer. This is the process of nitrate mining. No operation could be simpler.

If the miner works by the day, he is known as a *barretero*, literally a "crowbar man." If he is paid according to the amount of caliche mined, as the most energetic prefer to do, he is a *particular*, or private worker. The former earns about 6 pesos to 7 pesos a day, while the latter, under favorable conditions, often makes 9 pesos to 12 pesos a day. A group of *particulares*, working early and late, quickly dispels any idea that no people of that part of the world will work hard.

Carts or trains of small dumping cars carry the caliche to the *maquina*, as the refining plant is called. Here it is first crushed into pieces no larger than a man's fist. From the crushers it goes up inclined planes to the boiling tanks, or *cachuchos* as they are still known, though earthen pots have been replaced by great iron affairs 32 feet long, 9 feet wide and 8 feet deep, capable of holding 70 tons. The newest maquinas have twenty to thirty of these tanks. When the charge of caliche is in, water is added, steam is turned into a coil of pipes which runs around inside the tanks, and the boiling process begins to dissolve out the soluble nitrates from the insoluble and worthless earthy substances. Thus the industry, which in one respect owes its existence to absence of water, must have water in order to operate, for nowhere are there large amounts of caliche rich enough to ship without refining, and the process of leaching is the only economical method of refining.

Much Australian and English coal, costing 35 pesos to 50 pesos or more per ton, is used to generate the steam. About half a million tons of coal have been imported for this purpose in recent years; but the



The *maquina*, showing the ends of the *cachuchos*, at the left of the ladder; the tanks for water; and at the right a mule car carrying away the *ripio*.

possibility of substituting California petroleum, already used to some extent, is being considered seriously by many operators.

To get water for the maquinas is not everywhere easy, for the water supply always has been the chief problem in this region. Seacoast towns for a long time depended on supplies brought by vessels from four or five hundred miles farther south. It is interesting to note here that one of the prominent figures in the development of the industry after 1880 was an English iron worker, who is said to have come out to Chile to work on the tanks or boilers of some of these water-carrying vessels, and who later went home a "nitrate millionaire." The first railroads had trouble getting water for their engines, some resorting to the distillation of salt water, but now, for the railroads and the chief cities and towns, piping of water 100 to 200 miles from the Andine streams has relieved the situation greatly. Water, however, still must be used sparingly and almost everywhere the poorer people buy it by the pailful, a discarded kerosene tin generally serving as a pail. A common price is 10 centavos (= 2 cents) for five gallons. In the pampa, wells yield a good deal of water, commonly more or less salty, but this source can not be counted on everywhere. Thus in central Antofagasta one plant secures more than 35,000 gallons of water daily from three wells, the deepest of which is less than 100 feet, but another plant, less than a mile away, found no underground water after spending 250,000 pesos in the attempt.

After the water in the cachuchos has boiled for several hours, it is passed to another tank where it encounters fresh caliche, and so on, until a saturated solution known as *caldo*, or broth, eventually is secured. When this point is reached the water is run off to a series of

The crystallizing tanks. Refined nitrate in the tanks in the foreground; tanks recently filled with *caldo* in the background.

tanks, known as *chulladores,* where the use of wheat flour, stable manure, or other substances, causes the precipitation of the miscellaneous soluble impurities, except ordinary salt, which have been dissolved out with the nitrate. From this purification process the solution goes to the crystallizing tanks, or *bateas,* which are placed ten or twelve feet above the ground to permit free circulation of air and promote cooling and evaporation. Thus dryness which figures in the origin and preservation of the caliche also has an equally great value in the process of manufacture. As the solution cools and the water evaporates, the nitrate begins to crystallize on the surface, so a "stirring boy," or *rayandero,* is employed to break up the film and make it settle. Five or six days are necessary to complete the crystallizing process. A large plant may have 300 or more bateas, capable of holding more than 1,000,000 gallons of caldo, and yielding at each full charge as much as 2,500 tons of nitrate.

When crystallization has gone as far as it will, a valve in the bottom of the batea is opened and the liquid is drawn off, leaving behind a thick layer of glistening white crystals. This is the nitrate or *salitre* of commerce, being 95 per cent. or more of pure nitrate of soda; the remainder is largely water and salt. The liquid which is drawn off, known as *agua vieja,* or mother liquor, still contains a large amount of nitrate in solution, and is used over and over again in the boiling tanks. In fact, no water is ever thrown away, the only loss being that which passes into steam from the boiling tanks and evaporates from the crys-

Photograph loaned by Mr. C. E. Atwood, Antofagasta, Chile.

Nitrate in the *cancha,* being bagged and put on cars for shipment.
In the left background, a big accumulation of *ripio.*

tallizing pans. The finished nitrate is shoveled from the bateas into cars, drawn to the deposit, or *cancha,* and there after drying for several days is bagged ready for shipment. Shipment in bulk is impracticable because the nitrate so readily absorbs water. Even when shipped in sacks it sometimes becomes caked in the holds of ships and has to be taken out with picks.

From the agua vieja, iodine is extracted by a simple process of precipitation with chemicals (mainly sodium sulphites). It figures only as an important by-product of the industry, for the "iodine trust" makes an annual allotment to each establishment, commonly less than what could be made in a month, if there were no restrictions on production.

The only other important step in the refining of nitrate is the clearing and recharging of the boiling tanks. First, fresh water is run through to take out what it will of the remaining nitrate, this water being used subsequently, with aqua vieja, in the boiling process, for the more nitrate in solution at the outset the easier it is to get a saturated caldo. After the washing is over, a trap in the bottom of the tank is opened and the waste, or *ripio,* is removed. This process is the most bothersome in the industry, because for each charge of 70 tons of caliche, 50 tons or more of ripio must be removed. It is very hard on the men who work in the steaming hot tanks, and the disposal of the waste after it is removed, not uncommonly 1,000 to 2,000 tons a day, soon comes to be a problem. None of the operators succeed in getting much more than 75 per cent. of the nitrate originally in the caliche, hence ripio commonly contains 4 to 10 per cent. of nitrate, and the great piles con-

Residences of the manager and his assistants, from the "plaza."

taining millions of tons of waste some time may be reworked if conditions in the industry should make economies necessary.

A good deal of capital is needed now to start the nitrate business on a large scale. Many of the older *oficinas,* as the establishments are called, are small, representing an investment of not more than 25,000 pesos to 50,000 pesos. But a large modern plant may cost 6,000,000 pesos or more. For this reason the industry tends to remain in the hands of companies, about 80 in number, of which a few large ones really dominate the industry. In all there are about 160 oficinas in existence, English, Chilean, Austrian, German, etc., but for one reason or another not all of them are being operated. Exhaustion of the supply of caliche is the most common reason, for as a general rule an oficina is built for a given tract of nitrate land, with the idea of abandoning the oficina when that supply is exhausted. It does not pay to haul caliche any considerable distance, for a ton of average caliche will yield only about 30 pesos' worth of nitrate, on which the profits may be 10 pesos. There are only one or two "Yanqui" oficinas, the "powder trust" being interested in at least one of these. United States capital invested in western South America seems to have been attracted more strongly by other kinds of mining.

A modern oficina, like the Aníbal Pinto, in central Antofagasta, running twenty-four hours at full capacity, may have a daily output of 5,000 Spanish quintals (quintal = 101 pounds) of nitrate. The cost of production in May, 1912, at this plant, was stated to be about 2.50 pesos per quintal, covering everything up to the time of shipment. To this figure must be added the transportation charges to the vessel in Antofagasta harbor, about 1 peso per quintal, and the export duty of 2.50 pesos per quintal, making total costs on board vessel 6 pesos per

Part of Taltal harbor and city, with typical appearance of Coast Mountains.

quintal. At that time the selling price, on board ship, was 7.50 pesos to 8 pesos per quintal. Under favorable conditions, therefore, this oficina could market about 2,000,000 quintals a year, with profits amounting to 4,000,000 pesos. This particular oficina cost more than 6,000,000 pesos, but with the trade good, it would pay for itself in two years and give annual dividends of 10 per cent. at the same time. About five and a half square miles of nitrate lands have been set aside for the Pinto, a supply calculated to keep it going for twenty years, in most of which time the plant has nothing to do except pay dividends. The making of nitrate millionaires, therefore, is easy to understand.

The construction of a modern oficina uses supplies from widely separated places. Most of the buildings are of corrugated iron, for it withstands the intense dryness better than wood does. It commonly comes from Europe. The timber which is used is likely to be Oregon pine, for it is strong, durable and about as cheap as the Chilean product. German steel for tanks, cement from the United States, boilers from England, Belgian locomotives to haul the tiny cars and United States electrical equipment are found at one oficina.

Most of the laborers are Chileans, Peruvians and Bolivians, attracted there by the higher wages than are to be had elsewhere in most other pursuits. In fact, the complaint is often made that the nitrate industry has retarded development of other activities in Chile, especially greater agricultural progress in the south, by absorbing not only the capital, but the labor as well. About 40,000 persons are said to be employed directly in the oficinas, some of the larger of which have more than 1,000 hands each. Wages run from about 3 pesos to 4 pesos per day for boys and 6 pesos per day for the poorest paid men, up to as high as 15 pesos for some of the men working in the maquina. Per-

Shipping in the harbor at Antofagasta. Note the line of surf.

haps 10 pesos is a fair average for the majority. Houses are provided by the company, but heat, light and water must be paid for by all except salaried employes. This latter class, including the manager, or *administrador,* and his subordinates, the engineer, bookkeeper, chemist, electrical expert, etc., are given their quarters, heat, light *and water,* in addition to salaries that range from 1,000 pesos up to 4,000 pesos a month.

Though wages and salaries appear high in units of currency, the prices of food stuffs also are necessarily high, since next to nothing can be raised anywhere in the nitrate region. Some prices charged in company stores are as follows: flour, 20 pesos per quintal; beans, 30 pesos per sack of about one bushel; eggs, 6 pesos a dozen; coal, 6 pesos for about 100 pounds. Only canned milk can be had, for there is no way of keeping cattle in this barren land. All cuts of meat are 50 cents per pound, and the rule of "first come, first choice" results in the formation of a "meat line" early every morning. A good many of the cattle used here come overland from Argentina. Kerosene from the United States costs about 1 peso a gallon, but the tin in which it comes also must be considered, since it serves a multitude of uses from waterpail to roofing material and baking oven. Potatoes are commonly sold by the half *robo,* which equals about a half bushel, but the natives are fond of explaining, with a significant gesture, that *robo* also means robbery.

The laborers generally are paid not in money, but in *features,* discs resembling poker chips and bearing the company name, together with the equivalent value in actual currency. These features are used almost solely at the company stores, but if any workman desires his wages in money he may draw at any time all that is due him. For the salaried

The plaza of Antofagasta, with the barren Coast Mountains in the distance. The clock tower was the gift of English residents on the centenary of Chilean independence.

employees, the pampa looks like a good place to save money, since food is about the only thing he cares to buy in the local stores. Some of the larger coast towns have fairly good stores, but Valparaiso is the nearest real "spending place," and to get there takes four days to a week. The mail-order business, however, is said to thrive here mainly because of these very conditions, with disastrous results to the saving habit.

Large oficinas, with their many hands and the families, may make communities of 2,000 to 3,000 persons. Schools are provided by the government, the teachers getting 150 pesos to 200 pesos per month, to which some companies add 100 pesos or more, in addition to the customary free quarters, heat and water. Priests and physicians make regular visits. Musical and social clubs are organized; bands give open-air concerts two or three times a week, and worse music may be heard in many more favored parts of the world. Football is a favorite sport and there is keen rivalry between teams representing neighboring oficinas. There is the inevitable biograph, a dance hall, annual visits by a circus, a saloon and even a gambling house, for since the men will gamble anyway, it is deemed best to have it done where some control may be exerted over it. Little trouble ever arises, for the resident manager is in some ways a local czar, with the very efficient mounted police of the pampa to assist in keeping order.

It is sometimes claimed that the laborers are exploited outrageously by the companies; that two prices are the rule in the company stores, the higher price always being for the laborers; that buying outside is almost or quite impossible; that they are assessed for medical service which they never need, and so on. It is also pointed out that although provided with houses, the living conditions among the laborers are

The main street of Antofagasta, from the corner of the plaza.

decidedly primitive, especially as regards sanitary arrangements. It is quite true that the camp commonly is placed where the wind will not carry the odors to the houses occupied by the manager and his subordinates. But in the bright sun and dry air of the desert, most disease germs do not thrive, and there filth, unpleasant as it may be, does not lead to the sickness which it might cause elsewhere. In order to get some return from the monthly assessment of a peso for doctor's services, so it is said, the people commonly feign illness, until the free medicine is received, whereupon the medicine promptly is thrown away. There probably is some truth in all the claims that the lot of the nitrate workers is not everything which could be desired, yet it is undeniable that they are better off than a good many of their own countrymen who are working elsewhere.

Living in the nitrate pampa has some compensations, as in the feelings inspired by the desert and especially in the beauty of its nights, but not even the mighty Pacific can lend charm to the seaports which act as middlemen between the oficinas and the outside world. Iquique, Antofagasta, Taltal, Chañaral, Mejillones, Pisagua and Tocopilla, ranging in population from 50,000 down to 5,000, suggest mining towns of our far west in varying early stages of evolution. Some of the foreign residents profess to find enjoyment there, as in a morning plunge in the ocean and a brisk canter along the beach, and with the clubs later in the day, but all too commonly the pleasures take the form of hard drinking as the only way of varying the painful monotony of existence. Iquique, the largest, generally is regarded as somewhat better than the others, but one who visits the others first is comforted mainly by the feeling that it must be hard to find anything worse.

A picture of one of these ports does almost equally well for all the others. A crescentic indentation in the coast is called the harbor, for want of any other name. All vessels must anchor far out, owing to shallow water, the presence of reefs, or entire lack of docks. Cargoes are lightered to and from shore, while passengers run the gauntlet of the boatmen, or *fleteros,* and the surf, both of which at times are rather unpleasant. Protection for the vessels is poor in most cases, but fortunately storms are not frequent along this coast. Around the harbor, barren, colorless mountains rise to heights of 2,000 feet or more, and at their base lies a featureless town sprawled over a narrow, flat or sloping shelf. Within the town, wide, unpaved, dusty streets are lined with frame houses in varying degrees of dilapidation. Here and there one may catch a glimpse of some carefully watered plants or even a tiny patch of grass in a private "garden," and the main plaza of the town is sure to have some highly prized and proudly exhibited palms and other plants. But for the most part there is nothing to relieve the impression of dinginess and dejectedness that hovers over the place. Dirty hotels are crowded with patrons of a dozen nationalities, for all who come and go must use the only accommodations offered. For a time, the busy waterfront, and perhaps seals in the harbor, prove interesting, but even these quickly prove boresome, since every lighter piled with sacks of nitrate is like every other lighter, and after the seals have bobbed up a few hundred times, only to disappear as often, it ceases to be a novelty. Waiting for a steamer, the only means of escape from these ports makes one wish he had staid in the pampa, where the world seems big and less forlorn.

Ships of many nations come to carry away the nitrate, while many coastwise vessels bring supplies from the fertile valleys farther south. Nearly half the oficinas operating in 1912 shipped their product through Iquique, giving this port more nitrate traffic than is carried on by any other two ports combined. Antofagasta and Tocopilla are next in order. The value of nitrate exports is more than 70 per cent. of the total value of Chilean exports, and its tonnage is as great as that of any other South American export. As the nitrate goes out, the Chilean government levies an export duty, just as Bolivia tried to do when Chile took up arms on that account. The export duty sometimes is regarded as a device for checking overproduction, whereas it is simply an effective means of raising revenue for the national treasury. For a long time nitrate duties and proceeds of sales of nitrate lands have amounted to more than half, and in some years to not less than 85 per cent., of the total national income. These revenues alone represent more than ten dollars per capita or as much as the United States government spends from all sources of income. It is easy to see, therefore, why Chile often is charged with extravagance. Yet large sums have been employed wisely in the building of state railroads; something has been done, and much more is now being undertaken, to improve port facilities, especially at Valparaiso; and much of the money has been used in building up an army and navy to insure Chilean leadership and prestige among the West Coast countries. It is estimated that in the thirty years following 1880 the total revenue from nitrate duties has been more than $300,000,000 (United States gold), while with the present rate of production and the same tax continued, the next twenty-five years will give Chile nearly $750,000,000 (United States gold) more.

One check on overproduction may be exerted through a law providing that government nitrate lands are open to exploitation only after such lands have been disposed of at public auction. But, at the same time, this law has tended to check individual effort in exploring thoroughly the limits of the nitrate deposits. Another check on overproduction has been the "nitrate trust," or *Combinación Salitrera,* an agreement, entered into in 1901 by the larger companies, concerning the limitation of annual output and its allotment among the different oficinas. For a number of years prior to 1909 the trust worked well, but since then, despite all efforts to keep them in line, a good many companies have limited their output only by the maximum capacity of their oficinas. As an official of one of the largest Chilean companies aptly said: "There is no need for agreements when the demand is so heavy and the prices so good. If the price goes down—well, perhaps agreements can be revived then."

The nitrate business is so vital to the northern provinces of Chile, and even to the whole country as it is now organized, that the future of the industry has been a question of much concern. Some believe that the opening of the Panama Canal, with the resulting shortening of voyages from Iquique and Antofagasta to the United States, United Kingdom and Germany, will stimulate the commerce in nitrate very materially, for those three countries now take about 80 per cent. of the exports. Optimistic prophets, noting also the increasing popularity of nitrates, forecast a new era of greater prosperity than ever before. The more pessimistic, on the contrary, foresee the speedy exhaustion of the nitrate supplies and a crisis for Chile unless adequate preparation is made for the inevitable readjustment.

Most estimates of the available supplies of nitrate range between about 70,000,000 and 100,000,000 tons, which at the present rate of production would insure the life of the industry for thirty-five to forty years. Some estimates, however, place the amount as high as 200,000,000 tons. The totals given are about equally divided between Tarapacá and Tacna on the one hand, and Antofagasta and Atacama on the other. Private lands, however, are estimated as covering more than half the total, though it must be remembered that the state lands are less well known. The smaller estimates make little or no allowance for discoveries of new nitrate deposits, which is quite likely to happen, nor do they count on any improvements in processes of manufacture, which very readily might prolong by many years the duration of supplies now known. It also is possible that ripio, nitrate-bearing costra and low-grade caliche, thrown aside in the past, may be worked profitably in the future. Should all these things develop favorably, the nitrate industry could thrive for a good many decades to come. Otherwise its span of existence is not likely to extend much beyond the middle of the century, for increased production, which is entirely probable, must hasten the end.

Another possible "rock ahead" for the business has been found by some people in the production of nitrates from atmospheric nitrogen by an electrical process. Where water power is abundant and cheap, nitrates from this process can be made to compete with the Chilean product. It is being done now in Norway. But for most parts of the world which have large water-power resources the use of this power will be more valuable for other purposes as long as Chilean nitrates continue to be abundant and reasonably cheap.

It has been suggested that when the nitrate is exhausted irrigation may turn the pampa into a highly productive farming region. This may be possible for limited areas, but from what is known of the water supplies available it seems unsafe to look for any extensive agricultural development. Exhaustion of the nitrate apparently means a general decay of the region unless other mineral resources are discovered and developed. It means for Chile the loss of $100,000,000 (United States gold) in annual exports and $30,000,000 (United States gold) of government revenue. For the world it means turning to some other source of nitrogen for supplies to fertilize its crops. Happily the way already is open for the latter change.

THE POWER OF GROWTH IN PLANTS

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IT has been a matter of more or less common observation from time immemorial that plants possess the power to overcome obstacles. Some species of trees are not particular where they grow if there is enough soil and moisture, their roots often seeking places where apparently insurmountable obstacles must be overcome. In spite of the doubt often expressed, there are on record many cases of trees lifting large weights; and in mountainous regions large boulders are often found displaced by roots growing among them. Some trees even lift themselves slightly from their original positions into the air, as is evident from the location of the root buttresses, which are often found exposed above the surface, sometimes for a considerable distance. An instance is known of a tree growing in the center of a millstone, which later completely filled the hole and actually raised the stone from the ground.

Brick and concrete sidewalks are often ruptured and curbings displaced by roots, due to their growth in diameter, and perhaps in some cases to the actual uplift of the tree trunk and roots. The writer has had under observation for many years a black birch (*Betula lenta* L.), one root of which has entered a fissure in a large boulder and is slowly but constantly lifting this enormous weight. The fissure is at an

FIG. 1. Showing large black birch (*Betula lenta* L.), one of whose roots is lifting an 18-ton boulder.

angle of about 15 degrees. The vertical diameter of the root where it enters is only 4 or 5 inches, while its lateral diameter, owing to compression, is 18 or 20 inches, or more.

Careful measurements and specific gravity determinations would indicate that the weight of the boulder is about 18 tons, and this is annually being lifted higher and higher by the root growing in the crack.

The roots of trees often penetrate, and, as they grow, displace the foundation walls of buildings. We recall an old, heavy-timbered

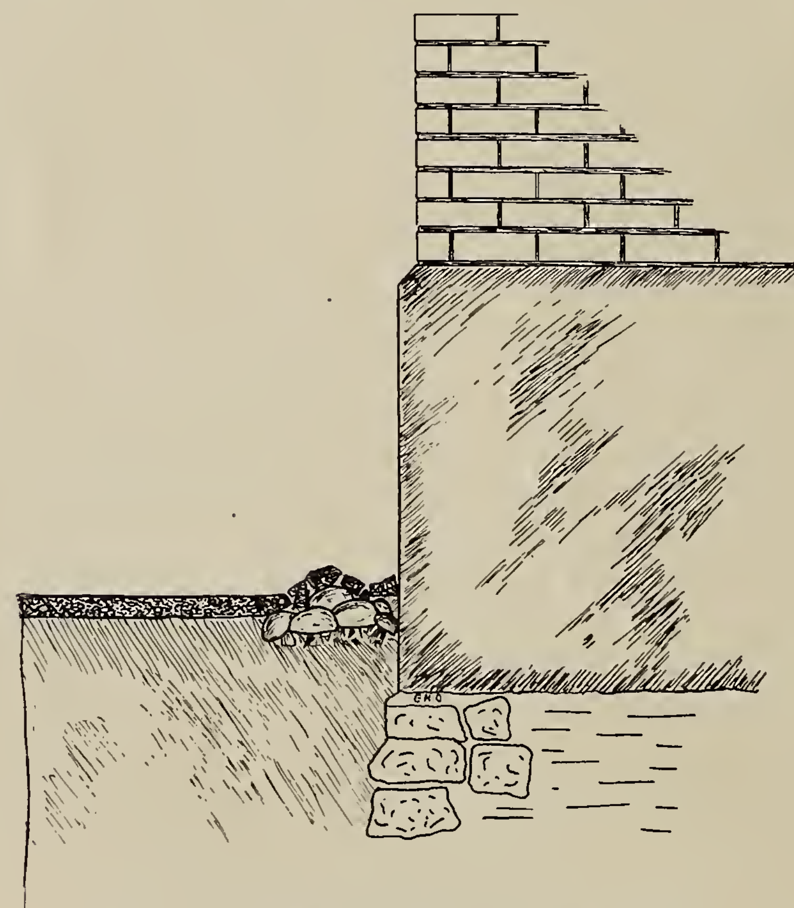

Fig. 2. Showing mushroom rupturing concrete.

colonial house which had one corner thrown considerably out of the vertical by the growth of tree roots under the foundation. In this case the roots must have lifted many tons in weight. In another instance a gentleman noticed that the stone in a walk leading to his residence had been displaced. He became alarmed and sent for the police, laboring under the impression that burglars were responsible for the displacement and were planning some deep plot against him. But on moving the stone, which weighed 80 pounds, three large mushrooms were discovered and the mischief was explained. Instances are known of mushrooms pushing up through hard tar walks two or three inches thick without the slightest difficulty or evidence of injury to their delicate tissues; and even seedlings often displace comparatively large masses of soil in pushing up through.

For several years we have been observing the rupturing of very hard concrete by ostrich ferns (*Onoclea Struthiopteris* L.). The concrete, which is two and a half to three inches thick and composed of sand, tar and coarse gravel, acts as a watershed next a dwelling house. Along the edge ostrich ferns were some time ago planted in loam rich in organic matter, and have since been growing most luxuriantly, the stalks often reaching a height of six feet or more. Like most ferns, the underground stem or rhizome spreads out in all directions each year and thrusts up new fronds; and quite regardless of the apparently impenetrable covering, the rhizomes work their way under it and attempt to throw up new shoots. And not in vain, for the ferns appear to break through the concrete as easily as though it were so much putty. This rupturing occurs almost every spring when growth is active and the fronds unfolding. Sometimes the concrete is broken up where it joins the underpinning of the house and where it is more easily dislocated, and again the ferns come up through the middle.

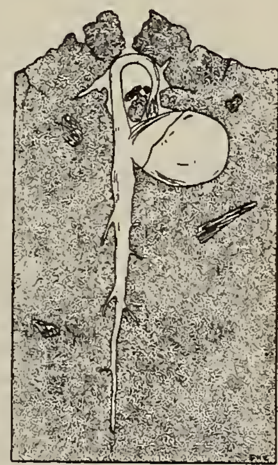

FIG. 3. Showing epicotyl of seedling bursting through the soil.

FIG. 4. Showing young fronds of ostrich ferns (*Onoclea Struthiopteris* L.) rupturing concrete.

The fronds which push themselves up through the concrete are necessarily more backward in unfolding than the unobstructed ones, although as a rule it requires only a week or ten days for them to break through. It required two years for one group of fronds to come through, though, as was evident from the constant upheaval of a part of the concrete one spring; but the next spring they succeeded in their attempt. The ease with which this breaking through is accomplished and the freedom of the ferns from scars and injuries are remarkable when the solidity of the concrete and the force needed to rupture it are taken into consideration.

Being interested in this phenomenon, we endeavored to learn approximately the power required by the ferns to rupture the concrete. In the experiment, some of the soil underneath was first excavated and a lever arranged in such a way that force could be applied in practically the same manner as was done by the ferns, *i. e.*, a round piece of wood was placed on the end of the lever of the same dimensions as the undeveloped cluster of fern fronds. The fulcrum of the lever was one foot

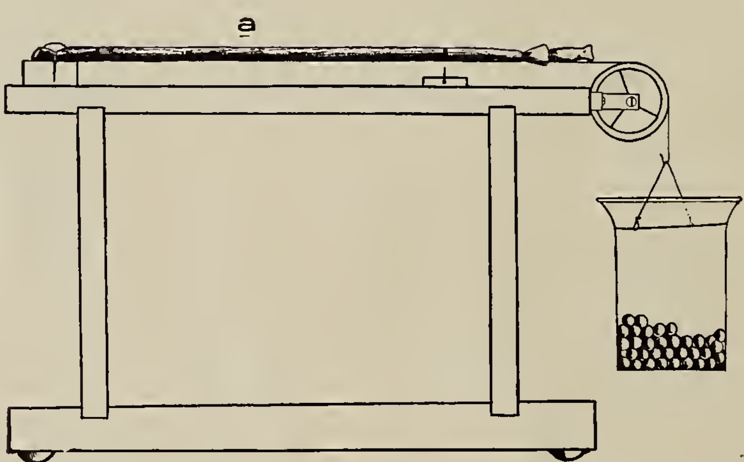

Fig. 5. Showing method of demonstrating power of growth. Growing flower stalk of tulip placed in 10 per cent. solution of potassium nitrate, which causes the stalk to shorten. The stalk is then stretched to its original length and the power of growth determined.

from the point of contact with the concrete, and weights were placed on the other end of the lever at different distances, as the case required. Our object in this test was to ascertain how long it would take to rupture the concrete and to determine the amount of weight necessary to do it. It was not intended to apply force enough to cause an immediate rupturing of the concrete, or even in a few hours, but in perhaps ten or fifteen days—the same length of time usually required by the ferns. A number of tests were made, care being taken to have all the conditions as nearly like those under which the concrete was broken by the ferns as possible. A weight of 699 pounds broke the concrete in a few hours. Next a weight of 262 pounds was applied, which required ten days, while in still another test a weight of 189 pounds broke through in thirteen days. Other tests were made, but it is not necessary to give them here. A weight of 189 pounds, therefore, seemed to rupture the concrete in about the same time as was done by the ferns; and in our estimation this test represents a fairly good duplication of the fern phenomenon. If we consider the average cross section area of the six fern fronds and divide this by the total weight lifted, we find that the cells of the young fronds exerted about 35 atmospheres to overcome the resistance offered by the concrete. This we consider a very fair estimate, although from our other experiments we are led to believe that as high as 50 atmospheres are sometimes required to accomplish the work with the conditions under which the ferns were growing. The concrete was so hard that after it had been ruptured it was impossible to make any impression on the ragged edges except by the use of tools. The work was done by a slow and constantly increasing pressure on the under surface of the concrete, the principle being somewhat the same as in the straightening of teeth and bones, although in such cases the pressure is not increased.

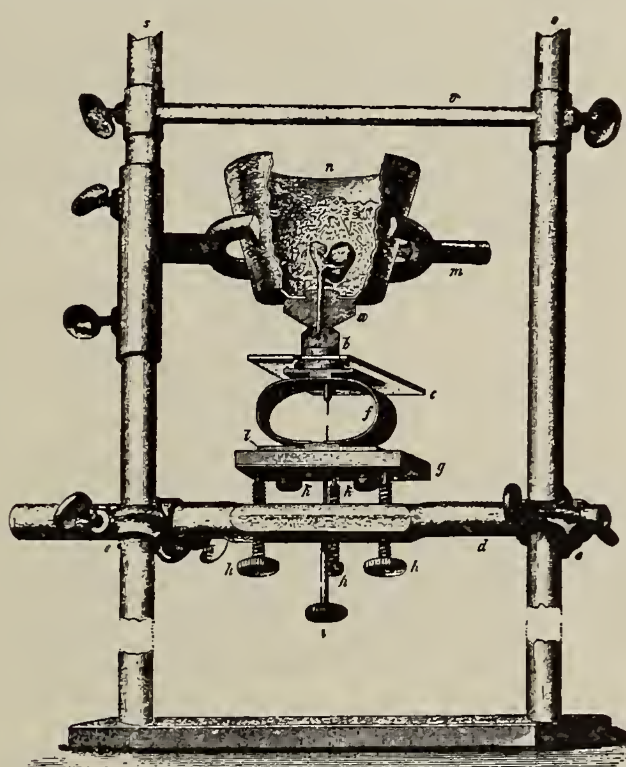

FIG. 6. Method of determining the longitudinal power of growth in roots. The roots are held firmly in two plaster of Paris casts, and the amount of pressure indicated by the spring. (After Pfeffer.)

At this point we might consider what growth is and how it is accomplished in a plant. Growth is defined as a stretching and fixation of the cell walls, accomplished by osmotic pressure characteristic of the solutions contained in the cell vacuole. In ordinary growth there is a pressure of 1 to 3 atmospheres on the cell walls—a fact which can be determined experimentally with some degree of accuracy. It is this pressure which gives plants their rigidity and freshness, and anything which destroys it, such as lack of water, causes the plant to wilt. Rapidly growing organisms—annuals and herbaceous plants, for instance—contain little mechanical or supportive tissue, and it is owing to the turgidity of the cells derived from osmotic pressure that they are able to hold their leaves and other organs in position. This could not be done without the exertion of considerable pressure, for their delicately constructed leaves and other organs often assume positions requiring a great deal of support. In trees and shrubs there is a large amount of mechanical tissue which supplies the necessary means for supporting the various members.

What is termed the "power of growth" can be determined by learning the amount of weight required to stretch a rapidly growing stem to its original length after the turgidity of the cells has been destroyed by placing them in plasmolyzing solutions, such as a 10 per cent. solution of potassium nitrate. The mean area of a cross section of a stem in millimeters, divided by the amount of weight obtained in grams, gives the number of grams per square millimeter of surface, and, as previously stated, there is usually obtained by this method a pressure of one to three atmospheres or more in the cell for ordinary growth.

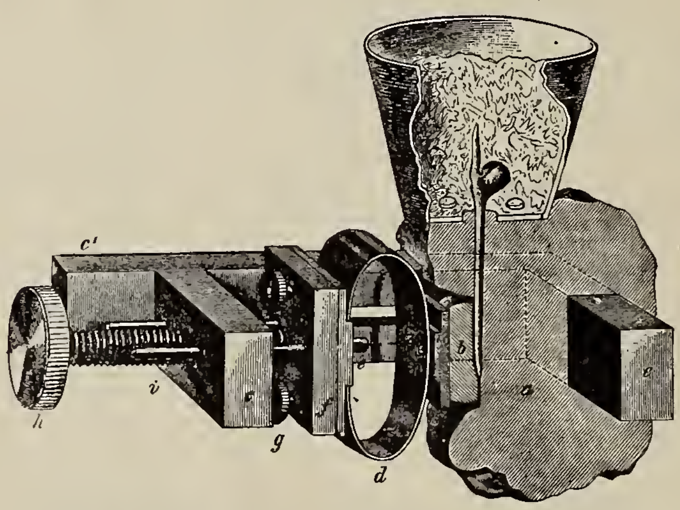

FIG. 7. Method of determining radial pressure of growing roots. (After Pfeffer.)

While this osmotic pressure is common in ordinary growing organs, it does not necessarily follow that it constitutes the limit, since in the case of the ostrich fern previously referred to it was much higher. When growth is mechanically restricted or the organism has obstacles to overcome, the cell turgescence or osmotic pressure may be greatly increased owing to the resulting stimulus, and this is what occurred in the case of the ferns.

If a cross section of a stem is made and the bark split vertically, a noticeable shrinkage of the bark takes place, demonstrating a difference in tension between the outer and inner tissues. On the other hand, if longitudinal slices are taken from the outside of a common sunflower stem, they will shorten from 1 to 4 per cent. of their length, while the tissues from the center of the stem (pith) will lengthen from 1 to 6 per cent. when removed. It is clear from these observations that the various tissues of the plant are under tensions which may exhibit differences equal to 12 atmospheres or more. What is termed the "shearing stress" often becomes so great that the resistant cell walls are ruptured, a condition associated with great pressure in living cells. The injection of poisons into trees may likewise cause a rupturing of

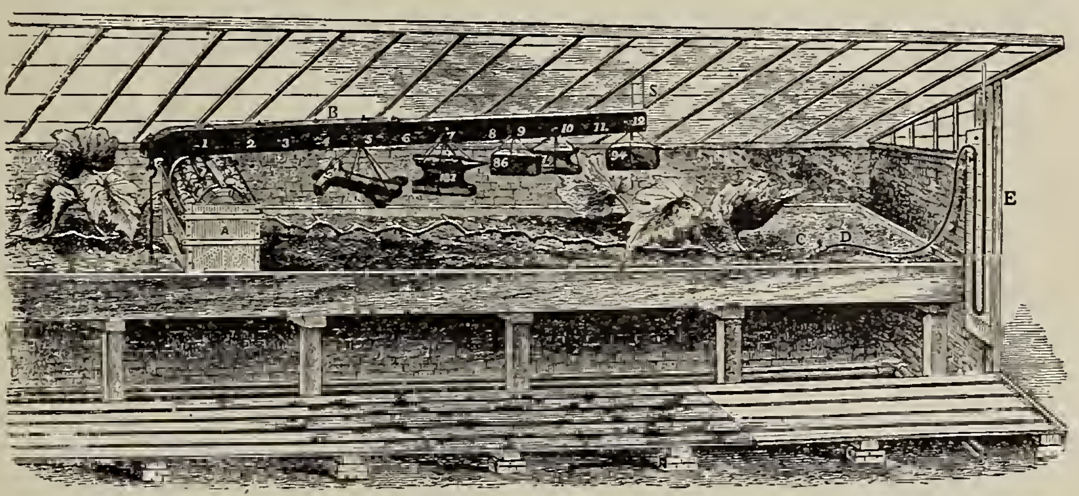

FIG. 8. Showing squash in harness. A weight of 5,000 pounds was lifted. (After Clark.)

the tissues owing to changes in the turgescence of the cells, and the splitting of melons in the field sometimes occurs from the absorption of an excessive amount of water into the inner cavity of the fruit. This increases the turgescence of the cells lining the cavity, and modifies the existing tissue tensions. The skin of the grape often cracks, possibly from the same cause.

It has been shown that the mechanical restriction of growth acts as a stimulus, inducing an increase in the osmotic pressure of the living cells, and in like manner, increased tensions may result in a much greater strength of the organism. It has been observed, for example, by Hegler, that a young sunflower seedling having an original breaking stress of 160 grams was able to maintain 250 grams after it had been stretched by a weight of 150 grams for two days, and later stretching of the stem by means of suspended weights over a pulley demonstrated that in a few days more its tensile strength was increased to 400 grams. This increase is correlated with thickness of the cell walls, a greater elasticity and the development of mechanical tissue.

The stimulation induced by the contact of tendrils and hook plants with objects is similar to that caused by stretching by weights. Experiments with the roots of various plants enclosed in plaster casts have shown large pressures. Pfeffer obtained osmotic pressures in the root cells of a common horse bean ranging from 5 to 19 atmospheres when the growth of the roots in length (longitudinal pressure) was mechanically restrained by the use of plaster-of-Paris casts, and from 2 to 6 atmospheres for the radial pressure of roots. The geotropically sensitive nodes of the wheat stem gave a pressure equal to 15 atmospheres when mechanically restricted. The maximum osmotic pressure in these cases would be obtained by a solution of potassium nitrate equal to about 5 per cent.

Colonel W. S. Clark's experiment with the lifting power of a squash, made in 1874 at Amherst, was one of the first attempts to learn the growing power of plants. This experiment attracted quite a little

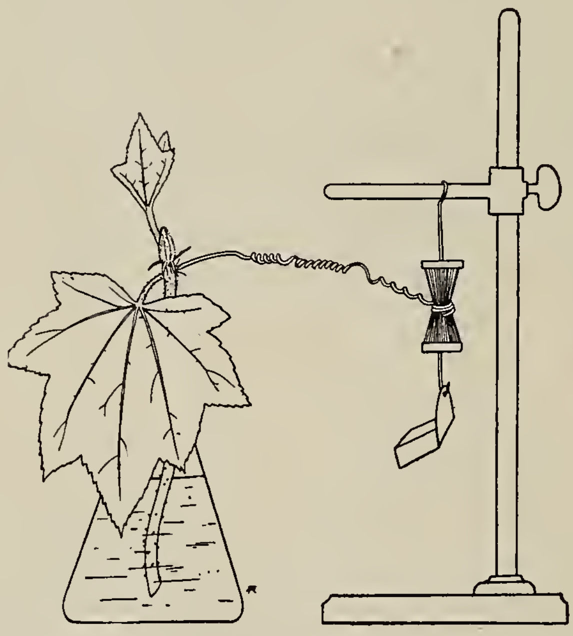

Fig. 9. Method of demonstrating clasping power of tendrils.

attention at the time. One highly respected minister of the gospel had a drawing of the harnessed squash distributed among his congregation in tract form to illustrate the great moral principle that "If God in his providence has given such enormous power to growing vegetation to overcome difficulties, how much more will he give to you power to overcome the difficulties that may be in the way of your reaching the true end of all living."

This experiment was carried on in a greenhouse under the most favorable conditions, and by arranging an iron harness provided with a lever attachment the squash was found to raise 5,000 pounds. The squash was horticulturally known as the Mammoth Yellow Chile variety, and at the close of the experiment weighed 47½ pounds. It is estimated that the squash developed over 80,000 feet, or about 15 miles of roots, an average of about 1,000 feet daily. From the data given in this experiment we have been able to estimate roughly the osmotic pressure of the cells, which might be supposed to be most active, but we have been unable to find that more than $2\frac{1}{2}$ atmospheres were involved. Professor Sachs, with the same data, estimated that the cell pressure developed was equivalent to a little more than one atmosphere.

Climbing and tendril-bearing plants, of which there are almost countless varieties, react to what is termed contact stimulation. Besides the many varieties which decorate our verandas and which are cultivated in our gardens for food, there are others with sensitive petioles (clematis and hook plant—*Uncaria*) which assist in anchoring the plant to supports. We have collected considerable data on the power displayed by tendrils and twining stems in clasping a support. Notwithstanding that the clasping results from the stimulation of the tendril, brought about by prolonged contact, the osmotic pressure does not ever appear to exceed the normal, only one to three atmospheres being found in these experiments. On the other hand, the effect of stimulation by contact in this case is to transmit the stimulus along the tendril, resulting in the formation of a spiral, and in most cases, if not all, the plant energy induced by the stimulus is directed towards the formation and modification of mechanical tissue, to render the union of the plant with the support more firm.

FIG. 10. Showing growth of tissue over street sign placed on tree. The growth is restricted only at one point. The sign acts as a constant stimulus, inducing the callus to grow over it.

The formation of mechanical tissue in a tendril is well illustrated in the tendril of the common grapevine, and in various hook climbers. At first the tendrils of the grapevine are quite delicate and even edible, but later they become extremely hard and wiry. It would manifestly be a waste of energy from the economic point of view for tendrils to develop excessive clasping strength by means of an increased cell turgescence or osmotic pressure, since the clasping strength resulting from the normal turgidity or osmotic pressure of the cells is sufficient to answer all requirements. On the other hand, the increased production of mechanical tissue or a modification in the elasticity of the tendril is obviously of great advantage to it from the biological point of view. What is true for tendril plants appears to be true for climbing plants, such as the bean, as well as of plants with sensitive petioles, since there is no loss of energy displayed in the development of a superfluous osmotic presure in the cells for the mere purpose of increasing its clasping powers.

THE ABSORPTION AND EMISSION CENTERS OF LIGHT AND HEAT.

By Dr. W. W. STRONG
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THE mechanical motions of nature are transmitted by solids and fluids from sources that consist of more or less well known mechanical systems. Waves on a pond may be due to a boat moving over the surface of the water. Sound waves in air may be due to the vibrations of a tuning fork. Wireless telegraph waves may be due to high frequency electromotive force and current waves in electrical circuits. In general the source of the above type of wave motion is a kind of mechanism that can be made in the laboratory or in the shop—a mechanism that is man-made and whose operation is quite obvious to us.

The phenomena of light and radiant heat introduce to us a type of wave motion that is altogether different. Not only may the medium that transmits this wave motion possess entirely different properties from that of matter, but the mechanisms that take part in the emission and the absorption of the wave motion are altogether different from any that we have been able to make in our laboratories. No one has succeeded in producing radiant heat, much less visible light and ultraviolet radiations by means of electromagnetic oscillators, although such a feat may be possible.

Inasmuch as matter is the source of all heat and light radiations, the mechanism responsible for the emission and absorption of these radiations must be intimately related to the nature and constitution of matter itself and therefore theories of emission and absorption systems depend to a large extent upon our theories of the nature of atoms and molecules. It must be remembered, however, that the nature and constitution of atoms and molecules that explain chemical and many other phenomena need not necessarily be at all related to the systems taking part in heat and light radiations.

In the past many different hypotheses have been advanced to extend the atomic and molecular conceptions of Dalton, Clausius, Maxwell and others. As long as the elastic solid theory of the ether prevailed, it was frequently assumed that the vibrating systems emitting light and radiant heat were of a mechanical nature due to the development of stresses and strains. The electromagnetic theory of Maxwell, while not even suggesting the nature of the mechanism, metamorphosed our views of radiant energy and indicated the whole phenomenon to be an electromagnetic one.

Black Body Radiations and Electron Atmospheres

Since the advent of the theories of liquid and gaseous ionization, many attempts have been made to construct a system composed of ions and electrons of various kinds that would be capable of explaining the phenomena of optics and radiant heat. In the case of black body or pure temperature radiations, the theory has been quite successful and seems to correctly describe the actual conditions. Solids or liquids are known to contain large numbers of electrons and when these bodies conduct metallically there is good reason to believe that the electrons move about in these bodies like gaseous molecules in a gas, the law of the equipartition of energy applying to an electron "gas" in a metal in the same way as it does to gases outside the metal. The emission of light and heat under these conditions is presumably due to the production of electromagnetic waves when the electrons are greatly accelerated or retarded in their motion. Laws of radiation like those of Wien and Planck can be derived from the conditions that would be expected to hold in an electron atmosphere. In this type of radiation the distribution of energy throughout the various wave lengths is practically independent of the kind of matter, but depends only upon the temperature and the nature of the electron atmosphere. Thus the radiation constants are universal constants depending upon one kind of radiating and absorbing system, the electron.

Selective Radiation and Absorption

Many sources of light and radiant heat emit radiations whose energy distribution over the various wave lengths is very different from that of a black body radiation. These radiations are selective and depend upon the nature of the body that is emitting or absorbing. Emission spectra illustrating this selective radiation are spark, arc, band and other spectra. Colored objects all show selective absorption. The problem of unraveling the constitution of the centers of selective radiation and absorption is a very difficult one and at present many efforts are being made to correlate the possible constitution of such centers with the ordinary molecular, atomic and ionic theories of matter. During recent years the trend of theory has been largely directed towards the view that emission and absorption spectra originate in systems that have a more or less momentary existence, owing to the fact that such optical systems are essentially dynamic in nature. It is very natural, therefore, that especial efforts should be made to find the existence of these momentary systems during periods of ionization and recombination of atoms, molecules, ions and electrons.

An Ideal of the Illuminating Engineer

The subject of selective emission and absorption is one of prime importance to the illuminating engineer. The rods and cones of the retina are selective absorbers of light. Any illumination should, therefore, be tuned to this selective absorbing mechanism of the eye. Under these conditions the illumination will be most pleasing and there will be a minimum amount of energy used in the emission of the radiation used for illumination. Naturally this kind of radiation will be a "cold" radiation and not a temperature one. It is represented in nature by the light from glow worms and fireflies and in laboratories, approximately, by various kinds of phosphorescent materials, the source of such radiation being at room temperature.

Definition of Emission and Absorption Centers

The problem of finding the constitution of the emission and absorption centers of selective types of spectra such as those of phosphorescent substances, sparks, arcs, flames, etc., is a very difficult one, and at present many efforts are being made to correlate the possible constitution of such centers with the various molecular, atomic, ionic and electronic theories of matter. Emission and absorption centers of light and heat are the smallest particles or entities from which one can obtain any given characteristic emission or absorption spectrum. A further division or change of the centers will result in making it impossible for the given spectrum to be emitted or absorbed although the resultant particles or entities may possess a characteristic spectrum of their own. From the definition it is to be noticed that the centers need not necessarily be matter, *i. e.*, possess mass. When the centers move with reference to the observer, their spectral lines and bands will show the Döppler effect.

Light centers seem to be very complex in their nature. Professor Rowland used to compare them to a piano and the work of Professor Wood upon resonance and fluorescent spectra indicate that the analogy is quite an appropriate one. Strike a key, *i. e.*, excite a vapor like that of sodium with monochromatic light and a whole set of harmonics will be set into vibration. In the case of sodium vapor, each series of lines or bands seem to be due to vibrations of systems that may be quite independent of each other. Apparently there are a large number of these vibrating systems in the light centers of the fluorescent spectra of sodium. The center itself may correspond to the atom of sodium, though at the present time no definite evidence has been brought forward to prove that the center is even of atomic magnitude.

The Problem of Light and Heat Centers

In the study of light centers, attention must be directed for a moment to the many and serious difficulties connected with the problem of determining the nature and constitution of these particles or entities. The conditions under which they exist are very different from the conditions under which we study the other physical and chemical units of matter. Then again, it seems that light centers have a comparatively enormous absorbing or emitting power, so that only a small part of the matter in a given region is concerned with the light and heat emitted or absorbed in the region. Light beams that are sufficiently intense to study are apparently emitted by a very large number of light centers and for this reason it has been found impossible to isolate individual centers; and even if this were possible it may be that the life of these centers is so short that even the isolation of centers would not permit their being studied. Then again, light emission is usually accompanied by many intricate phenomena such as ionization and chemical reactions and this adds to the complexity of the problem. When we consider our profound ignorance respecting even the nature of chemical forces, the constitution of the molecule and atom, the nature of the electric and magnetic fields and even the nature of light itself, it is not at all remarkable that little definite and certain knowledge has been obtained concerning the nature of light centers.

Some Methods of Approaching the Problem

There are several avenues of approaching the problem of the nature and constitution of light centers that seem to be extremely inviting.

1. At the present time a wonderful field is being opened concerning the dynamics of chemical reactions. As chemical reactions are intimately related to heat and light effects, the discoveries in this field are bound to give a great deal of information concerning light centers.

2. A study of the far infrared promises to break the gap between electromagnetic waves and radiant heat and light centers will probably be found to consist of molecular systems vibrating in a way similar to that of the sources of electromagnetic waves. At the present time we can compare light and heat centers with more or less well-known aggregates of matter and make as many identifications as possible.

3. The separation of complex line and band spectra into series of related lines or bands promises to give us a great deal of information ultimately as to the nature of the vibrating centers, although at present the problem is so complex that no one has been able to devise any mechanism or structure that is adequate to explain the known phenomena. The theory of Ritz has been one of the most successful so far advanced.

4. The Zeeman effect obtained by placing the heat and light centers in a magnetic field is important. This effect indicates that many of the centers of spectral lines consists of negative electrons.

5. The Humphreys-Mohler pressure shift of spectrum lines, the Döppler shift of lines and bands emitted by moving centers as studied by Stark and others, are also very important.

Possible Structure of Light and Heat Centers

One may picture light and heat centers as consisting in part as follows:

1. Neutral "aggregates" of charged particles possessing, in general, translatory and rotatory energy. When undisturbed from without these aggregates would have little if any external electric field. When the equilibrium of such a system is disturbed by collisions or by electromagnetic waves, it may possess temporary fields that will serve as the source of heat and light radiation. This radiation may be due to a rapid oscillatory motion that may be radial, transverse or tangential and would probably be characterized by a definite period. On account of the magnitude of the forces necessary for stable equilibrium, the period of the radiation would probably be small. The spectroscopic models of Thomson, Nagaoka and others are of this type.

2. "Aggregates" may possess charged parts; these may be so far apart from each other that local fields of considerable intensity may exist. If such an aggregate were to rotate, an alternating electric field would result and radiations would be emitted. This radiation, depending on a central acceleration, would vary in period with each impact, so that the various periods emitted would vary about a mean, which would depend on the average rotational energy before impact and the nature of the impact.

3. Freely charged particles torn from neutral "aggregates" will radiate energy when their velocity is changed. The quantity of this radiation will vary with the velocity and the acceleration. The breaking up of the neutral "aggregates" may be called ionization if the resulting parts are charged. Ionization processes may take place within molecules and this is believed to be the condition existing in many kinds of organic compounds when they absorb light or heat.

The relation between ionization and luminosity is not yet clear. Some physicists believe that the two are related to each other and that luminosity becomes perceptible when the intensity of ionization is sufficiently great. It has been stated that a gas may become luminous when one molecule in every $(10)^7$ is ionized. This would mean that the expenditure of about $(10)^{-5}$ ergs is necessary to excite luminosity.

Ionization and Light Emission and Absorption

There appears to be considerable evidence supporting the view that some band spectra such as those of bromine and iodine may be due to the dissociation of molecular systems or to a recombination of the dissociated parts. Ladenburg has found that luminous hydrogen gives an anomalous dispersion in the neighborhood of H_α, while this kind of dispersion is absent in ordinary hydrogen. The phenomena of dispersion indicate that different series of lines in a spectrum may be emitted by very different kinds of vibrating centers, while a particular center may emit only a single line of a series, depending on the manner of its excitation. Faintness in the intensity of lines may be due to the fact that there are very few light centers emitting the given line, or that the vibrations have only a very small amplitude. Koenigsberger and Küpfur and others consider that the band spectra of iodine, bromine, nitrogen peroxide (N_2O_4), sulphur, iodine trichloride, nitrogen, etc., are due to a dissociation or recombination of the respective molecules, atoms or ions. In the case of iodine this change might be represented by the equation

$$I_2 \rightleftarrows I + I.$$

At about 800° C. this reaction is about complete and the fine-banded absorption spectra should therefore disappear. Galitzin, Wilip, Evans and others have shown that the bromine absorption spectrum disappears as dissociation becomes more and more complete.

Canal Rays

Canal rays have their source in positive ions that start in front of the cathode, move towards the cathode and pass through any openings in it with a velocity of about $(10)^8$ cms. per sec. After passing the cathode the canal ray particles may lose their charge or even become negatively charged. The spectrum lines of hydrogen, nitrogen, mercury, sodium, potassium, etc., emitted by canal rays show the Döppler effect when they are viewed in the direction in which the canal ray particles are moving. Accompanying the shifted lines are lines showing no displacement, "rest" lines due to centers that are comparatively at rest. The "rest" line is usually narrow while the shifted line, due to rapidly moving centers, is rather wide, the violet side of the line often being the sharpest. The width of the line indicates the range of velocity of the canal-ray emitting centers. Making certain assumptions as to the potential gradient through which the centers have passed, Stark has calculated the charge carried by centers emitting the various lines.

Since the "rest" and "shifted" lines are separated by a dark region, Stark concluded that canal-ray centers can only radiate line spectra when their velocity exceeds a certain critical value, this critical velocity increasing as the wave-length decreases. Increasing the purity of the gas increases the relative intensity of the "shifted" lines. Strosser has caused a stream of canal-ray centers to impinge into a current of a foreign gas. The lines of the foreign gas were found to increase in intensity on leaving the cathode, pass through a maximum and then decrease in intensity. The intensity of the lines of the canal-ray centers decreased in intensity as the distance from the cathode increased.

Carriers of Spark Spectra

Spark spectra have been photographed on rapidly-moving films by Schuster, Hemsalech, Schenck and others. The length of time the metallic vapor continued to emit line spectra was found to vary from

10 to $45(10)^{-6}$ secs., depending on the line. The velocity of the centers of Mg λ 4481 was found to be about $2.5(10)^5$ cm. per sec. near the electrodes, dropping to $1.7(10)^5$ cm. about a millimeter from the electrodes. Air line centers have an existence of about $7(10)^{-7}$ sec. The emission centers in flames and arcs have been studied by Lenard and others. The results obtained do not agree with those found by Stark working with canal rays.

Negative Electrons as Emission and Absorption Centers

The Zeeman effect produced by the action of a magnetic field upon the emission or absorption light centers shows that for many spectrum lines of gases and vapors the light center consists of a negative electron and the ratio of the charge to the mass of the electron obtained in this way agrees very well with the value obtained by other methods. The more accurate experiments give $e/m = 1.775$ while direct experiments give 1.772.

The Positive Electron

The positive electron has never been isolated in any experiment with vacuum-tube discharges, radiations from radioactive materials, etc. The Zeeman effect of certain band spectra of chlorides and fluorides of some of the alkaline earth elements studied by Dufour and of the absorption spectra of neodymium and erbium compounds as studied by Becquerel indicate the existence of positive electrons. These Zeeman effects may be explained, however, as being due to induced magnetic fields being set up in the region of the light centers, magnetic fields whose intensities are very different from the field impressed from without.

Absorption Centers of Solutions of the Rare Elements

Many solutions of salts of elements such as uranium, neodymium, erbium, somarium, etc., show a banded absorption spectrum. Many of these bands are very narrow. Jones, Anderson and the writer have found that the absorption centers of many of these salts (*e. g.*, uranous chloride) consist of centers containing the salt and an "atmosphere" of the solvent, the whole center apparently acting as a compound. Thus in the above case it is possible to have "water and alcohol centers" of uranous chloride in a solution of uranous chloride in water and alcohol. Increasing the amount of one solvent appears to increase the relative number of the centers of that solvent without apparently changing their composition. The different solvent centers have different degrees of persistency. The water and alcohol bands of neodymium chloride are of about equal intensity when the salt is dissolved in a solution containing about 3 per cent. water and 97 per cent. alcohol. Changes of temperature change the relative persistency of the light centers.

In the case of some uranyl salts the addition of free acid of the salt causes a shift of the bands. This has been explained by the writer as being due to the fact that the light centers consisted of "aggregates" of salt and acid. Evidences of series of "aggregates" were obtained by spectrophotographs of chemical reactions, spectrograms of the absorption spectra of a solution of a given salt being taken as increasing amounts of some other kind of acid was added to the solution.

Centers of Phosphorescent Spectra

Lenard, Klatt, Urbain and others have studied the phosphorescence of various calcium phosphates of bismuth, manganese, nickel, etc. Lenard and Klatt have proposed the view that these light centers or "dynamids" store electrons, the state of motion of the electrons depending upon the temperature. At high temperatures the electrons possess a much greater freedom of motion than at low temperatures. They visualize the states of motion as being "gaseous," "liquid" and "solid." In the "gaseous" state the electrons can occasion the conduction of electricity between the atoms if the latter exist in the same way as they do in metals. In the "liquid" state the electrons are in a state of motion sensitive to light vibrations and therefore they take part in light absorption. In the "solid" state the electrons take part neither in conduction nor in absorption. At low temperatures the spheres of action of the "dynamids" are considered to extend to greater distances than at high temperatures and the free paths of the electrons are therefore greatly reduced.

To each phosphorescent band Lenard and Klatt assign three phases: An upper momentary or heat phase; a permanennt phase possessing quite definite temperature limits; and a lower momentary or cold phase. These phases succeed each other as the temperature falls. The upper momentary phase results when the dynamids do not store electrons. Whenever electrons are stored these return afterwards to the atom from which they were expelled by the light-wave, thus producing the permanent phase of the phosphorescent band. At low temperatures a few electrons return to the atoms from which they were expelled and these cause the lower momentary phase.

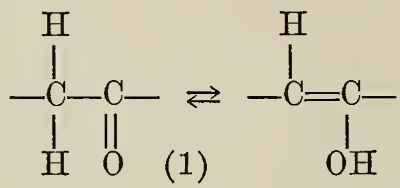
The phenomena of phosphorescence are generally conceded to be due to some kind of electrolytic dissociation or ionization of the dissolved substance in the medium about it. Among the first to hold this view were Wiedeman and Schmidt. The theory explains the law of Stokes and many of the other phenomena of phosphorescence.

The Light Centers of Organic Compounds

During recent years a very large number of investigations have been carried out concerning the nature of the absorption light centers of organic compounds, both pure and in a state of solution. These centers have been roughly defined as chromophores, the chromophores consisting of radicles of the given compounds that are found necessary and sufficient to produce the given absorption. Among the chromophores that might be cited are $>C=C<$; $=CO$; $>C=NH$, $-N=O$; $=N=O$; $=C=S$, etc. A bathochrome introduced into an organic compound causes the absorption band to become wider. An auxochrome causes the intensity of the absorption to be greater.

Dynamic Isomerism

Baly and many others have supported the view that the absorption of many organic compounds is due to a change in the valency linking of a compound. This dynamic isomerism is known to take place in many chemical compounds in the presence of a catalytic agent or at high temperatures. Take the case of acetylacetone and ethyl acetoacetate. The absorption in this case may be due to a reaction changing the ketonic (1) into the enolic (2) form and some experimental evidence favors this view.



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Résumé

From the above brief account of our knowledge concerning the nature of the absorption and emission centers of light and heat radiations it will be noted that many advances have been made toward the solution of this problem in recent years. The existence of "electron" atmospheres in many solids, liquids and gases has explained the emission and absorption of spectra that are ordinarily described as continuous; the existence of negative electrons serves to explain many phenomena such as those of the Zeeman effect, etc.; models containing elementary magnets arranged in various ways have been used by Ritz to explain the series classification of spectrum lines; the various phenomena of ionization are being found to be intimately correlated with the phenomena of light emission and much evidence is being accumulated to show that light and heat centers may ultimately be identified as consisting of certain kinds of ions; a very large amount of experimental data has been accumulated concerning absorption spectra of solutions of organic and inorganic compounds and the centers of this absorption seem to consist in certain "aggregates," "chromophores," etc., which can be studied from other points of view; much evidence is found to point to the view that light and heat centers depend upon certain dynamic conditions and are not stable systems such as we usually conceive atoms and molecules to be.

IN QUEST OF THE ALCOHOL MOTIVE

By Professor G. T. W. PATRICK
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ONE of the problems which has been definitely set for psychologists to solve during the twentieth century is the cause of the almost universal desire for alcohol. It is a curious fact that in the thousands and hundreds of thousands of books, articles and writings of every description relating to the many phases of the alcohol problem, this simple and fundamental question—Why do men desire alcohol?—has until recently never been carefully considered at all and even now has not been answered. The belief that the desire for alcohol is due to total depravity or original sin seems to be about as far as we have got in answering this question. One author wrote a serious article not long ago to show that the cause of drinking is to be attributed to bad cooking in the home! He evidently did not appreciate the fact that the desire for alcohol, as well as its use, is at least as old as the lake-dwellers of the neolithic age. Few if any savage tribes known to anthropologists, whether in ancient or in modern times, except certain tribes of Eskimos who have no fruit or grain from which alcohol can be prepared, have been without this drug or some other having similar properties. The discovery and use of alcohol have not spread from tribe to tribe, but have been autochthonic, arising independently in all parts of the world. So keen has been the desire for alcohol and so eager the quest for it, that always and everywhere some means have been discovered by which this water of life could be expressed from fruit, or grain, or vegetable.

And yet we do not even know why it is desired.

The whole vast machinery of the temperance movement, employing thousands of skilled and zealous workers, controlling large sums of money, and making use of wise educational, social and legislative methods, seems to have accomplished little or nothing in reducing the consumption of alcohol. At the very time that legislative and social control of the manufacture, sale and use of alcoholic liquors is extended over larger and larger portions of our country, the relentless figures of the U. S. Commissioner of Internal Revenue show that year by year with almost fateful regularity the per capita consumption of these liquors is increasing instead of decreasing.

The following table shows the per capita consumption of all liquors in the United States from the year 1850 to the year 1911, inclusive:

Per Capita Consumption of all Wines and Liquors

Period	Gallons	Period	Gallons
1850	4.08	1899	16.82
1860	6.43	1900	17.76
1870	7.70	1901	17.65
1871–80	8.79	1902	19.14
1881–90	13.21	1903	19.57
1891	16.72	1904	19.87
1892	17.13	1905	19.85
1893	18.20	1906	21.55
1894	16.98	1907	22.79
1895	16.57	1908	22.22
1896	17.12	1909	21.06
1897	16.50	1910	21.86
1898	17.37	1911	22.79

These figures should not be interpreted as showing the failure of the various means used for the limitation of the sale of intoxicating drinks. There is every reason for believing that these means are in a high degree effective and that without them the increase in the use of alcohol would have been much greater than it has been. The true meaning of the figures is, rather, to show the increasing force of this desire in modern society.

There are, of course, other great human desires besides the desire for alcohol, but in respect to these other desires it seems less difficult to explain the cause. It is not difficult to explain the desire for bread, nor the keen interest in all matters relating to the means of acquiring it. Problems of labor and capital, problems of high prices, problems of production and distribution of food, relate more or less directly to the bread question and become thus wholly intelligible, because bread is necessary to life. Neither is it difficult to understand another profound human desire, which involves serious social problems, the desire of the sexes for each other. Difficult as these social problems may be, the psychologist's part presents here less difficulty, for the place of this great passion in human economy is clear.

The desire for alcohol approaches the above desires as regards both its force and its universality, but its place in human economy is not thus far clear.

The following familiar statistics are not cited in this case to show the extent of "human depravity," nor to point out an "evil" to be suppressed, but rather to indicate the force of a human desire whose cause we seek to determine.

The people of the United States are now consuming annually about 2,000 million gallons of malt liquors, nearly 64 million gallons of wine and more than 138 million gallons of distilled liquors. In Germany the per capita consumption of distilled liquors is about the same as in this country, while their consumption of malt liquors is, per capita, about one third larger than ours and of wine about twice as large.

In England the per capita consumption of malt liquors is still greater than it is in Germany, while the consumption of wine and distilled liquors is somewhat less than in Germany or in the United States.

It is little to the point to call attention to the fact, as has often been done, that the cost of alcoholic drinks to the German people, which is about 3,000 million Marks per year, is nearly three and one quarter times the total cost of their army and navy combined; the cost should rather be compared with other "necessities" of life, such as bread and meat. The force of the desire for alcohol is better shown by noting that its cost to the German people is about the same in amount as their total expenditures for meat, fish and fowl combined, and only one eighth less than their total expenditures for bread, meal, bakery goods and potatoes combined. In this country we have no means of determining accurately the outlay of the people for alcoholic liquors, but we know that the wholesale value of the malt, vinous and distilled liquors produced annually in the United States is approximately six hundred million dollars, almost the same as the total value of our wheat crop. These figures do not take into account the value of wines and liquors imported, nor the output of illicit distilleries. Of these illicit stills, according to the last report of the U. S. Commissioner of Internal Revenue, 2,466 were seized and destroyed during the fiscal year ending June 30, 1912.

An intense human interest clusters around everything connected with alcohol. The very names of the countless forms of beverages, as well as their odors, tastes and colors are all interesting. Language itself reflects the depth of this interest, particularly in the many synonyms for intoxication. Partridge, in his book on "The Psychology of Intemperance," gives a list of about 370 words and phrases in English expressive of intoxication, and he says that a list of more than 600 words in German has been collected. In his opinion nothing except the sexual relation has made a stronger impression upon popular language.

The praise of wine has been celebrated in the poetry of every age. Drinking songs have a peculiar charm. In the history both of religion and of medicine, alcohol has occupied a prominent place and in some form it has been regarded as a cure for every ill. Huge volumes could be filled with the legislative acts of civilized people in their efforts to regulate its sale and use. In recent years an almost incredible number of books and articles has appeared relating to some phase or other of this subject.

It is evident, then that there exists in the human mind, for some reason or other, a profound, persistent and intense desire for alcohol. The psychologist is interested in discovering the cause of this desire and the sociologist well knows that it will not be until this cause has been determined that any real progress will be made in solving the social problem of alcohol.

How, then, shall the cause of the desire for alcohol be determined? It would seem *a priori* improbable that anything so profoundly and universally desired should not answer to some real need of the human organism. It is clear, therefore, that the first thing to do is to make a scientific study of alcohol and its relation to the body and mind. It is only in recent years that any real attempt has been made to carry out such studies, but they have already cast a flood of light upon the subject. Physiological, psychological and sociological laboratories, hospitals and asylums, medical records and the reports of life insurance companies have all contributed to give us a more accurate knowledge of the action of alcohol on the human body and the human mind and to pave the way for a scientific theory of the alcohol motive. These researches are particularly instructive for the reason that they deal with the real question, *i. e.*, with the effects of alcohol in moderate doses, not with its excessive use. The literature on inebriety, alcoholism and intemperance has always been sufficiently abundant.

It would be impossible in an article of this length to attempt even the briefest summary of these researches. It will be sufficient simply to recall the more important conclusions.

1. The desire for alcoholic drinks is due to the presence of ethyl alcohol, C_2H_6O. Beer, ale, wine, and even whiskey and brandy, have characteristic odors, pleasant to many people and ravishing to some, but it is not on this account that they are desired. The pleasantness of the tastes and odor are largely if not wholly due to association with ethyl alcohol.

2. It is not on account of its food value that alcohol is desired. The researches of Atwater and others have seemed to show rather conclusively that a certain amount of alcohol, say two and one half ounces per day, may under favorable circumstances be oxidized in the body and so act as a substitute for other food by furnishing heat and possibly energy. It is not claimed, however, by those who hold that alcohol may in some cases act as a food that it is on this account that it is desired. The history of drinking, which shows that it has been wholly convivial among primitive people and that it is still largely so, precludes this view. It is only in modern industrial drinking that any attempt has been made to work on alcohol or to live on it, and here the attempt has not been successful, as Sullivan has shown in his careful and painstaking work on "Alcoholism."

3. It has now been pretty definitely shown that alcohol is not a stimulant, and thus there is overthrown at once the most commonly accepted theory as to the cause of the desire for it. Alcohol acts as a depressant upon all forms of life from the simplest micro-organism to the most complex nervous structures in the human brain. It is inter-

esting, however, to call attention to the fact, especially since a few physiologists still claim that under some circumstances it may act as a stimulant to certain bodily organs, that if alcohol were a stimulant, this would not, after all, afford any evidence that it plays a useful part in human economy. A stimulant as such adds nothing to human economy, whether such economy is considered from the standpoint of the race or of the individual. It offers no gain in the long run and could be of no real advantage in the struggle for existence. A stimulant can be serviceable only in emergency cases and under abnormal conditions and as such can not serve as an explanation for a desire extending to nearly all people in all periods of history.

4. The supposition may be made that alcohol increases muscular efficiency, at least temporarily, and that the desire for it may be explained in this way, but the experimental evidence forbids this view. Many series of experiments have been made by Warren, Frey, Schnyder, Destrée, Tavernari, Kraepelin, Féré, Partridge, Rivers and others, using the ergograph and other forms of dynamometer, to determine the effect of small doses of alcohol upon muscular power and efficiency. These experiments have shown that, as the result of small, or so-called normal doses of alcohol, there is a slight initial increase of muscular power followed by a decrease, so that on the whole the results reveal a loss rather than a gain in efficiency. With an increase in the size of the doses, the decrease in efficiency is greater. Later experiments carried out by Rivers and Webber, using a control drink so that the subjects did not know when alcohol had been administered, showed no initial increase of power whatever, Rivers believing that the increase shown in other experiments was due to suggestion. There seems some ground for believing that alcohol, while it does not increase muscular efficiency, shortens reaction-time at first and facilitates the liberation of energy. This may account to some extent for the feeling of increased efficiency which follows the ingestion of alcohol. If it be true that it shortens reaction-time and facilitates the liberation of energy, it still does not appear that this would offer any explanation for the world-wide desire for it. It has not been shown that any decided advantage accrues from the shortening of reaction-time or the quicker liberation of energy. The normal reaction-time and the normal liberation of energy would seem in the long run to be more advantageous. Kraepelin's conclusion is that the laborer who gains his livelihood by the strength of his arm destroys by the use of alcohol the very foundation of his efficiency. The experiments of Hodge, with retrieving dogs showed that the dogs given alcohol did about half as much work as the normal animals. The experiments of Durig in mountain climbing, with and without alcohol, showed that moderate doses of alcohol resulted in a loss of about 20 per cent. in efficiency.

5. Alcohol, again, does not increase mental efficiency. The experi-

ments of Kraepelin and his associates show that moderate doses of alcohol exert a deadening influence on all mental processes. Apprehension is slower, accuracy is lessened, errors are increased, and memory is impaired. The character of associations is also unfavorably affected, the number of higher logical associations being decreased while associations depending upon similarity and contiguity in time and space are increased. Schnidman made experiments on the effect of alcohol in the work of translating from one language to another, with the result that under the influence of small doses of alcohol there was an increase of errors and a decrease of rapidity. The experiments of Lieutenant Boy upon Swedish soldiers in revolver and rifle shooting with and without alcohol showed that accuracy was affected unfavorably by the drug. Mayer found that the speed of writing was lessened by alcohol. In Dr. Aschaffenburg's experiments with typesetters, he found that there was an average impairment of efficiency amounting to about 9 per cent. as the result of small doses of alcohol. Smith experimented on the effect of small doses of alcohol upon memory processes when the drug was administered for successive days. The alcohol in these experiments was administered in the evening and was found to exert a damaging effect upon the memory processes to a very marked degree, the effect increasing from day to day. Fürer found that 80 c.c. of alcohol taken in the evening was followed by increased errors in choice-reactions during the whole of the following day.

Experiments such as the above are difficult to carry out and possible sources of error may enter. It is highly desirable that still further researches should be made in this direction, eliminating every possible source of error. The work to be undertaken in this field by the Carnegie Institution under the direction of Dr. Benedict and Dr. Raymond Dodge will be awaited with great interest. It may safely be said, however, that the experimental evidence is already sufficient to show that it is not on account of any increased mental efficiency due to alcohol that the world-wide desire for it is to be explained. The testimony of Helmholtz in his speech at Berlin on the occasion of his seventieth birthday is significant in this connection. Speaking of the conditions under which he had had his most brilliant intuitions, he said that the smallest amount of alcohol seemed to frighten them away.

The experimental evidence of the damaging effect of alcohol on physical and mental efficiency is confirmed by the practical experience of railroads, steamship companies, shops, manufacturing establishments, contractors, surveying and exploring parties, athletic teams, etc. An increasingly large number of railroads forbid the use of alcoholic liquors to their employees, in some cases even when off duty, while in shops and in mercantile establishments of all kinds statistics show a significant increase of accidents and decrease of efficiency immediately following Sundays and holidays.

If next we consider the contributions of recent science to the use of alcohol in its relation to human health and longevity, we are again met with disappointment in our quest for the explanation of its use. Alcohol was formerly very freely used by physicans in both surgery and medicine, but faith in its therapeutic powers has now been almost wholly lost. The figures given by Horsley showing the decrease in the use of alcohol in English hospitals and asylums during the last twenty years are exceedingly striking. In surgery alcohol has been replaced by antiseptics and in medicine by milk and eggs. Alcohol has now come to be regarded by physicians not as a cure for disease, but as a prolific cause of it. As an excretory product of the yeast plant, its action upon higher organisms is that of a toxin. Its regular moderate use renders the individual less resistant to disease and its excessive use brings a long list of diseases in its train.

The influence of alcohol upon longevity has now been studied with some thoroughness by physicians and actuaries and some definite results have been gained, although here much work needs to be done. The results show at any rate that alcohol does not increase longevity and hence we have here again no clue to the world-wide desire for it. Robert Mackenzie Moore, actuary of the United Kingdom Temperance and General Provident Institute, in a recent report based upon sixty years' experience of that company in the insurance of the lives of abstainers and non-abstainers (the latter being moderate drinkers and good risks and belonging to the same class and following the same occupations as the former), found that in respect to longevity the abstainers showed a marked superiority over the non-abstainers throughout the whole period of life for every class of policies and for both sexes, however tested. For instance, at the age of 30 the expectation of life for the non-abstainers is 35.1 years; for the abstainers, 38.8 years, a difference of nearly 11 per cent. At the age of 40, the percentage of difference is the same. Another very thorough and impartial investigation has been made by Mr. Edward B. Phelps on the mortality due to alcohol. It is based on the testimony of the medical directors of three prominent life-insurance companies of America. Mr. Phelps's conclusion is that 8 per cent. of all deaths of adults in the United States are due to alcohol.

If we turn finally to the social relations of men in our search for an explanation for the universal desire for alcohol, our reward is even less. Alcohol indeed encourages sociability, but it would be hard to show that this in itself is a benefit proportional to the desire for it, and we find in connection with its use a long list of social evils, such as poverty, crime and racial degeneracy. These evils are connected for the most part with the excessive use of alcohol and consequently they interest us only indirectly here; but it would appear to be one more disadvantage to be attributed to alcohol that its moderate use is apt to issue in excessive use and so lead to many unhappy and disagreeable consequences, such as drunkenness, disability for work, domestic trouble, poverty, crime and degeneracy of offspring.

We are thus brought finally face to face with the question, Why do men desire alcohol? The theories hitherto advanced in explanation of the alcohol motive have failed to take into account certain essential facts in regard to the problem and have therefore been incomplete. Among these facts are the following: The desire for alcohol is common both to civilized and uncivilized man. It tends to increase rather than to decrease with the advance of civilization in spite of vigorous and to some extent successful efforts to restrain it. It has reached an unparalleled degree of intensity at the present time in prosperous communities relatively rich in comforts and luxuries. It is strong, again, in industrial and manufacturing centers among plodding and underpaid laborers. It is somewhat stronger in northern progressive races than among the less progressive southern people. It is particularly characteristic of the adult male individual, the desire being decidedly less strong in women and children. It is not an appetite in the ordinary sense of the word, as it answers to no inner need of the body so far as is known. To these facts should be added those specially noted above, namely, that alcohol apparently adds nothing to either physical or mental efficiency, that it contributes nothing to health or longevity, and does not enhance social well-being.

Is it possible to explain the desire for alcohol on the ground of its immediate pleasurable mental effects? It deadens pain to some extent and drives away care. It produces a feeling of euphoria, of well-being, comfort, contentment, ease and inner harmony. Under the influence of alcohol many of the unpleasant feelings accompanying the daily drudgery of life temporarily disappear or are at least alleviated, such, for instance, as fatigue, apprehension, fear, worry, anxiety and to some extent physical pain. Selecting one from any number of illustrations which might be drawn from literature, we read in Gösta Berling:

> The year had dragged itself out in heavy gloom. Peasant and master had passed their days with thoughts on the soil, but at even their spirits cast off their yoke, freed by brandy. Inspiration came, the heart grew warm, life became glowing, the song rang out, roses shed their perfume. The public house bar-room seemed to him a tropical garden, grapes and olives hung down over his head, marble statues shone among dark leaves, songsters and poets wandered under the palms and plane trees.

Another author, picturing the hopeless grinding toil of the coal miner, his monotonous and unillumined life, his long work day, his hasty and insufficient supper and his hard bed, says that at the end of the week when a little respite comes, the "demand for joy" drives this coal miner to the saloon.

But this explanation, at first sight partially adequate, when more carefully considered, encounters serious difficulties and only adds to the obscurity of the subject. Are we to understand that the desire for alcohol is due to the "demand for joy"? There never was a time in the history of the world when, quite apart from alcohol, joys were so abundant as they are in America at the present day. The rich have every comfort and luxury and the poor have every humane consideration, while laborers have shorter hours, better pay, better food and better clothes and more books, papers and other forms of entertainment than ever before in the world's history. We are comparatively prosperous, happy and well fed, have abundant leisure and countless comforts, yet it appears that we need 2,000 million gallons of alcoholic liquors yearly to complete our "joy." Furthermore, if this were the correct theory, it would be impossible to explain the lesser desire for alcohol among women, for although at present in America the lot of woman is a relatively happy one, this has not been the case among primitive people, nor in historic times, nor even in other countries at the present time. Her life has been relatively monotonous and laborious and her joys and amusements have been fewer.

But serious psychological objections to this theory appear also. Joy and pleasure are the mental accompaniments of physical well-being, of mental and physical health, while alcohol acts as a poison in the presence of all forms of life. Against this apparent contradiction little is gained by saying that the joy of alcohol is an abnormal joy answering to an abnormal or diseased condition. The desire is too universal, too fundamental, so to speak, for that. Or if we say that alcohol brings an immediate and temporary joy, while its poisonous effects are delayed, we encounter two difficulties, first the difficulty of showing what particular kind of benefit corresponds to the immediate and temporary joy, and second the difficulty of explaining on any principles of evolution the desire for a drug whose effects are on the whole injurious—a desire which is so strong and so universal as almost to merit the name of an instinct. This seems to be a kind of deadlock to any further progress in arriving at a theory of alcohol. But the joys of alcohol are evident and its injurious effects are equally evident. It is clear, therefore, that the "demand for joy" theory is only a superficial statement of a certain truth whose explanation lies deeper.

But leaving for the moment the "demand for joy" theory, let us consider the view that alcohol banishes care and drives away sorrow and pain, in other words, that it is narcotic in its action, a kind of sedative or anesthetic. This theory seems at first sight to account for some of the facts. It is now generally, though not quite universally, admitted by physiologists that alcohol is not a stimulant but a narcotic. It apparently paralyzes the higher brain centers and in thus inhibiting the inhibitory centers produces effects resembling stimulation. Furthermore, pain, sorrow and care are ever present in human life, making the universality of the desire thus far intelligible.

But clearly the narcotic theory encounters difficulties from the same sources as the "demand for joy" theory. It fails first to account for the lesser desire among women, who have certainly at all times had their share of sorrow, pain and care. It fails likewise to account for the increase of the desire in times of prosperity and activity, or in times like the present of improved hygiene, increased longevity and multiplied pleasures and comforts. Finally, the narcotic theory, if it were true, would seem to be nature's checkmate upon itself, for pain in all its forms is evidently purposive. Are we to suppose that nature has discovered a way to tear down its own danger signals? The narcotic theory would be available only in respect to times of degeneration and national decay. Nordau, who explains the desire for alcohol in this way, regards the present as such a time of degeneration, and Partridge, who recognizes the narcotic motive as one of the elements in the desire, seems to think that so far as it is present it betokens "old age and disease in a nation." But since the desire flourishes most strongly, as we have seen, in times of great national vigor, such for instance as prevail at the present time in Germany, England and America, the narcotic theory seems to fail. Nevertheless, it may appear below that the narcotic motive is present, after all, only not in the form hitherto recognized.

Another writer, Reid, has broached the theory that the desire for alcohol is a by-product of evolution, a specific craving which nothing but alcohol will satisfy. It is coextensive with the human race and harmful in its results, and is to be met in only one way, namely, by the automatic action of "evolution against alcohol," by the action of natural selection in gradually eliminating those not immune to the desire. It is part of Reid's theory to maintain that the people of southern Europe have become partly immune to alcohol, owing to its abundant supply, and are therefore more temperate. Almost all the facts upon which this theory is based are open to doubt.

Partridge, while recognizing the narcotic motive in the desire for alcohol, "the longing to escape from pain, to seek relief in inactivity and rest, a turning backward from the strenuous life," apparently believes that the so-called "intoxication motive" is more important. It springs from the desire for states of consciousness of higher intensity, for feelings of exaltation, for life and life more abundant, for freedom and expansion, for states of higher tension. It is the erethic impulse, a craving for excitement. But the evidence is overwhelming, as we have seen, that alcohol, so far from contributing to the more abundant life, contributes from every point of view to the less abundant life, and as for the desire for states of higher tension, there is every reason to believe, as will be shown in what follows, that alcohol produces states of lower tension and is desired for precisely this reason.

And if the desire for alcohol were due to a longing for excitement, life, tension, movement, this longing would seem to be well satisfied by the conditions in modern American cities without recourse to 2,000 million gallons of alcoholic liquors yearly.

Any satisfactory theory of the alcohol impulse must not only take account of the facts to be explained, some of which we have mentioned above, but it must also be grounded on an accurate knowledge of the whole life history of man, particularly his mental development and the corresponding development of the brain. It would be necessary, furthermore, for such a theory that we should have an accurate knowledge of the action of alcohol on the human brain. Neither psychology nor physiology is able as yet to furnish this knowledge completely, so that any theory of the alcohol motive must be tentative, awaiting further scientific advance. The following observations, therefore, although for brevity's sake put in somewhat dogmatic form, may be considered as suggestions toward such a theory.

Human progress seems to be in a certain definite direction and to involve the development of certain definite mental powers and of the corresponding higher cerebral centers. The chief of these powers is that of voluntary, sustained attention, which differentiates man sharply from the lower animals and likewise distinguishes civilized man from the savage. Progress has been possible because man has been able to narrow the field of attention, to concentrate or focus his powers, to live under mental stress, strain and effort and to hold his attention on a definite object. The word "tension" may perhaps express both psychologically and physiologically the subjective correlate of progress. It is characteristic of the savage as compared with the lower animals, of civilized man as compared with the savage, of northern races as compared with southern, and of the male as compared with the female. As concentration, sustained attention and abstraction, it issues among civilized man in science and invention. Whether the product be Newton's Principia or Edison's talking machine, or even the long-sustained working-day of the common laborer, it presupposes the above-mentioned powers and involves the constant enlargement of the higher cortical centers of the brain. There is something, whether it be the "will to live," or a "vital impulse," or the cosmic consciousness, or only natural selection, that is eternally driving us on in this direction.

Now the higher and newer the brain centers, the more subject they are to fatigue and the greater is their need of rest. During sleep these centers enjoy almost perfect rest, our dream activity taking the form of passive revery. But eight hours of sleep are not sufficient for this part of the brain. Sixteen hours of sustained attention would probably result in immediate insanity, if such an act were possible. Nature seems to demand some form of activity which shall allow the higher brain centers to rest while providing employment for the lower ones. To such a condition of mind and body we apply the name *relaxation* and it embraces a considerable portion of our daily activity. It is most perfectly typified in play and sport, but includes many other forms of human interest and activity, such, for instance, as the enjoyment of music, of the drama and of other forms of fine art, the reading of fiction, and countless other kinds of amusement and entertainment not commonly included under the terms play or sport.

But it is in children's play and in adult sport that we find the principles of relaxation best exhibited as they will be found presently to bear upon our problem. The active life of the child is almost wholly a life of play. The brain centers developed late in the history of the race come to maturity late in the life of the child. Hence he rebels instinctively against work, for it involves yet undeveloped centers, those connected with spontaneous and sustained attention. Play is self-developing and supplies its own interest. Furthermore, a study of children's plays shows that they are largely reversionary in form, following the old racial activities of our remote ancestors. The boy, therefore, runs, races, rolls, wrestles, wades, swims, climbs trees, shoots with sling or with bow and arrow, goes hunting, fishing, canoeing, camping, builds tree houses, cave houses, wigwams and pursues a hundred occupations recalling the life of primitive man and far removed from the serious life of modern man, the life of the farm, the shop, the office, the factory, the bank or the schoolroom. The brain paths involved in children's play are the old time-worn easy paths requiring no new associations, no abstractions, no strong and sustained effort of will or attention.

In adult sport we have a still better illustration of the principles of relaxation. If we recall those forms of sport which afford the most perfect rest and relaxation, we shall see how true it is that they are of a character to use the old racial brain paths and rest the higher and newer centers. The tired teacher, lawyer, doctor, preacher or business man, when his vacation comes, reverts to the habits of primitive man. He takes his tent, rod, gun or canoe and goes to forest, lake or mountain, wears more primitive clothes, sleeps on the ground and cooks over a camp fire. Hunting, swimming, yachting, dancing, wrestling, prize-fighting, horse racing—all these are illustrations of the rest afforded by primitive activities. As forms of relaxation they seem so natural to us that often we do not realize how primitive they are and how far removed from the real work-a-day world of modern life, the world of mental concentration, of pen and ink and books, of clerks and stenographers, of office and court room, of flats and congested cities, of business and finance. A football game, which resembles the rough and tumble physical contests of former days, brings together fifty thousand wildly enthusiastic spectators, while an intercollegiate debate commands at most only a handful of hearers with mild enthusiasm, so great is the need of some form of relaxation that shall completely relieve the tension of modern life. The gladiatorial exhibitions of old

Rome attracted enormous crowds of eager spectators because of the primitive character of the spectacles. The direct physical contact of man with man or man with beast intoxicated the Romans, whose work-a-day world was not unlike our own and far removed from the life of the arena. Such spectacles awoke the echoes of the past, revived primitive instincts and afforded perfect rest and relaxation. The behavior of the spectators at a football game is an illustration of perfect relaxation. They act for a time like children or savages and return to their work rested and purified.[1] Mankind appears to be under the dominance of two opposing forces. On the one hand we are driven on by the relentless whip of progress, which demands ever greater and greater specialization, application, concentration and powers of conceptual analysis. On the other hand the tired brain rebels against this ceaseless urging and seeks rest and relaxation.

But, now, even in the early history of the race, there was discovered another means of relaxation, artificial to be sure, but quick, easy and convenient. Drugs of various kinds, owing to their peculiar action upon the brain, produce a kind of artificial relaxation. Ethyl alcohol, produced everywhere whenever the ever-present yeast cells come in contact with the sugar of crushed fruit or fermented grain, has the peculiar property of paralyzing to a greater or less extent the higher and later developed brain tracts which are associated with those peculiar forms of mental activity accompanying work and the strenuous life. The later developed and more delicate centers of the nervous system are more susceptible to the attacks of an intruding destructive agency, such as alcohol. Thus it comes about that alcohol answers the demand of the body and mind for relaxation and accomplishes in an artificial way what is effected in a natural way by sport and play and other forms of relaxation. The latter effect this end by turning the energy of the brain into lower and older channels, leaving the higher centers to rest; the former, by directly narcotizing the higher centers and thus liberating the older, freer life of the emotions and the more primitive impulses.

It should not be understood that alcohol has any "selective affinity" for any part of the nervous system. Its action, like that of other toxins, is no doubt diffusive, but affects most seriously those parts of the brain having less power of resistance, particularly the centers late in the order of development. Its depressive effect is felt to some extent, however, upon the lower reflex centers and as such results again in physiological relaxation. This is owing to the fact that its depressive action raises the threshold value of the reflex arc and so diminishes reflex excitability.

From this point of view, therefore, we see that while the action of

[1] For a fuller account of the anthropological theory of sport and play, see the article by the present writer on "The Psychology of Foot-ball," in the *American Journal of Psychology*, Vol. XIV., pp. 104–117.

alcohol is narcotic, nevertheless the narcotic theory, as it has hitherto been presented, is very one-sided, and the truth in the narcotic theory as well as in the stimulation or intoxication theory is now brought into proper relief. One would not say that play and sport are narcotics. They seem to be very refreshing and stimulating. In the same way alcohol is stimulating, not directly, for its physiological action is wholly depressive, but indirectly by inhibiting the higher brain centers and setting free the older and more primitive psychoses. Thus it appears as a depressant of voluntary attention and effort, of logical associations and abstract reasoning, of foresight and prudence, of anxiety and worry, of modesty and reserve and the higher sentiments in general, while, on the other hand, it acts indirectly as an excitant of speech, laughter and song, of emotional feeling and expression, of sentimentality, and in increased doses, of still older and more basic impulses, such as garrulity, quarrelsomeness, recklessness, immodesty and, finally, of coarseness and criminal tendencies. Thus under the progressive influence of alcohol we see the whole life history of the race traversed in reverse direction, for the criminal life of to-day represents the normal life of primitive man.

We thus trace the desire for alcohol to the inherent need of mind and body for relaxation, a need normally supplied by all the varied forms of play and sport. Physiologically it is expressed by the need of rest felt by the higher brain centers upon which conditions of civilization bring so severe a strain. Psychologically it is the expression of the desire for release from the tension of the strenuous life. In a sense, therefore, it is the strenuous life which is responsible for the alcohol impulse, but it should be noted that the word "strenuous" is here used in a broad sense. It does not refer necessarily to an exciting, active, high-pressure life, but refers rather to any condition of unrelieved tension, where sustained effort is demanded with little opportunity for complete rest and relaxation. While these conditions are perhaps best encouraged by the high-pressure life of our cities, they are also present in the unrelieved toil of the industrial worker.

We are in this way able to understand some of the facts which, as we have shown, must be considered in any theory of the alcohol motive. We may understand not only the increased desire for alcohol in modern life, but also the lesser need for it on the part of woman. Woman is less modified than man and presents less variation. Her life is calmer and more even. She is more conservative, representing the child type, which is the race type. Her life is less strenuous. She is not keyed up to so high a pitch and hence has less need of relaxation and feels less demand for play and sport. Man, on the other hand, represents variation. The mental powers peculiar to advancing civilization are more developed in him. He has to be in the vanguard of progress. With him, therefore, the stress of life, the tension, the excitement, are greater and he feels more the need of the harmonizing action of alcohol.

Again, we can understand why even the primitive man finds alcohol a relief, for the tension of his life is great as compared with the lower animals and we can understand why the desire increases with the progress of civilization and the corresponding increase of tension. The stress of life is greatest among the Anglo-Saxon people and greatest of all perhaps in American cities at the present time. In this country especially, the intense life of concentration, of effort, of endeavor, of struggle, of rapid development, has for its correlate an intense longing, not for stimulants,—for our life, our climate, our environment are surely stimulating enough,—but for rest, for relaxation, for harmony, for something to still temporarily the eternal turmoil.

Does the fact that the desire for alcohol is increased by the indulgence in it and the apparent fact that those who fall victims to its excessive use are not always those most in need of its harmonizing action present any difficulty in this theory? Probably not. The desire for relaxation is not necessarily increased by the use of alcohol but only the ever renewed demand for that which produces the longed for effect, and, again, it is not certain that those who fall victims to its excessive use are not those most in need of its harmonizing action. Here the element of prudence and self-control must be taken into account. Excessive users may be those having lesser control or greater opportunity, not those experiencing stronger desire. While the desire for alcohol is increasing with the complexity of society, it is actually true that drunkenness is decreasing and it is possibly true that the number of total abstainers is increasing. These things are determined by custom, by individual environment and education and by the power of self control. But the steady increase in the desire for alcohol is shown not merely in the steady increase in its consumption but still more in the fact that it increases in the face of public and private sentiment, legal statute and social effort.

We see also why the use of alcohol has commonly followed the law of rhythm. Among primitive tribes drinking was periodic, wild orgies of intoxication following considerable periods of the plodding life. This periodicity is seen in convivial drinking of all times and is a familiar fact in every community at the present. The power of self-restraint, strengthened by public sentiment and private prudence, deters from the use of alcohol up to a certain point, when the cumulative force of the desire, which is the cumulative need of release from painful tension, overthrows all barriers and excess and complete relaxation follow for a season.

So it appears that the effect of alcohol is a kind of "catharsis." We recall Aristotle's theory of the drama, which, he says, purifies the mind by giving free expression to certain of the emotions. In a way, therefore, the significance of alcohol is that it is an escape. It is not in itself desired; often enough it is hated. But the user finds himself under the rule of an imperative, an insistent idea, a tormenting presence, and this presence is his whole deep human personality crying out against the eternal urge of the "will to live." The spirit of the age proclaims that we must be efficient. Efficiency, and ever more efficiency, is demanded and the desire for alcohol is the desire for rest, for release from the tension, for freedom and abandonment. Nietzsche, crying out against this spirit of progress, says:

> Why does precisely this gloomy and vehement oppressor pursue me? I long for rest but it will not let me.

The relation between the effect of alcohol and that of the drama is again clearly expressed by Benjamin Ide Wheeler, when he says:

> That which was at the beginning the charm of the drama, and has been, so far as it is true to itself, ever since, is its power to release those who behold it for a little while from the burden and enthrallment of the commonplace workaday life, and bathe their wearied souls in dreams. This is the very heart of Dionysus, and this too is his claim to control the fruit of the vine.

But now, if this theory is correct, what is the conclusion? Is alcohol a means of purification through relaxation? Just so far as it affords rest to the wearied higher brain centers and relief from the tyranny of the will, it is a means of purification, but unfortunately it is at the same time a poison, bringing in its train a heavy residuum of damage not only to society, but to the individual. The imperative need of relaxation is apparent, but, while play and sport are relaxing and recreative, alcohol is relaxing and destructive. The colossal evil of its excessive use is evident to every one, but there is reason to believe that even its moderate use detracts from the sum-total of well-being of the individual in exact proportion to the amount used. It is possible, however, that the case is still worse. Let us suppose that alcohol were not a poison, that it had no effect beyond a slight paralysis of the higher brain centers. What will be the cumulative effects of such action upon the individual and the race? This question can not at present be answered. It seems probable that this constant doping of the highest and most delicate nervous centers, while it affords the needed relaxation, may work havoc with the delicate organization of the brain. Possibly alcohol represents a factor of maladaptation in the evolution of man and will prevent the realization of his highest destiny. If we consider the degree of civilization attained by the ancient Greeks, several stages above our own in art, and on an equal plane at least in poetry, in eloquence, and in philosophy, we are impressed with the slight progress we have made, when measured by a reasonable expectation based on the time which has elapsed and our rich intellectual inheritance. Gladstone bemoaned the lack of progress in intellectual power made by man in recent centuries. Is any one in position to say that this has not, in part at least, come about from meddling with ethyl alcohol?

THE NEXT COLLEGE PRESIDENT

BY A NEAR-PROFESSOR

IT was in the autumn of 1911 that the press gave wide publicity to a meeting of college presidents, deans and professors convened in honor of the installation of the chancellor of a metropolitan university. At the dinner that closed the ceremonies one of the speakers, himself the president of another great university, assured the audience that being a university president was great fun since among other perquisites of the position was that of being able to dine on college professors.

The press reports of the dinner were read by a near-professor as he sat in his modest study in a distant college town. The phrase used by the distinguished university president seemed strangely familiar, and turning to a package of notes in his desk he found among them the record of a conversation with a former colleague and read in the words of his friend, "Sometimes the board of trustees eats the president, sometimes the president eats the board of trustees, but both always eat the faculty."

It was indeed passing strange, the near-professor pondered, to find such unanimity of opinion between a great university president and a humble college professor as to the part in the educational system played by the college faculty, and henceforth he felt his own course was clear; if the high cost of living restricted his own daily menu, he could at least serve the cause of education by cheerfully recognizing his place and becoming the baked meats for the table of his academic superior.

But before consciously laying his head on the president's dinner platter, it seemed wise to the near-professor to turn again to his bulky package of notes. They were the accumulations of several years and they represented the reports of presidents of colleges in nearly every state in the union, anonymous articles by college professors that had appeared in all of the leading reviews of the country, anonymous letters on educational organization written to the press and turned over to him by a journalist brother, memoranda of conversation that he had had with professors from other colleges when they were separated by the Atlantic from their academic dinner tables, descriptions of the organization of education in nearly every country in Europe, private letters from personal friends whose official heads had yielded a Barmecide feast to various college presidents, and fragments from his own observation and experience.

As he examined the mass of material he was conscious of a secret fear lest its very presence in his desk should betray him into the hands of his official superiors. He could indeed justify its presence there on the ground that the accumulation was in large part accidental, that "he had not meant to do it," that the small field of knowledge in which he had been permitted to work had been so intimately connected with all questions of organization that he could not well avoid an interest in the by-product of educational organization—still and all, he had to admit that he was a victim of abject, craven fear. Yet in his early youth he had fortified himself against the oncoming of age by committing to memory Longfellow's "Morituri Salutamus," and now its appeal to banish fear, doubt and indecision stood him in good stead, not so much against old age, for that seemed farther away than it had at twenty, as against the spectre of a frowning chief and a possible official decapitation. The material in his desk, he reasoned, might be of some slight service in the discussion of a question that was filling every year a larger and ever increasingly larger place in the minds of all engaged in educational work, whether as college professors or as teachers in the public schools. He was as much in honor bound, he reasoned again, to make his contribution to the cause of education as he was to pay his pew rent in church and to give of his wife's substance to the foreign missionary cause.

Turning his attention first to the organization of the so-called "higher institutions of learning," the near-professor found that the factors directly and indirectly concerned are eight.

The factor least immediately involved is the public at large and it may be called collectively the state. It has no direct part in the government of higher educational institutions except in those states where members of the boards of regents are elected by popular vote. The state has, however, a direct financial interest in the subject since the property of educational institutions on private foundations is exempt from taxation, and on the other hand public educational institutions are supported by state taxation.

The parents of students have as such no part either direct or indirect in the management of a college, nor do they consciously to themselves exert the most remote influence on the conduct of its affairs. Nevertheless, the parent is a potent factor in shaping the policy of a college, through serving as a foil against proposed innovations. Do the students desire a larger measure of self government, the parent "who would not approve" prevents its realization. Do the alumni favor a radical departure from the curriculum that has been in force, the parent "likes what we have and sends his son here to get it," and hence no change is made. Does some one suggest dropping the Latin salutatory and the valedictory from the commencement exercises, the parent "likes the present plan" and therefore the Latin salutatory and the valedictory are retained. If the college authorities believe that they stand *in loco parentis,* they are certainly right in governing their action by the supposed wishes of parents. Yet it is not known that a poll of the parents has ever been taken on any subject of college policy, it is quite possible that the expressions of approval or disapproval of proposed changes are purely individual, it is even probable that the opinions expressed are such as are felt to be in harmony with the wishes of the administration, and it is altogether credible that the shade of the absent parent has been evoked to give countenance to policies of the administration as unalterable as were the laws of the Medes and Persians.

The benefactor has long been recognized as a powerful, although unacknowledged, influence in the administration of the college on a private foundation. He is a member of the board of trustees and as such wields great authority. He is consulted on all matters of college policy, his wishes are deferred to whenever a difference of opinion arises between him and his colleagues, and he is the power behind the throne on which sits the college president. To him more than to any other giver is applied the adage that one must not look a gift horse in the mouth. If the benefactor is interested in science and wishes to give the college a physical laboratory, the college accepts it without question although its greatest need may be for a new library building. If the benefactor thinks "the boys" need more athletics, he spends a fortune on a stadium even though the college may be in crying need of funds to pay the salaries of its professors. If the benefactor thinks a building would adorn a sightly part of the campus, he puts one there, even though the college may not have sufficient funds to keep it adequately cleaned, warmed and lighted. "I would a thousand times rather have dealings with a state legislature than with the private benefactor on whose will or whims the welfare of a university depends," said a president who had had experience as the head of a state university and of one controlled by "the munificent benefactor." It is possible to meet political influence fairly, squarely and openly, but it is impossible to meet the undue personal influence of the private benefactor who may be giving to the college his time and his energies, as well as his funds, but is practically irresponsible. The zeal of the benefactor is appreciated, yet it often is an illustration of misdirected energy since the educational interest realized on the capitalistic benefaction is sometimes in inverse proportion to the amount invested.

The student body is as yet a somewhat inert mass as regards its attitude toward educational policies. The force of tradition is strong and tradition makes the student, at least in theory, passive and receptive rather than active and creative; it teaches him unquestioning obedience to authority; it scoffs at his desire to know the meaning of what he does; it mocks his wish to have a part in deciding the policy that controls his daily actions. Even the community in which he lives is prone to scorn his efforts to play a part in the settlement of the questions that intimately concern him.

A few years ago internal troubles in one of our universities led to a rumor that the president had asked for the resignation of every member of the faculty. In consequence of this a mass meeting of the students was called, but before the students assembled a message was sent them by the president saying that no meeting would be permitted unless the students agreed to act in accordance with his wishes.

A few days later one of the city papers in discussing the situation said editorially,

> First of all a warning should be given to the students. They should be politely, but firmly, ordered off the stage. They are not in the remotest degree a factor in the present affair. The factors are the president, the directors and the taxpayers as a body. The students, who contribute next to nothing to the finances of the university, represent only 400 or 500 taxpayers. The student body of the university represents an insignificant fraction of one of the three factors of the present issue, and, therefore, should have so small a voice in the affair that it is not worth considering. And they should remember that what voice they have is as taxpayers, not as students.

Nevertheless, tradition does not always remain impregnable and there are signs of weakness in some of its strongholds. The college student may have come from a school city where in a public high school he has had some small share in educational legislation and administration. He may have entered from a private secondary school where self-government has attained a vigorous growth. If in college his abilities lead him into the field of science, the spirit of investigation he meets there turns his questioning mind to the investigation of education; if his interests lie in political science the organization of the state directs his thoughts to the organization of education; if he is absorbed in economics, the question of the mutual relations of capital and labor, of employer and employee, of the individual and the state lead to questions of the mutual relationship of all parties concerned in education; the very process of education trains him in mental activity and he is quick to apply this activity to the study of the conditions in which he is placed.

Again, he can not escape the discussion of all phases of the question as it is presented in the daily press and in current periodicals. The spirit of research, of investigation and of inquiry in every form is abroad in every land, and it has its influence on the college student. Democracy in the state, in society, in industry, is taking on new meanings and is making new applications. Experiments in self-government are being tried in reformatory, corrective and penal institutions, and even hospitals for the feeble-minded and for the insane are turning to the same plan as part of their remedial treatment.

Even the college student himself has often had personal experience in matters of government. The average age of the college man at graduation is about twenty-three and he has been a possible voter for two years. If he has sufficient maturity to have a voice in the decisions of affairs of state, is it not reasonable to suppose, he asks, that he can be given some small share in the decision of educational matters that immediately affect him?

That the college undergraduate has had as yet so small a share in the conduct and policy of the institution with which he is temporarily connected by no means augurs that his share will continue permanently negligible.

The alumni of a college have but recently been given a representation on boards of trustees. This representation has not always been warmly welcomed by the boards as previously organized, and it has been granted only through the persistent efforts of alumni organizations. These efforts have been made because of a growing feeling that some official medium of communication is necessary between a board of trustees and the undergraduate body. The college has, moreover, been enlarging its activities along lines not strictly academic, and with the increasing interest in college athletics, college dramatics and college musical clubs, appeals have been made to the alumni to assist in financing these enterprises. These appeals have usually been made through class organizations, alumni associations, and the graduate and undergraduate college press, and the very appeals themselves have stimulated interest in general college affairs. One result has therefore apparently been to increase the general contributions of the alumni to their alma mater and this fact has furnished another and perhaps more valid reason for the election of a limited number of trustees by and from the alumni themselves.

Just how effective this representation is in influencing the policy of boards of control is at least a question. The alumni trustees are always in a minority, they hold office for a limited term while their colleagues on the board usually are elected for life, their point of view may not always be that of the other members of the board, yet they are often cautious, if not in reality timid, in expressing views divergent from those of the majority, they represent a body having no legal but only a sentimental relationship to the institution, and they are as a rule only contributors of ideas not signers of checks. But if the direct results of alumni representation seem somewhat negligible, the indirect results of such representation have been most wholesome. It has stimulated the loyalty and the enthusiasm of college graduates in behalf of their own college, it has led to acquaintance among the alumni representatives of different colleges and thus to the exchange of facts, opinions and experiences to the profit of all concerned, it has resulted in a more intelligent appreciation of what the great educational problems of the day really are, and it has aroused a desire to have these problems investigated by experts in order that the layman may have put before him authoritative data as a basis for discussion. If we have everywhere to-day a passion for education that partakes of the religious fervor of an earlier time it may in large part be explained by this thin entering wedge of alumni representation on boards of college trustees.

The part taken by the state, the parent, the benefactor, the undergraduate body and the alumni is either too slight to have an appreciable effect in formulating educational policy, or it is too irresponsible to be met and discussed in the open, or it is prophetic of future opportunities rather than a chronicle of past achievement.

In the eye of the law the only authority responsible for the conduct of the affairs of a college is that vested in the board of control, usually denominated a board of regents or a board of trustees. The nature and the measure of this responsibility is largely determined by the source of the financial support of the institutions concerned.

Higher institutions of learning are of two general types as regards this support. In universities supported by the state, the members of the board of regents may be appointed by the governor of the state or elected by the qualified voters of the state; in either of these cases, the members of the board hold office for a limited term of years. Colleges on a private foundation are controlled by a board of trustees whose members form a close corporation. They are self-perpetuating and are elected for life, although a recent modification of this plan provides that members of the board are to hold office for a limited term and membership may be automatically changed at the end of a definite period. But irrespective of number of members, term of office, and method of appointment or election, the result is the anomalous one of placing in control of nearly every great and every small institution of higher learning in America a body of men that have no connection with the educational work of the institution, that are not members of its faculties, that are not necessarily numbered among its graduates or its former students, or indeed among those of any other college or university. Yet the control of these external bodies over our educational institutions is absolute in that both the financial and the educational policy come within their jurisdiction, and their control is irresponsible in that they render no account of their stewardship and as a rule they hold office for life, not during good behavior. Technically and legally all-powerful, these external boards of control do not exercise their authority directly, but they delegate it to their appointee, the college president. He thus in his turn becomes all-powerful, not by virtue of original and vested authority but through authority delegated to him by these boards.

It is thus seen that the most important function of this external board of control is to-day that of appointing the college president, and that the great power in the educational world thereby becomes the college or university president.

The position of the American college president is absolutely unique in the educational world, yet the evolution of the office has been a simple one and it is easily traced. The great majority of the older colleges in America were founded either by ecclesiastical organizations or, in communities where the civil and the ecclesiastical power, were identical, by the state, and the function of its college was to educate young men for the ministry. Thus it followed that at first the college president sustained much the same relation to the student body that the pastor of a church sustained to the members of his congregation—he was the spiritual teacher and adviser, the religious head of an institution founded for religious purposes. The first and the final test of his qualification for the position was that of orthodoxy, and when this was called in question his position as president of a college was no longer tenable. But as the ecclesiastical rigor that bound both church and state gradually relaxed, a change took place in the qualifications demanded of a college president. Education as a process came to be more emphasized and it became necessary for the college president to be not only a clergyman, but also to have a strong and commanding personality. The college president became the great teacher—a class of which Mark Hopkins will always stand as the type—and his chief financial duty was to raise funds for scholarships for the education of "worthy young men."

The next step in the evolution of the college president came when the college was frequented by young men whose career in life was to be, not the ministry, but one of the other learned professions, or business, or some branch of applied science. This necessitated the development of the secular side of education, and with this development came the demand for increased appliances, for laboratories, for large additions to libraries and museums, for the enlargement in every direction of the educational plant. Funds must be raised to provide this equipment and on the shoulders of the college president was laid the burden of securing them. Thus the college president became not only the religious head and the educational head of the institution, but its financial agent.

But it followed naturally that if large endowments were to be secured by the college president, he must be "a good mixer" with those who might be persuaded to contribute to the college. A clergyman, a scholar, a recluse, might possibly teach, but other qualifications for raising funds were imperative. He must be a man of fine presence, genial manner, consummate tact, a ready and acceptable public speaker—he must be in the best sense of the work, "a man of the world." The college president thus added to his previous qualifications of clergyman, teacher, and financial agent that of a fitting social representative of the institution.

But increased and increasing endowments entailed the burden of organizing and administering them. The funds secured must be wisely used and no one could hope to be successful as the head of an educational institution who did not unite with the ability to raise funds that of a wise administrator.

But wise administration is a complex term. It implies the organization not only of the internal but of the external affairs of an institution—the care of buildings and of grounds, and even familiarity with a species of hotel-keeping if the college has dormitories or residence halls.

Thus by an accumulation of duties that have been added as the scope of the college has broadened, the college president has added to his primary qualification of religious head that of educational head, financial head, social head and administrative head, including the duties of superintendent of buildings and grounds and even those of hotel proprietor. It has been a veritable piling of Ossa on Pelion and the office has become so burdened with duties and responsibilities that it seems as if it must break down of its own weight.

A person unfamiliar with the situation might reasonably conclude that all of our colleges and universities were threatened with bankruptcy and had been placed in the hands of a receiver so unlimited are the powers that have been conferred on their presidents. But those whose acquaintance with present conditions makes it possible for them to understand the steps by which this present development has been reached know that the powers now placed in the hands of the president have been cumulative and in a measure accidental rather than the result of fixed plan.

Of the eight factors concerned in college legislation and administration, seven have been considered. It remains only to examine the part taken by the faculty in the government of the colleges with which they are associated. Singularly enough this part seems entirely negligible. The faculty of a college has no voice in the election of a president who is to rule over them by appointive if not by divine right, nor are its members, as far as known, ever consulted when a choice of president is to be made, nor are even expressions of opinion sought from them.

It is also true that no college professor is ever a member of the board of trustees that governs the institution with which he is connected, and that he is even in some cases expressly prohibited from ever becoming a member of the governing body. The corporate state may be represented by its governor who may be *ex officio* a member of the board of trustees of a college within the state; the state at large may through the votes of its citizens choose the boards of regents who control the policy of the state university; the educational system of the state may be represented by the state superintendent of the public instruction who may also be an *ex officio* member of a board of trustees; ecclesiastical bodies are as such sometimes represented on boards of trustees; the alumni now have representatives elected by and from their own number on many boards of trustees. But members of a college faculty have no voice whatever in the election of boards of trustees who control the policy of a college, nor have they any representation on the board of trustees. It is indeed sometimes said they are so represented by the president of the college, but since the president is elected by the trustees, not by the faculty, such a statement seems to be a mere juggling with words.

The question therefore of who is in actual control of our colleges and universities can be answered clearly, authoritatively and emphatically—it is the college president and the university president. The answer does not follow as a result of eliminating from the eight factors concerned in the problem all of the other seven whose authority has been shown to be either negligible or negative—it has been given in unmistakable terms on more than one occasion when a new college president has been elected or inaugurated, as also at other times and in other places.

The theory of the presidency is definitely stated in a series of statutes defining the powers and duties of the president that were drawn up a few years ago when a president was sought for an important university. They were formulated by the trustees after consultation with the leading candidate for the position, and they are given in full as being probably the most explicit statement as yet made concerning the office.

First. The president shall be ex-officio a member of each faculty, and it shall be his right and duty to preside at every meeting thereof.

Second. The president shall have the power of nominating the dean of each faculty, subject to the approval of the board of trustees.

Third. The president shall have the right to attend all meetings of the board and to address the board upon all subjects connected with the university. He shall be ex-officio a member of all standing committees of the board.

Fourth. The president shall have the exclusive right to transmit all communications from each faculty and from each member thereof, to the board.

Fifth. The president shall have the right to recommend to the board the vacation of professorships and other positions in all departments.

Sixth. The president shall have the exclusive right to nominate professors in all departments except in so far as this may be inconsistent with the contracts under which certain of the departments are now conducted.

Seventh. The president shall have ultimate authority in all matters of discipline.

Eighth. The president shall have the right to advise the board in all matters of expenditure.

Ninth. The president shall have control of all employees engaged in the preservation and maintenance of the buildings of all departments of the university, and he shall be the chief custodian of such buildings.

At another great university a popular professor of another institution was offered the presidency, but he

delayed his acceptance until he had come to a clear understanding with the regents as to their future relations. He said with much frankness that one great disadvantage of the University of ——— had always been the disposition of the regents to meddle in the internal management, especially in personal matters, such as appointments, promotions and salaries; and he received assurance that the initiative in these matters should rest with himself.

At a third great institution where the power of control came to be vested in a single person, it was announced that the trustee had paid "a high compliment to President ——— by giving him absolute power over the management of the educational affairs of the University."

At a fourth institution the candidate selected by the board of trustees dictated his own terms in accepting the office of president of a college and it was announced that "the board of trustees has accepted the principles proposed by ——— and all direction of the faculty will proceed from him."

At another time a university president took summary action in regard to several members of the faculty, and when "the persons concerned" asked the reason for the action they received the reply from the president, "I have no reasons to give. It is my pleasure." It is possible that the distinguished president was only unconsciously reflecting his morning lesson from Kipling,

Now these are the laws of the Jungle,
And many and mighty are they;
But the head and the hoof of the Law
And the haunch and the hump is—Obey.

The privilege of overriding legislation of the faculty is claimed by the president of at least one great university. Somewhat recently when the name of a student who was a candidate for a degree in arts was presented to the faculty, the head of one department reported that the candidate had not completed all the work prescribed by the faculty as necessary before obtaining the degree. The president refused to allow the faculty to vote on the case and later stated in the press, over his own signature, "that the president of the university has the authority and privilege of submitting to the trustees a recommendation for any degree without consulting any faculty or any member of a faculty."

These illustrations could be multiplied almost indefinitely. They seem to furnish some ground for the observation of a college professor that "the college presidency is a despotism untempered by assassination."

That the college president "is bearing up well" under these manifold duties and responsibilities and that unlike his brother politician in the state he does not "view the present situation with alarm" there is abundant evidence on every side to prove. He has in the first place written two or three books on the subject—that the number is so limited is in itself perhaps indicative of the insignificant part the whole subject takes in his mind. A more extended source of information is found in the memoirs of college presidents who have taken the public into their confidence. Occasionally the college president has written an anonymous magazine article; in one of these he has enlarged on the perplexities of his position, which he likens to those of a stage-coach driver compelled to prod one lazy horse into doing his share of the work while at the same time trying to prevent another spirited one from kicking over the traces. The near-professor was a near-instructor at the time he read this particular article, but he still vividly recalls the strong desire he felt to urge the college president to give up stage-coach driving for a living and get another job.

But the college president, unlike the college professor, seldom finds it necessary or wishes to conceal his identity. Educational reviews, educational associations, the inaugurations of brother presidents, and public educational functions of every description give him abundant opportunity to express his opinions in regard to the present distribution of powers between president and faculty and to give his general approval of the principle "it's heads I win and tails you lose."

At a somewhat recent inauguration of a university president, the previous incumbent of the position gave an address on "The University Presidency." In this he states that "the president must mark out his official course for himself and bear the responsibility of it without cavil. He can not expect that the work he has to do will make everybody happy. It will discomfit many. In one way or another they will give him all the trouble they can." This statement seems so absolutely final as to make it unnecessary to add further illustrations, many though there be at command.

But extreme as this statement of a former university president must seem to all who take an active interest in the organization of our educational system, much as these extreme statements are in themselves to be deprecated, irritating and exasperating as must seem the official relationships between college president and college faculty in view of this apparently prevailing conception of the college presidency as held by the college president, it must, after all, never be forgotten, even by those who suffer from the system, that the college president of to-day is the victim of the very virtues of his official predecessors. An overconscientious desire to do all that he should has often led him to undertake more than he can accomplish; a real desire to save his colleagues from undue burdens has led him to assume tasks that his colleagues needed to perform for the sake of their own educational growth; a belief in his own divine right to rule—a belief born of his ecclesiastical ancestry—has carried with it the corresponding belief in the right of others to be ruled; a conviction that if it is his duty "to break in" an unruly team, it is the duty of the team to be broken in; all of these and still other inherited and accumulated beliefs explain the origin of conditions that in the great majority of colleges to-day result in probably more or less friction between the president of the college and the faculty. If there is little friction evident, it is because of strong personal attachment between the president and the members of the faculty individually—there is occasional lack of friction in spite of the system, not because of it.

But explanations, however reasonable and satisfactory they may be, do not alter the fact that the college president has not only freely expressed his opinion in regard to his own place in the educational system, but he has also on occasions shown why the present arrangement has been foreordained to perpetuity.

The first reason alleged for the continuance of the present system of external legislation and autocratic administration is that college faculties are unable to do business. "It goes without saying, and properly and without adverse criticism, that the temper of mind which turns a man to the higher forms of scholarship and to investigation and research is not the temper which fits him for executive work," is the statement of a former university president, but it was made before the election of President Wilson. Another president finds that "a faculty is made up chiefly of specialists, for the most part untrained in the business of administration and without special responsibility for the college and the larger relationships." Still a third finds "that a faculty that governs itself in an extreme degree is likely to be extremely conservative; it is likely to perpetuate traditions; it is likely not to be in touch with progressive thought," though the danger to be anticipated from faculty government is, in the opinion of a fourth, "its radical tendencies." This difference in point of view may, however, be explained by the geographical location of the two institutions whose presidents have given these judgments—one is east and one is west. And yet another emphatic, unqualified statement is made that "the very worst form of government for college or university is that of a faculty."

This very insistence on the inability of the corporate faculty thereby tends to make a faculty incompetent. That a man quickly becomes what he is thought to be has been learned in nearly every other field but that of normal education. Even those who deal with criminals are learning that the quickest way to make a man guilty of crime is to believe him capable of committing a crime, that trust and confidence win a wavering man to the side of law and order while suspicion and distrust send him to the side of lawlessness and crime. But no hope seems to be held out for the college faculty—it ever hears from the platform and through the press that it is incapable of doing business and the discouraging feature of the situation is that the American college faculty is coming to believe it.

It is also asserted that the college professor does not wish to take a larger part than he now has in the direction of educational policy. "I have heard a good deal about the growing impatience at the amount of business detail forced on the faculty because of this faculty form of government" is the statement made by a university president. "By far the greatest number in every faculty neither desire to assume administrative burdens nor are extraordinarily competent for such tasks" is the opinion of another president. Even so eminent a man as ex-President Eliot has shown much solicitude on this point when he says:

> Most American professors of good quality would regard the imposition of duties concerning the selection of professors and other teachers, the election of the president and the annual arrangement of the budget of the institution as a serious reduction in the attractiveness of the scholar's life and the professional career.

The near-professor from the safe retreat of his desk in the middle west ventures to ask by what authority ex-President Eliot presumes to speak for the American college professor, why he assumes that the election of a college president, once in say forty years, should be a more serious reduction in the attractiveness of the scholar's life than is a vote every four years for the electors of the federal president, why the cooperative annual arrangement of the budget of an institution should be a greater infringement on the professional career than is the unaided preparation of the domestic budget with a limited salary and a growing family, why the implication is made that it is only professors of bad quality who grasp at things so far beyond their reach as the selection of professors and other teachers, and why indeed a representative of Puritan New England could imagine that even a college professor would falter in his duty if that duty led him for a brief period from the attractiveness of the scholar's life into the more arduous paths heretofore trodden alone by the college president.

Another reason assigned is the infirmities of temper charged up to the college professor. One president complains:

> Truly the academic animal is a strange beast. If he can not have something at which he can growl and snarl, he will growl and snarl at nothing at all.

Another reports that he has to deal with men "not altogether ripe for translation." It is a member of a board of trustees who arraigns the entire faculty over which he and his fellow trustees exercise jurisdiction with the seven deadly sins of "jealousy," "bickerings," "professional incompetency," "demoralization," "discourtesy," "lack of discipline," and "laziness"—if this term properly translates the statements that "no original work worthy of note has been done by the members of the faculty," and that "the professors are practically unknown to the literature of their respective subjects, even after long years of identification with their respective departments of instruction." Truly the members of university faculties may set forth not only the private tables of university presidents, but also the extension dining tables of boards of trustees.

The near-professor recalled that he had once read the story of a conversation between Browning and a Jewish friend in which the latter had sought an explanation for the repugnance often inspired by some of his race and found it, he thought, in the difference in appearance and manner between the Jews and the Christians of a certain class. Browning replied:

> Naturally their characteristics would become more intensified through long exclusion from other groups of men; their manners would be unlike those of others with whom they were not allowed to mix. No wonder if, hedged in as they were, those peculiarities took offensive shapes. Does not every development, to become normal, require space? Why, our very foot, if you restrict it and hedge it in, throws out a corn in self-defense!

Still another reason assigned is that it is not the business of the faculty. "The business of university faculties is teaching. It is not legislation and it is not administration," is the emphatic statement of one president. "The special office of the faculty is to teach," states a second president. "The duties of a professor are investigation and instruction," adds a third. No statement seems to be so generally endorsed by college presidents as that "it is the business of teachers to teach."

It is altogether probable that college professors would agree that their chief, if not their only, *raison dêtre* is teaching, if the term teaching is made elastic enough to cover the time and opportunity needed to pursue knowledge. For how can the blind lead the blind, how can we make bricks without straw, are the ever iterated and re-iterated cries of those weighed down with the burdens of daily teaching, of those who have no opportunity themselves of drinking at the Pierian spring, yet must hold the cup to the lips of others. "Our function in the educational system is indeed teaching," they may well say, "but we must ourselves seek and find knowledge if we are to pass it on to others."

But who shall define the limits of teaching, or prescribe the boundaries of the educational field, or determine the nature of those questions that are "purely professional," or set now on this side and then on that the subjects that concern special departments and those that concern education in general? Teaching and new buildings, teaching and improved equipment, teaching and additional instructors, teaching and academic freedom, teaching and pensions, are all questions of Siamese twinship. Who shall separate teaching from any other part of the educational body without thereby taking from it the breath of life?

It must be evident that the present method of collegiate organization has not only produced friction, for among all the colleges and universities located between Maine and California and between Florida and Washington the number can be counted on the fingers of one hand where there is no friction of an aggravated character either between the board of trustees and the president, or between the president and the faculty, but that it has also resulted in serious incongruities of conditions and of relationships.

Some of these incongruities are connected with the office of the president. They result from attempting to fit the round peg into the square hole and they would be amusing did they not so vitally concern our entire educational system. If a successful business man is elected the president of a college, he may inaugurate a campaign of efficiency in order to determine "just how much work each member of the educational staff is doing in the matter of instruction, what he is producing in connection with his chosen line of specialization and—in short—to determine his value to the institution as compared with that of his colleagues." If a person without even the first college degree is called to a college presidency, he may be solemnly asked in the first interview granted the representatives of the press to enunciate his views in regard to the graduate school. If a clergyman is transplanted from a city or a country parish to the presidency of a great university, he may at once begin planning for new schools of civil and mining engineering. If an eminent physician is invited to become a college president he may immediately promulgate fantastic schemes for strengthening the college by the introduction of a plan to promote friendly rivalry among the professors.

It is safe to say that if positions were reversed the incongruities would be apparent to all. No professor of mathematics would be called to the pastorate of a city church, no head of a department of modern languages would *ipso facto* be deemed qualified for the headship of a theological seminary, no professor of English could without special medical training receive a license to practise medicine, no professor of chemistry would be considered a qualified lawyer.

One of the most unfortunate features of the official relationship between president and faculty is that if a member of the faculty raises a question in regard to a matter of college policy it is regarded as an unjustifiable interference on his part. His question may seem to him altogether devoid of harm—he may ask in regard to the probable site of a new building, the nature of the campus hedge that is to be set out, or whether the city fathers have ordered the campus drinking water boiled, but in any case he is probably warned that the shoemaker should stick to his last.

It is also unfortunately true that any criticism of the policy of the administration is often resented as "a personal attack on the president." A member of the faculty may question the wisdom of admitting students poorly prepared, or of retaining students whose ill health makes it difficult for them to do their college work, or of dismissing students who have presented a petition stating what they believe to be grievances, but all such questions are too often interpreted as "attacks on the president."

In one institution where autocratic rule has been carried to an intolerable degree, one of the professors at one time suggested some improvements that might be made in the institution. He was quickly removed and no protest was made by his colleagues either collectively or individually because they were too timid to do so or because they were too much hampered by the meager salaries paid to feel justified in running the risk of removal. But in spite of apparent acquiescence in the action of the president, one by one the members of a small group were dropped on the suspicion of being sympathizers with the erring professor because known to be his personal friends. They were afterwards pursued by a relentless persecution that for years prevented any of the number from securing positions in the educational field for which their ability and professional qualifications fitted them.

At the time of friction between a president and members of the faculty due to the unexplained demand made for the resignation of several of its members, the professors involved sent to the board of trustees a respectful petition asking for a full and open investigation of their work. This petition was characterized by the board as "rank insubordination," since a by-law of the university provided that all communications from the faculty should come to the board through the hands of the president. "The communication should be treated with just the respect it deserves," said a member of the board of trustees in a public meeting. "It is an insult to the board and to the President; it is rank discourtesy, and for one, I do not propose to stand it. I move the letter be sent to the writer." "And the board concurred," is the comment of the press, "smashing the right of petition at one very large and full swoop."

The policy of concealment that prevails makes it difficult for the public to know what the situation really is. The public knows that more than one university professor has been dismissed, or his resignation has been demanded "for the good of the institution," and it draws the conclusion that these are examples of martyrdom in the cause of academic freedom of speech. In a few instances such has been the case, but in other instances, men have been relieved of their positions because they have been incompetent to fill them. Such men have sometimes chosen to assume that they were dismissed for holding opinions at variance with those of the administration, but those who have been familiar with the situation have wondered less that these professors were dismissed from their positions than that were ever appointed to them. To president and faculty alike lack of frankness and freedom of expression brings needlessly harsh and often unmerited criticism.

What wonder if members of college faculties, on their part, sometimes feel that they are employees, hired by the year, with a time-card, and with a "boss" to enforce discipline; that they are clerks in a department store with the floorwalker ever present to keep them at their tasks; that they are horses in stalls conveyed by railway train to some distant point unknown to them; that they are tagged and pigeonholed in the desk of the president; that they are parts of a machine, irresponsible for the results of its work. Yet they never forget that it is also true that at rare intervals great educational leaders have arisen who by natural ability and educational training have seemed ideally qualified for the headship of great educational institutions. And it has been unfortunately true that these leaders have led where there have been few to follow. Trustees, faculty, alumni and undergraduates accustomed to the old order have feared to break with the past and have turned back again when the path has narrowed and clouds have obscured the heights.

The inorganic nature of the college and the lack of relationship among its different parts is well illustrated in the typical college campus. This is crowded with buildings representing every period of architecture known and not infrequently having buildings that utterly refuse to be classified; every variety of building material has been used in their construction; when several buildings have been erected of the same material, as of brick, the incongruities are needlessly multiplied by the use of pressed brick, tapestry brick, cream brick, and every other variety and color known to the builder; when one form of brick has been somewhat consistently used, the trimmings of granite, of white marble, or of red sandstone, or of brown sandstone, add the seemingly inevitable note of discord. Even single buildings illustrate the same spirit. One college received the gift of a physics laboratory and the building was planned by the president and a local mechanic without any consultation with the professor of physics. In another university the president secured the funds for a new library building and this he felt gave him the right to decide on the plans for it and also to select its location on the campus; incidentally, the site selected was next to the athletic field. In another college, the planning of a large lecture hall to be occupied jointly by several departments was turned over to a young architect who had never planned an educational building of any sort. Without consultation with any of the departments concerned, the plans were drawn up, the building was erected, and the members of the faculty moved in. That some rooms were to be used for classes in mathematics and others for work in modern languages and still others for English had apparently in no way affected the plans.

Nor are these conditions necessarily due to differences in the periods at which college buildings have been erected—they prevail on more than one campus where the greater number of buildings have been erected in a single generation during the incumbency of a single president. Nor are they always due to the selection of different architects—in more than one instance a single architect has planned the greater number of the buildings of a college campus, yet he has been the chief of sinners in including among the buildings he has planned those that range in style from the classical period through the gothic, romanesque and renaissance to a Queen Anne house, a French château, or a feudal castle for the president.

The Architectural Record has recently published a series of articles by Montgomery Schuyler on the architecture of American colleges and more than one of the articles has emphasized the lack of harmony and the absence of a consistent plan in the buildings of a college campus. The author writes of one college:

> Seemingly, there has been enough money spent on buildings to execute such a scheme (of unity and variety) handsomely and impressively. The actual result is simply deplorable in the crudity of the parts and the absence of anything that can be decently called a whole. . . . There is not a trace of a general plan. The disposition of the buildings in relation to one another is as higgledy-piggledy as the design of each considered by itself.

The architecture of college buildings and the planning of a college campus may not seem to come within the range of a discussion of the next college president, but in fact nothing else in the domain of education seems to illustrate so well and so vividly the incongruities of the educational system itself. What the college is in brick and mortar, that the college is in its organization and in its educational plan. He who runs may read the incongruities of the college campus, but he who loiters has perceived but dimly, if at all, the intellectual incongruities reflected through it.

In view of these conditions who shall be the next college president? A former university president at the recent inauguration of one of his successors enumerates some twenty qualifications that should be found in the man who fills the office, although he states that "the qualities which enter into the making of an ideal college president are very widely distributed and never can be found represented in a great many men."

The members of a college faculty are ready to accept this statement of the difficulty of finding the ideal college president. But unlike members of boards of trustees they are concerning themselves not with candidates for the position of president, but with the organization of the presidency. And first of all it seems clear to one who "can easier teach twenty what were good to be done than be one of twenty to follow his own teaching" that the first plain duty is to recognize the existence of the situation and then frankly meet it.

A recent inquiry instituted among three hundred professors of science in this country seems to indicate that in the opinion of eighty-five per cent. of these the present conditions are intolerable. This opinion may be entirely wrong, but it behooves even the college president either to disprove it or to accept it. Since he is to-day, by the very nature of his position, an administrative officer and business manager, rather than an investigator, it seems improbable that he will be inclined to undertake such investigation as would give a larger basis for generalization than that already carried on by a college professor. Until such time, therefore, as the college president can broaden the basis of generalization already provided for him by a college professor he should accept the conclusions drawn and adapt his course to them.

This investigation seems to show that what many college professors to-day desire is not more administrative work, but greater legislative power. Time is now frittered away by college faculties in administration that ought to be done by the administrative officer; college faculties wish less rather than more of these responsibilities. But many college professors do believe that every question of legislation that concerns the educational work of the college no matter how remotely or how indirectly should be acted upon by themselves, that they should have representation on the boards of control, and most of all that they should be educationally enfranchised to the extent of choosing their own president. They would probably at the outset agree with Dr. Patton that "the qualities which enter into the making of an ideal college president are very widely distributed," and that "it is their assemblage and their blending in the charm of an engaging personality that creats difficulties and also makes the selection of a college president a weary search." Recognizing the weariness of the search, they would abandon it at the outset and concentrate their efforts on the consideration of what should be the organization, powers and duties of the presidency.

What many college professors also desire is greater community of interest and of action with each other and with their official head. College presidents are wont to boast of the infrequency of the faculty meetings in their own institutions and they seem to believe that one measure of their official success is their ability to dispense wholly or in part with such meetings. Yet what is needed for the good of the cause is not fewer but many more faculty meetings. College professors are tempted, under present conditions, to confine themselves exclusively to their own line of work; they do not make connections with the work of other departments, or seek out relationships between different branches of knowledge, or see things as a whole. The college professor has in large measure been made what he is by the conditions in which he has been placed and he has lacked the courage to insist on having these conditions changed. But many men are conscious of the present, though not inevitable, limitations of vision, and they would most gladly welcome an opportunity to exchange opinions and experiences with others of the guild. Faculty meetings that should be genuine discussions of the large educational questions of the day would lengthen the range of vision of the college professor, perhaps even that of the college president; they would deepen and broaden his educational foundations; they would make him more sympathetic with the difficulties of his colleagues and more tolerant of opinions that differ from his own. "How can I hate a man I know?" asked the gentle Elia, and his own implied answer would be that given by the vast majority of college professors could friendly relationships be established among them. The great national learned societies whose annual meetings are a source of profit and inspiration to all who attend them show that college professors, given freedom of action, can conduct large meetings with decorum, and without bickerings and petty jealousies. Can it not be assumed that these same men in their own college faculties, were the opportunity offered them, could and would discuss large educational questions in the same tolerant, inquiring spirit? Is not the spirit of the seeker after truth the same both at home and abroad, and should not his own college receive the benefit of this spirit? Many men are heard year after year at the sessions of these learned societies whose voices have never been heard in their own colleges outside of their own class-rooms. Is not the college the loser, whether the college be interpreted as meaning board of trustees, president, faculty, students or alumni?

Members of college faculties want at least the opportunity of taking a more active part in the smaller as well as in the larger affairs of the college. Probably nearly every member of a college faculty belongs to a club that has rooms or a building of its own, and he finds there, hung in a conspicuous place, a "book of suggestions" wherein he is not only invited but even urged to enter any ideas he may have for the improvement of the club. He goes to the public library and he finds a box of slips whereon he may record the title and author of any book he thinks it advisable to add to the library. He works for a summer in the British Museum and one of the first books he sees is a portly volume in which he may register inquiries or make reports of conditions to be changed, and to all inquiries he speedily finds an answer recorded in the same volume, together with the thanks of the administration for calling attention to matters to be remedied. He dines on a railway train, and at the bottom of the menu card he finds an invitation to report to the officer named any lack of attention on the part of the waiters. He goes to a great railway restaurant and he finds there a request to report at the desk any complaint in regard to food or service.

In more than one line of public business he sees evidences of a friendly desire for cooperation between business managements and the general public.

It is probable that few persons, even few college professors, avail themselves of these privileges or heed these invitations and even urgent entreaties. Yet the very fact that such opportunities are given the public is at once a safeguard to the organization making them in that it forestalls carping criticism, and at the same time it affords an outlet to the ill humors that would otherwise poison the minds of even reasonable men. The situation is precisely the same as that involved in the resumption of specie payments, as long as men can not get a dollar in gold for every dollar of paper money they hold, they will continue to demand gold; when every paper dollar can be redeemed in gold at its face value, men prefer the more convenient paper bills to the gold coin.

But no "book of suggestions" now hangs in the office of a college president, no slips calling for ideas are circulated by boards of trustees among college faculties, no invitations to report leaks, screws loose, or balky window shades are sent out by managers of college buildings, no notice is posted in any college building asking college professors to register complaints of the failure of other college employees to have the lantern ready at the hour appointed for the lecture or to set up on time a piece of apparatus necessary for an important experiment.

Then, too, the college professor would like to have the next college president not only listen to his suggestions, but even go so far as to occasionally ask him for opinions! As it is, the college president when he first meets his faculty and in his public inaugural address states his own conception of the function of a college and outlines what his policy is to be in connection with the particular institution over which he has been called on to preside. It is not on record that he has ever asked the members of the faculty what their opinions are on these questions. He may not be an alumnus of the college or have ever served on its faculty, yet election to the presidency of an institution with which he has no personal connection and with whose history he can have been but imperfectly acquainted is assumed to endow him with omniscience and his utterances are received as those of a prophet. The college professor would sometimes like to play the rôle of prophet!

The near-professor passed a pleasant hour as he reorganized the office of the college presidency, and then he turned to his Quentin Durward and to the conversation between the Scot and the Bohemian who boasted of his liberty.

> "But you are subject to instant execution, at the pleasure of the Judge."
> "Be it so," returned the Bohemian; "I can but die so much the sooner."
> "And to imprisonment also," said the Scot; "and where, then, is your boasted freedom?"
> "In my thoughts," said the Bohemian, "which no chains can bind."

THE MATTER OF COLLEGE ENTRANCE REQUIREMENTS

By President FRANK L. McVEY
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IN the past several years a marked change has taken place in the attitude of colleges and universities toward the matter of entrance requirements. An examination of catalogues, articles and discussions, shows clearly the swinging of opinion from the former college view to the high school way of regarding the question. It is, moreover, now generally conceded that the relationship existing between the college and the secondary school is a part of the whole system of education and not a specific relation between two of the factors of that system. The growth in the high-school attendance and the emphasis upon the importance of it as a factor have been brought about by a clearer recognition of the high school in its relation to public education.

Perhaps the most fundamental point in all of this discussion is the fact that the secondary period in the school-boy's life is far more favorable than his college years to the free exploration of the boy.[1] Self-realization has come to be a motive that has reached down into the high-school period, and it has been found, in the opinion of able directors of secondary education, that restricted preparatory courses prescribed by colleges do not afford the experience needed in the high school. It is further stated that individual pupils can not know at the beginning of the high-school course that they can go to college four years later on. Moreover, it has been shown that the specification of subject matter for the four years of the high school tends to materially hamper rather than help in the direction of secondary education. The confusion in the requirements of different colleges east and west makes it impossible for the ordinary high school to meet the demands of all of them. The result is that those who have observed the boys and girls working in the high schools of the country have come to the conclusion that there is a wide discrepancy between preparation for life and preparation for college as defined in the ordinary entrance requirements. For these reasons and many others it has come to be felt that the high school should serve as an open door through which may pass the boys and girls looking for a larger education.

The placing of the emphasis upon citizenship and the efficiency of the individual seems to point conclusively to a larger freedom on the part of the high schools and their management to meet the specific needs

[1] Abraham Flexner, "The American College," p. 223.

of the group of young people who come to their doors. The recognition of the mechanic arts, household science and agriculture, together with the attempt to reflect the major industries of the community, have brought the vocational idea in conflict with the traditional one of culture. A middle ground seems to be the saner position to take, since it is possible, and ought to be possible, for young people to secure a blending of liberal and vocational training at the same time, and through this combination education can receive the proper emphasis upon its social significance. The combination of the two makes possible a closer relationship of the work which the boy is doing to the welfare of society. Consequently, it appears to many educators that the requirement of four years of work in any particular subject as a condition of admission to the college or university is illogical and unhappy as a part of the educational machinery. Yet, on the other hand, it is distinctly understood that the attempt on the part of the high school to reach out and enrich its curriculum does not, and must not, mean the teaching of too many subjects to the same students at the same time.

The report of the Committee on the Articulation of High Schools and Colleges to the Secondary Department of the National Education Association in 1911 presented not only the various considerations that may be advanced regarding the function and field of education in the high school, but endeavored to define the meaning of a well-planned high-school course, and why it should be adopted as the basis of college admission. It is accepted without argument that fifteen units should be required for admission to the college or university, and that the specific subjects that should be offered may be summarized as three units of English, two units of one foreign language, two units of mathematics, one unit of social science (including history), and one unit of natural science. This makes nine units, and to these should be added two more units, so as to enlarge the requirements to at least two majors of three units each, leaving four units to be used as best meets the needs of the individual.

The suggestions of the committee have been more than accepted by the action of the University of Chicago in the new entrance requirements adopted by the faculties of that institution.[2] Accepting as fundamental the requirement of fifteen units, the University of Chicago requirements place the first emphasis upon English and the demand for three units of that subject. The departure from the idea of the committee, and for that matter from the general plan adopted by most universities of the country, is in the option granted to the student in the choice of subjects for the remaining units. Seven units must be selected from five groups in the proportion of three in one and two in

[2] "Changes in Entrance Requirements at the University of Chicago," by C. R. Mann, *Educational Review*, September, 1911.

another. These groups are ancient language, modern foreign language, history or social science and science. The remaining five units may be selected from any subjects offered by the high school for graduation, but no student is to be admitted to the university on less than the fifteen units required for entrance.

Under the plan that has been outlined by the University of Chicago, it is possible for the student to enter the university without mathematics, or, if he takes another combination under the second provision of the plan, to present his credits without languages, either ancient or modern; or, he may enter with modern languages, mathematics or history, and without ancient languages or science. This statement of the plan, however, does not complete it by any means, since the university adds two additional features, one relating to the observation and control of students, and the other to the continuance of certain lines of work. There has been established a grading system, which automatically eliminates the student who falls below grade, while the university maintains a statistical comparison of school and college records, so as to follow up the work of the high-school student, not only after he has entered college, but to bring the comparison with his record as a high-school student. To this a third feature is added, namely, a conference of high-school men. Having entered college, the student must pursue one of the subjects followed in the high school, and by the end of the second year must have completed two years in history and economics, two years of mathematics and science, and be able to read a foreign language; and if he comes up for a degree he must have spent three years of work in one department and two in another. You have under this plan a systematic attempt to coordinate the work of the high school and the college through the entire course of both.

An examination of the table of admission units required in the liberal arts colleges of state universities, shown below, indicates a stricter adherence to type and quite a marked tendency toward a hardening of lines in the establishment of certain prescribed studies for entrance to the colleges of state universities. Under ordinary circumstances one would expect a closer coordination between the state universities and the secondary schools than in the instance of the privately endowed schools and the high school. The explanation for the advanced stand of the University of Chicago is to be found partially in the fact that her officers have studied the school situation more carefully perhaps than have those of other institutions, and partially in the fact of her location in a city well endowed with high schools. In most of the states the universities are compelled to hold to the general conditions existing in those states, rather than follow the lines of development in the older and better established communities. Consequently, while the state universities attempt certain vocational subjects, the practise in this direction is by no means so extended as it is in the case of the University of Chicago.

The average entrance requirements of the state universities are three units of English, one of science, one of history, and two and a half of mathematics. These correspond rather closely to the provisions set forth by the committee of the National Education Association, but that committee adds additional academic units in order to make a second major of three units. The vocational subjects permitted by the state universities amount on the average to two units, leaving the remaining units to be selected from foreign languages, mathematics, civics and history. The University of Minnesota has gone farther than any other state university in the larger freedom of election given in the prescribed English requirements. Two units of mathematics are demanded, and four units of English, while vocational subjects may make up the remaining number of units, if desired. Universities like Arizona, Kansas, California, Cornell, Georgia, Iowa and others do not accept vocational subjects for entrance requirements.

Most of the state universities have a system of courses based upon prescribed and free electives, prescribed limited electives and free electives, or upon the group system. The question of majors is left to take care of itself in most instances, the idea being that if the student is forced to take certain prescribed subjects, he will follow them up in his choice of electives. A study of the situation, however, shows that in the majority of instances where no majors are required the student scatters his free electives over a large number of subjects. Entrance to state universities is based upon the idea of the need of general knowledge and certain requirements for specific courses. That is, for the purpose of pursuing the social sciences, the student in the high school should have had elementary mathematics, foreign language and the beginnings of civics. This is merely an example of the point of view, and in support of this position it may be said that the student's preparation is materially limited from the college side if he enters upon his freshman year without some elementary training in science or mathematics. The movement to carry down into the high school the elementary work in these subjects is materially retarded, and the colleges are forced to establish courses of study in beginning languages and mathematics. Whether this is a calamity or not remains to be seen. The old Scotch university way of looking at it permitted any boy who thought he had in him the ability to carry on higher studies to go up to the university. No restriction was placed upon his entrance. The searching power of examinations was relied upon to determine his ability to maintain a standard sufficient for the granting of a degree. If, however, there can be aroused in the secondary period of the student's education a larger appreciation of his relation to society, some understanding of the forces of nature, and some fundamental principles instilled relative to citizenship, with at least some glimmer of what it means to study, the colleges and universities have all that can be expected or hoped for.

TABLE SHOWING ADMISSION UNITS REQUIRED IN LIBERAL ARTS COLLEGES OF STATE UNIVERSITIES

Note.—Compiled from Catalogues, 1911, in the President's Office, University of North Dakota. Any table of this kind can not be complete and fully accurate. Its purpose is served if it shows the situation.

Names of Universites	Admission Units Total	Prescribed Units							Optional Elective Groups									
		For. Lang.	Eng.	Science	Hist.	Algeb.	Geom.	Total	Eng.	Math.	For. Lang.	Anc. Lang.	Science	Civics	History	Voc. Subj.	Elec. Units Available	Units to Gr.
Alabama...	14	3	3	1	1	1½	1	10½	3½	3½	3	5	2	1	3	2	3½	3½
Arizona....	15½	4	4	1	2	1½	1	13½	*	*	*	*	*	*	*		2	2
†Arkansas...	15½		4		3	2½	2	11½			8	8					4	4
†California ..	15	4	2	1	1	1	1	10	*	*	*	*	*	*	*	3	5	3
Colorado...	15	4	3	2	2	1	1	13	1	2	2	2	2	2	2	2	2	2
Cornell.....	15	5	3		1	1	1	11	*	*	*	*	*	*	*		4	
‡Florida.....	12	3	3		2	1½	1½	11			1		1		1	1	1	1
Georgia....	14	2	3		2	1½	1	9½			*	*	*	*	*		4½	2
Illinois.....	15	3	3		1	1½	1	9½			4	4	6	1	3	2	5½	
Indiana....	16	3	3	1	1	1½	1½	11	*	*	*	*	*	*	*	*	5	5
Iowa.......	15	2	3	1		1½	1	8½	*	*	*	*	*	*	*		6½	
Idaho......	16	6	3		1	1½	1	12½	1	1	2	4	2	½	2	2	3½	2
Kansas.....	15	3	3	2	1	1½	1	11½	1	1½		1	4	1½	3	1	3½	3
Kentucky ..		Catalogue not available																
Louisiana...	12	1	3		1	1½	1	7½	*	*	*	*	*	*	*	*	4½	3
†Maine......	14	4	3		1	1½	1	10½		½	2	2	3		2		3½	2
Michigan...	15	2	3		1	2	1	9	1	½	4	4	1½		2		6	4
Minnesota..	15		4			1	1	6		1	8	6	7	2	3	9	9	9
Mississippi .	14	1½	3	2	1	1½	1	10	*	*	*	*	*	*	*		4	4
Missouri....	15	2	3			1	1	7	4	4	6	7	7	1	4	3	8	4
Montana...	15	2	4	1	1	1	1	10		2	4	4	3	1½	1½	6	5	5
Nebraska...	15	3	2		1	1½	1	8½		*	*	*	*	*	*	*	6½	3
Nevada....	17	6	3	1	2	1	1	14	*	*	*	*	*	*	*	1½	3	3
New Mexico	16	3	4	2	2	1½	1½	14		1	1		1				3	1
‡N. Carolina.	14	5.7	3		2	1½	1½	13.7			Vary with course followed						3	
N. Dakota..	15	2	3	1	1	1	1	9	*	*	4	3	6	*	2	9	6	5
Ohio.......	15	4	3	1	1	1	1	11		2	4	4	4			2	4	4
Oklahoma..	15	2	3	1	1	1½	1	9½	1	1½	4	4	1	1	3	2	5½	4
Oregon.....	15	2	3	1	1	1½	1	9½	1	2	2	2	5	½	3	2	5½	3
Penn. St. College...	14	7	3		1	1½	1½	14		·	Election in required groups							
§S. Carolina .	14	2½	3	1	2	1½	1½	10½	1	1	2	2	1	1	1		3½	2
S. Dakota..	15		3			1	1	5	1	2	6	7	6	1	4	1	10	4
Tennessee ..	14	4	3			1½	1½	10		4	3	4	4	1	4	4	4	4
Texas......	14	3	3		2	1½	1	10	1	1	2	2	2	2	2	2	3½	2
Utah.......	15		3		1	1	1	6	*	*	2	*	*	*	*	6	9.	
Virginia....	14	4	3		1	1½	1	10½	*	*	*	*	*	*	*	2	3	3
W. Virginia.	15	2	3	1	1	1	1	9	*	*	*	*	*	*	*		6	3
Vermont ...	14½	7	3		1	1½	1	13½	*	*	*	*	*	*	*	*	1	1
Washington.	15	2	4	1	1	1½	1	10½	*	*	*	*	*	*	*	*	4½	4
Wisconsin ..	14	2	2			1	1	6	*	*	*	*	*	*	*	*	8	4
Wyoming...	15	2	3		2	1	1	10	1	½	4	4		1	2		5	4
Av. Entrance Requirement	15	3	3	1	1	1½	1	10½	1	1	2	2	3	½	2	2	4½	2

Summary

Number of universities requiring 15 units for admission	25
Number of universities requiring less than 15 units	13
Number of universities requiring more than 15 units	5
Number of universities requiring less than 14 units	2

* Stars mean options, amount of credit offered not shown.
† Reduced to definition of unit.
‡ Deficiency of 2 units allowed.
§ Deficiency of 4 units allowed.
|| Can postpone foreign language.
The figures refer to number of units that are offered for entrance.

This means that the movement of a few years ago to force down into the high school many of the subjects taught in the college must necessarily stop; that while the high school in the larger places may reach up to the fifth or sixth year, yet the college will still be called upon to give instruction in the beginnings of languages and of the sciences to even a greater degree than has been true in the past. If this will change the idea that so many points are required for graduation and that certain credits must be received, for one which will emphasize the thoroughness of preparation and ability to think, the whole educational scheme now existing in America will be materially improved.

In many of the states there are systems of organization that adapt themselves especially to the maintenance of fixed types of high-school courses, though this is not necessarily true of an administration of the system from a liberal point of view. The more important of the endowed colleges have established an examination board, which provides for the presentation of examinations in entrance subjects under uniform conditions. Such a plan has much to commend it, since the questions set are likely to be worked out carefully and the marking of papers carried on thoroughly and well. Yet it has a tendency to maintain certain lines of examinations and tends to place emphasis upon the topics specifically called for in examinations. There is, moreover, no public force behind it other than the desire on the part of small groups of students to avail themselves of its facilities to pass entrance requirements to the schools represented on the examination board.

The diploma plan of admission, sometimes called the "Michigan system," rests upon the supposition that high schools of certain types are likely to give instruction of uniform value. It has not, however, been accepted by many of the states, since the tendency is to establish, even in those states where the diploma method exists, inspection by persons designated by the state universities. This plan has much to commend it, and where the inspection is made by some one especially skilled in secondary work, rather than by a group of men from the faculties of the university, it produces good results.

In other states a high-school board has been established, with the power of classifying high schools and of requiring certain courses of study from them and the fulfilment of certain conditions relative to equipment, selection of teachers and the form and character of buildings. In some instances, specifically in the cases of Minnesota and North Dakota, examinations are presented by the board, and in the last named state the high schools are required to accept them as the basis of promotion. This, however, is not rigorously adhered to and usually applies to schools of the second and third class that have hopes of becoming first-class high schools. In other instances, even where the high school board plan of examinations exists, principals' certificates are accepted in subjects for entrance to college, where the high schools have passed the inspection of the high-school board.

Too strict emphasis upon and adherence to specific courses of study result in lack of adaptation, regarding which much criticism has arisen. Just what credit shall be given for specific courses where the whole purpose of the high school is not taken into consideration is a question which arises again and again. This objection is fully met in the Chicago plan and partly in the average entrance requirements of state universities. The tendency in the latter instance, however, is to multiply the subjects in which credit can be given, in the hope of covering, as it were, the miscellaneous features of the high-school course.

So much emphasis has been put upon the "fitting for life" side of high-school work, that the ability of the ordinary high-school subjects to do this, even where they are called vocational, has not been brought into question. The president of a vocational college in his annual report for 1911 says:

> A more difficult aspect of the problem (referring to the question of entrance requirements) is the amount of credit that may be given to the study of vocational subjects in the high school. While the pursuit of vocational subjects in the high school would seem to be a natural preparation for the vocational college, and while some of the technical arts are better acquired in the earlier years, yet because the high-school course is designed to be a finishing course and covers the whole of the subject matter in an elementary and superficial manner, it does not give a preparation upon which the more intensive and mature college course may be built. The ground must be covered again by a more thorough method and the time that has been spent on the subject in the high school is largely wasted, while the general subjects that have been replaced are permanently lost. If the schools would separate the technical arts from the elementary consideration of principles, the former might be accepted by the colleges and the later course built upon them without loss of time and with real advantage.[2]

In the statement which has been quoted above, the president of Simmons College has pointed out one of the difficulties in the teaching of vocational subjects so-called, and in a measure justifies the attitude

[2] From the annual report of the president of Simmons College, December, 1911.

which the state university has taken in the matter of their acceptance. The high school is not a trade school and ought not to be considered one. But the problem, which has been looked upon as one largely interfered with by the admission requirements of colleges, is after all a problem associated with primary, secondary and higher instruction rather than any one of its parts. The secondary school, therefore, should be given a large opportunity to work out its place in the scheme of education and to determine for itself, more than it has been able to do thus far, just what scope and methods of vocational training should be introduced in its course. The attitude of the state university in accepting numerous small credits in miscellaneous subjects of a scattered nature tends to retard rather than to hasten a closer investigation of the situation, while the granting of a certain amount of option and liberty to the high schools in the determination of the subjects to be offered in their courses will undoubtedly tend to reduce the number and to hold them in lines that will be more adapted to the needs of the community. Unquestionably, uniformity in the schools is desirable so far as it means uniformity in subjects, time, amount and speed of instruction, but if it means uniformity of instruction by the requiring of individuals the same subjects without regard to their actual needs, it is under all circumstances to be avoided. Looked at broadly, the state universities occupy a vantage ground, in the first instance, in that they have not moved to radical attitudes which upon closer investigation of the problems involved can not be held, and in the second instance that they are not so conservative as to stand in their own light. They are really in the position of modifying somewhat the average requirements for admission to meet the needs of the high schools as they stand to-day and to give them larger local option in the settling of their problems, if they are willing to give over the choice of a certain amount of their credits to the high schools rather than continue the policy of accepting credits in many small subjects. These universities are a part of the school system, and the adjustment which takes place will be from the bottom upwards rather than from the top downwards, but in this adjustment there is need of all the wisdom which the universities may have, as well as the cooperation of all the factors involved.

THE LESSON OF CANAL ZONE SANITATION

BY J. S. LANKFORD, M.D.

SAN ANTONIO, TEX.

WE have learned two great lessons in the construction of the Panama Canal. One is that with money, modern machinery and men who are healthy and happily situated there is hardly anything impossible in civil engineering and building. This matchless piece of work now nearing completion testifies to the constructive genius of man, and can not be studied at close range in all its colossal proportions without exciting wonder and admiration. It is impossible to get any adequate conception of its magnitude without personal investigation. The first impression is the unlimited audacity of man in ripping open the mountains, draining marshes and lakes, penetrating the jungles and impounding rushing rivers in an effort to throw two great oceans together. It is the greatest assault ever made upon nature; but the white man, brushing aside all obstacles and scorning danger, will soon have finished this greatest of all monuments of marching civilization. It is impossible to escape a deep interest in the employees and their environment; in the systematic and effectual supervision of the material, the supplies and the work, and in the general progress that has been made. The bigness of it all and its possibilities in changing the commerce of the seas, the destiny of nations and the history of peoples appeals to the imagination as well as to sober thought.

But these things are soon lost sight of temporarily in the contemplation of the greater lesson which is as broad as the human family of the present and of the future, for it touches human suffering and sorrow, and human happiness—the lesson of sanitation and health. The unhealthiest section of the globe, so acknowledged by all the world, has been converted into the healthiest. Accurate and unbiased records and reports have demonstrated this repeatedly and conclusively. The land of the jungle where the mosquito sang her weird song of death unmolested for four hundred years vying with the germs of dysentery, typhoid fever and pneumonia in the destruction of human life; the country where death with grim terror reigned as king, queen and prime minister has yielded to modern methods of sanitation and has become the home of health and happiness, a plain fact almost approaching the miraculous.

It is a mistake to think this has been done under military power. It has been accomplished by the forceful and efficient efforts of a corps of intelligent sanitarians who have proven themselves master pioneers in the prevention of tropical diseases, and it stands out as a startling lesson that none should fail to learn. Nor has this great work been very expensive, as some newspaper writers assume without warrant. Taking the number of men employed and the amount spent for the prevention of disease it is found that about one cent per day per man has been expended. In comparison with similar expenditures in American cities it should not be forgotten that practically nine tenths of the cost of sanitation in the Zone is in mosquito fighting and quarantine. In order to appreciate what has been accomplished it is necessary to understand the condition of the country at the beginning of the occupancy.

The Canal Zone, ten miles wide and forty-five miles long, is composed of mountains of moderate height, marshy swamps, numerous small lakes, jungles, almost impenetrable in some places, and streams, the most important of the latter being the Chagres River, celebrated for malignant malarial disease. The temperature ranges from 65° to 100°, March being the hottest month. The average annual rainfall varies strangely in different localities from 75 to 125 inches. The fog, clouds and hot sun follow each other in quick succession. The heavy rainfall insures permanent stagnant water where the larvæ of the yellow fever and malarial mosquitos thrive in countless millions; the perpetual moisture, warmth and rich soil lead to extravagant growth of hundreds of varieties of tropical grasses, plants, flowers, vines and trees, furnishing favorable harbor for the insects; and there is an almost constant stream of decaying vegetable and animal matter pouring into lakes and marshes that are never drained. Decaying animal matter leads to the generation of innumerable flies, ever ready to convey disease, and the water supply is polluted, and pregnant with disease germs.

This is the condition of things now in the surrounding country, and was the condition of the Canal Zone when the United States took charge. It was bad enough in the wilds of nature, but worse in the habitation of man. Colon had no sewer system, and human excrement was disregarded; there was no proper water supply; the cisterns, puddles and lakes furnished convenient breeding places for mosquitos; the streets and sidewalks were in horrible condition, and sanitary ordinances were lamely drawn and poorly executed. There were no screens, and flies literally swarmed over the food.

The conditions were little better in Panama City and in the intermediate towns. Yellow fever had been endemic for hundreds of years, and epidemic when new material was available. Malaria was ever present, consuming the life blood and limiting the capacity of generation after generation of the native population, and attacking the unacclimated with vigor and fatality. Typhoid fever was very common, and the ravages of dysentery were sorely distressing. The history of the Isthmus is inseparably linked with disease and death. For more than three hundred years it was the favorite highway from ocean to ocean and many thousands perished en route from tropical disease.

The Panama railroad is only forty-five miles long, but it took five years to build it, and the cost in human life has never been satisfactorily estimated. Two different times a thousand imported men all died within one year.

One of the most pathetic incidents in all the history of human effort was the failure of the French, and the awful toll of death the French people and the laborers paid for their ignorance of scientific sanitation, which came later and is now universally accepted. Gorgas himself says that the Americans could have done no better than the French without the knowledge of the mosquito as a disease carrier. De Lesseps stood at the very head of his class in his field, and he had the best engineers of his time, and the brainiest supervisors; he had ample money and the latest machinery; but death stood in the path of every effort, defying progress. His annual death rate for the eight years was about 240 per thousand, and, after spending over $260,000,000 he met with complete failure, a failure that glares like a death dragon from the old discarded machinery and seems to breathe forth from the very silence of many thousands of graves. Colon, with a population of ten thousand, has a cemetery with one hundred and sixty-seven thousand graves.

And this is the country from which yellow fever has been banished for more than six years; where the mortality from typhoid fever and dysentery has been reduced to the minimum; where malaria has become mild and controllable; the country where the deaths per thousand among canal employees, instead of De Lesseps's 240, is only seven and one half. It is almost unbelievable, but it is true. Among white American employees the death rate is less than three per thousand. The lowest death rate of any considerable number of people in the world is now found in the Canal Zone.

How this has been done is the interesting question and therein lies the great lesson. After a short-lived error which threatened a repetition of the French disaster the government wisely decided to improve the sanitary conditions first, and not send workmen to the slaughter. The unconquerable Gorgas with a good force of physicians, surgeons, nurses, expert sanitarians, skilled engineers and helpers, with ample supplies of disinfectants, were put in the lead. It was recognized that Colon and Panama City must be made habitable the first thing. The little city of Christobal was started by the side of Colon. Houses were built well off the ground, arranged for good ventilation, provided with scientific plumbing, and carefully screened so that the operatives might be protected from mosquitoes during sleeping hours. Colon and Panama City are in the Zone but do not belong to the United States government. Sanitary and police authority over these places, however, had wisely been retained by treaty rights. The unsanitary condition of Colon was vigorously attacked. Lakes were drained and filled and oil was used freely where draining was impracticable; a good sewer system was installed and connection required; an adequate supply of pure water was brought from a distance and cisterns abolished; streets were graded and sidewalks built; wharves were constructed, and the tide water controlled; suitable ordinances were passed, order was established and sanitary regulations of every kind were rigidly enforced. A quarantine system was inaugurated that was unyielding and of great value. As soon as possible a modern hospital was built with up-to-date equipment and every possible facility for scientific investigation and the most skilled surgical and medical treatment. This hospital has grown to great dimensions and has few equals in results. The annual death rate of Colon under this method has been reduced from 50 to less than 20 per thousand.

Panama City, not quite so bad as Colon, was treated in a similar manner. Adjoining Panama City is Ancon, the attractive American suburb, where are established the administration buildings, and the great Ancon hospital, which has no superior anywhere, furnishing the employees every facility for recovery that money can buy.

The problems confronted in the intermediate country were somewhat different, but similar in principle. The trains were screened and regulations put in force for the protection of the public health. A number of living stations for employees were arranged along the railroad and every house was built well off the ground and screened. Now the real war against disease was begun, lakes and swamps that had never been drained since nature made them poured out their accumulated filth to the sea; those that could not be drained were oiled; ditches were dug only after the lines of skilled engineers so that drainage might be perfect; a large force of men were kept busy oiling three or four times a month all lakes, puddles, sluggish streams and marshes, so that mosquitoes could not breed. Each little station or town was furnished a pure water supply, brought down from the distant hills in some instances, and provided with an efficient system of sewers, or in some rare instances well arranged cesspools. The jungle was cut away some distance from all residences so that the mosquito could find no resting place. Plague-carrying rats and other vermin were destroyed. Disinfectants were freely used, and fumigation resorted to when necessary in handling contagious diseases. Rotting vegetable and animal matter, offal and garbage, were burned. The life and habits of the men were carefully regulated. Government dining halls furnished good meals, well cooked, and protected by screens; sleeping quarters were clean and neatly screened and comfortable; the hours of rest and labor were well arranged; prohibition was strictly enforced; good dispensaries were established in convenient places; a hospital car was run with every train for the ill or the injured; medical and surgical service was skilled and prompt, and the hospital attention was second to none. But it was the *one cent per day per man* expended for the prevention of disease that worked the miracle.

It was a tremendous undertaking beset by human hardship and hazard and surrounded by difficulties apparently insurmountable. But the canal will soon be finished, and its construction has been made possible only by the intelligent application of our most recent knowledge of sanitation. It will mark a distinct era in human civilization, an era in which all else must and shall be subordinated to the prevention of disease. And this will not be altogether humanitarianism, for a human life has its commercial value, a definite value worthy of consideration.

One of the first results of this remarkable sanitary crusade will be noticed in Central and South America. Idle money of several nations is now restless and seeking investment; tropical peoples, depressed by climate, and enervated by centuries of disease, have not kept pace with the progress of the world, and opportunities for good dividends are easily found; and capital will throw every protection around employees for selfish reasons. Great commercial, agricultural and industrial development immediately follows new and important lines of transportation; and, in addition to the enormous investments of the United States government in the Zone, private capital will flow into the country in a steady stream. No individual, corporation or nation can afford to ignore this striking lesson in sanitation. The country will first be made fit for habitation and then development will follow. This movement will be far reaching, and will have its effect upon the history of Central and South American republics.

If this can be done in Panama, most unhealthy of all countries, what should we not accomplish in our own country, with so many superior advantages? Shall we go on permitting hundreds of thousands of people to die of preventable diseases like typhoid fever, malaria and tuberculosis? The heavy mortality from these and other diseases is highly discreditable to an enlightened people. It is a lamentable fact that while this marvelous transformation was taking place in the Canal Zone, poisoning patent-medicine makers and conscienceless food adulterators were spending money by the millions to defeat the purpose of the people to establish a health bureau in Washington to prevent disease and promote the public health. Our national, state and municipal health officers, and our citizens, should study this great lesson well and profit by it. Thorough instruction of our twenty millions of school children on practical sanitation would result in reducing the mortality from preventable diseases by half in one generation. This proposition was demonstrated beyond all question in a great educational campaign on the mosquito in the San Antonio public schools several years ago in which the mosquito was completely exterminated.

It is an inspiring sight to witness this unseemly, death-ridden tropical country, changed into a place of beauty and a veritable health resort, right in the midst of disease and death. The Panama Canal is a wonderful feat of engineering, and we can easily imagine civil engineers attempting in the near future to conserve and utilize the motor power of the ocean waves and the trade winds. All due honor to the engineers.

But when the world's vessels sail through Lake Bohio, whose waters will be impregnated with millions of dollars worth of the rusting iron of the French failure, it will be a glorious triumph of scientific sanitation, and a great lesson to all nations and peoples down the centuries; an example that will be emulated and add much to human health, happiness and longevity.

A BIOLOGICAL FORECAST[1]

By Professor G. H. PARKER
HARVARD UNIVERSITY

THE biologist, like other organisms, has been evolved. The mutations of the Greek and Roman period never established themselves as permanent stocks. They were crushed out by that rank growth of political and theological weeds that finally destroyed itself by its own vegetative excesses. The prototype of the biologist of to-day is essentially a modern product and came into existence with the Renaissance. He is the man who lighted our torch of learning and handed it on to us. But this naturalist of the early days bears almost no resemblance to his modern descendant. Like all reformers, he was an eccentric oblivious alike to popular praise and ridicule. I picture him now with his collecting net under his arm, his hat bristling with the pinned trophies of the hunt, and the pockets of his great coat distended with bottles and phials, which, be it said to his honor, came home fuller in contents than they went out. He widened our horizon by discovering a charm in the reptile and the worm and, with his hand-lens as an instrument of war, he conquered the unknown inhabitants of slimy pools and green puddles. He was indeed in all respects the veritable "bug hunter." I might here quote with perfect appropriateness as descriptive of his sympathy with nature, a certain well-known passage about books in brooks and sermons in stones but I have been instructed to avoid anything that resembled a Phi Beta Kappa oration and so I desist.

Lest you think I have overdrawn my picture of our ancient progenitor, let me read to you a sentence or two from the pen of one who well represented his class and whose book, a "Synonymic Catalogue of the Macrolepidoptera of North America," was a delight to my boyish heart. I quote a few sentences of advice as to costume.

> I would further add that for these excursions a coat made of some light woolen material is preferable: linen coats are abominable, as the suspenders by the aid of perspiration, adorn the back of that garment with a St. Andrew's cross, which, though of no moment to our country cousins, is by no means desirable as we get within the city limits on our return homeward, if it be still daylight. This coat should be plentifully supplied with pockets, two inside breast pockets, one of great capacity to put the net rim and all in, if you don't want to carry it in your hand, the other for your handkerchief, segar-case, small glass jar, etc.; it should also have two outside pockets near bottom of coat, the one to put your collecting box in, and the other for lunch, which latter, although

[1] An address delivered at the annual banquet of the Brown University chapter of Sigma Xi, May 28, 1913.

when you start you think your breakfast will last all day, becomes of vital importance about the time the sun is directly over your head, when you will devour every crumb, and, like poor Oliver, cry for more. Carry a little india-rubber, leather or tin drinking-cup with you but don't put much water inside of you—it is deleterous during these tramps; once give way to the temptation of guzzling creek water and by the time you are ready to drag yourself home, you will be as near a gone case of foundering as any undertaker need delight to see. If you feel thirsty smoke segars, if you can't smoke moisten your lips with a little lemon-juice or whisky, but don't moisten with too much of the latter so that the last seen of you is adorning the corner of some fence, with the flies hovering around your mouth trying to ascertain whether it was "Mountain Dew" or "Lavan's Best Proof" that has put you in a position for your friends to be ashamed of you, sir.

How detailed and considerate the instructions are! That these old naturalists were proud of their outfits, we can judge from the fact that Linnæus, the passed master of them all, had his portrait painted in his Lapland collecting costume. There are many descendants of these worthies at this board to-night, but where among us is a single representative. As Joseph Jefferson once said in describing his own person, we find ourselves disguised in the clothes of gentlemen, and no one here this evening has moistened his lip with "Mountain Dew," not to mention lemon-juice.

But what did these old masters do for us? They undertook and partly performed the enormous task of delivering to us a descriptive catalogue of the animals and plants of the world. To be sure this seemed a simpler proposition in the old days when, as Linnæus declared, there were as many species as had been created in the beginning. But even then the number must have seemed considerable, for Linnæus himself gave us descriptions of over four thousand species of animals. Probably, however, he had no suspicion that the total of described animals alone was to rise in our day to half a million and even after this heavy draft, nature would still have the appearance of inexhaustibleness.

But nature is not only vastly richer in species than the older naturalists probably suspected; she is continually at work creating new forms. The simple faith of Linnæus in the special creation of animals and plants was forever overthrown by Darwin, whose "Origin of Species" established a new point of view for this whole question. And recent evolutionary work has shown that organic transformation is not only in progress to-day, as it has been in the past, but, in the hands of man, it is rapidly assuming the aspect of an important element in civilization. Within the last few years such mastery has been gained over the factors controlling the color of the hair of some of our smaller and more rapidly breeding mammals that, within reasonable limits, a pure breed of guinea pigs of a previously designated color, for instance, can be produced in an incredibly short time. And when it is kept in mind that some of the colors thus produced had long been sought in vain by the old-fashioned animal breeders, the advantage of the new methods over the old must be apparent. Instances of this kind give us good reason for believing that before many years have passed useful forms of animals and plants will be produced on demand, not in the somewhat haphazard way of the present practise of breeders, but with the certainty and precision with which a modern inventor constructs a new piece of machinery.

This change in the aspect of evolutionary matters can not be better illustrated than by three quotations that preface one of the most important publications on evolution in the last decade, "Species and Varieties, their Origin by Mutations." The quotations, which are arranged in historical sequence and come from the three great masters in this field, are as follows:

> The origin of species is a natural phenomenon.—Lamarck.
> The origin of species is an object of inquiry.—Darwin.
> The origin of species is an object of experimental investigation.—De Vries.

The last statement, that the origin of species is open to experimental study, is the keynote to modern evolutionary work. But it is not simply the keynote to this particular part of biology; it marks a change in front of the whole army of biological workers whereby the science of the organism is being transformed from one of observation pure and simple to one which includes experiment. We sometimes hear astronomy, chemistry, physics, etc., described as the exact sciences, and our friends in these domains of knowledge occasionally take a hidden pleasure, I suspect, in intimating that what lies outside their realm, including biology, must belong to the inexact category. That biology has not been exact in the sense that physics and chemistry have been, we freely admit, but physics was not always exact, and before the days of Lavoisier, chemistry had few quantitative results of which it could boast. Biology, from the nature of the materials it has had to master, has of necessity been slow in growing to that stage where it was imperative to use those refined methods that have long been employed by physics and chemistry. But these methods are rapidly being assimilated by the more progressive members of the biological fraternity, who are discovering that there is nothing inherently inexact about the subject-matter of biology or its treatment. This subject-matter is open to the same searching method as is that of the so-called exact sciences. But though we are not yet admitted to full fellowship with these sciences, we are at least the center of the observational group and, if we wished to retaliate on our good friends of the exact sciences, we might declare them non-observational with as much reason as they call us inexact. But you will accuse me of falling into a word controversy. And such it would be. The truth is that biology is rapidly becoming experimental, and in doing so it necessarily assumes all those methods and procedures that have long been the special possessions of the exact sciences. As a result of these coming changes we expect to see biology established in a short time as an observational science of a highly exact order.

This general change, though characteristic of the last decade, may in reality be said to be no change at all, for the experimental attack on biological problems had its inception in the early days of the science. Its growth, however, has been limited almost entirely to the narrow field of human physiology, and the physiological laboratory is now proving to be a source of inspiration and help to the biologist as he faces the new set of problems put before him by the experimental method. It is customary to date the beginning of experimental physiology from Harvey's discovery of the circulation of the blood, not because this important discovery was a central biological fact, but rather for the reason that it was the first considerable discovery in physiology that was made by a rigid application of the experimental method, a method which has made possible almost all the subsequent progress in this field of research.

It is the acquisition of the experimental method that is converting the old biology into the new. Never before in the history of the science has there been such an expansion as the last decade has witnessed. Without diminishing activity in the fields that have long been under cultivation, this change has added enormously to the territory open to biological investigation. We still need revised and improved catalogues of the animals and plants about us, even though we now know that the unit of this kind of work, the species, is a highly artificial conception and that in nature all is in slow but continual flux. We need to know more about the distribution of animals and plants past and present, about their gross structural composition, their methods of development, their mutual interdependencies, their lines of descent, and the like. Biology is still a rich field for the purely observational worker, but the new territory laid open by the experimental method is, to my mind, the land of greatest promise. This method brings us face to face with some of the most fundamental problems of the organism, the solution of which, in my opinion, will yield results of the utmost importance to mankind. At this stage it would be presumptuous to attempt to predict what these results may be. But I can not let the present moment pass without hazarding a guess at a few of them.

No organism can exist long without food. Every animal and plant is appropriating materials by the chemical readjustment of which it is gaining the energy necessary for its own activities. We, as organisms, form no exception to this general rule. Our food, like that of other omnivorous animals, comes from animal and plant sources, but ultimately all food is drawn from the green plant. Destroy completely all green plants and in a short time all other organisms on the earth would die of starvation. The green plant is the one independent organism on the globe; all others are in a way parasitic. As you well know, the green plant in sunlight elaborates starch from water and carbon dioxide, and the primitive food thus synthesized becomes the basis for further changes whereby nitrogen and other materials are built into the body of the plant. Thus arise the starches, sugars, oils and proteid materials which constitute the substance of the plant body and which serve us as foods, absolutely essential to the continuance of our lives.

In my opinion the time is not far distant when we shall be emancipated from this slavery to the green plant. No seriously minded chemist of the present day believes that there is any inherent impossibility in the repetition of the chemical processes of the organism, in the laboratory. The days of this form of vitalism have long since passed away. The difficulty that confronts the biological chemist in attempting to repeat the chemical processes of the organism is the enormous complexity of even the simpler of these operations. Hence he has not yet achieved that kind of success that even the scientific public seems to expect of him. But is this expectation reasonable? Are we warranted in finding him wanting because he has not yet made an amœba? I think not. To ask him to make an amœba is like asking an engineer to duplicate New York City. With infinite toil and pains it could be done. But who or what would be the better? One New York is enough. Better study the processes of New York or the amœba than attempt to duplicate in totality either organism and, having learned what these processes are, apply them to human welfare. This is the attitude we must assume toward the green plant. We must learn its processes and, having learned them, we must apply them to our needs.

If the green plant in sunlight can elaborate from water and carbon dioxide one of our chief food substances, starch, there is no reason why the biological chemist should not discover the secret of this process and imitate it on a commercial scale. Starch, I believe, has never been synthesized, but some sugars have been so constructed. Two years ago Stoklasa and Sdobnicky made the remarkable discovery that by the action of ultraviolet light on nascent hydrogen and carbon dioxide sugar was formed. Such discoveries as this suggest the means by which we are to throw off our slavery to the green plant and I am convinced that in time this overthrow will become so complete that our staple foods will be the products of the biological chemist.

From this standpoint the attitude of many of our pure food enthusiasts seems to me entirely erroneous. Why object to the cheaper synthetic colors and flavors in prepared foods provided they are not poisonous in themselves and contain no injurious by-products? As a matter of fact these very colors and flavors are often purer than the natural materials. From the point of view of public morals, such mixtures should be rightly labeled, but to stigmatize them as necessarily inferior to the natural products is, to say the least, unprogressive. We do not object to artificial indigo because the chemist has superseded the green plant in its manufacture. Why, then, should we object to a currant jelly composed of wholesome artificial products? It may not only be as good as the old-fashioned kind, but I can imagine that a connoisseur in this new venture might impart to it a flavor even more delicate than that from the kitchen. Our descendants, I am sure, will some day sit down to dinners of synthetic dishes, the products of clean laboratories, with as much appetite and pleasure as we now partake of a meal hewn from the animal and dug from the earth, and we must not object if they prefer, on esthetic grounds, the source of their food to that of ours.

But food is only one of the many things we need. We number ourselves among the very few organisms that use tools and we need energy to drive many of our tools. Historically we have abandoned in much of our work the muscle for the steam engine. Contrast the construction of a modern building by a handful of Italian workmen and a donkey engine with the wall pictures we have of the long lines of Egyptian slaves straining every muscle as they pull a heavy load at the end of a rope.

But have we done best to ignore the muscle? When this organ is functioning at its highest, it yields two kinds of energy, heat and power to do mechanical work about in the proportion of two thirds heat to one third work. From the energy that enters the ordinary steam engine about one tenth is given back in work and the other nine tenths are dissipated as heat. Even in the highest grade of turbine engines, this efficiency seldom reaches as much as a quarter of the available energy. Thus the muscle returns us over thirty per cent. of its energy in effective work, and the best steam engines only about twenty-five per cent. If we knew the secret of muscle action, I have no doubt that a mechanism could be constructed that would far outrun the steam engine as a means of doing work.

Another kind of energy that we seek is light. Primitive man was forced to content himself with the sun by day and the moon and stars by night. When he first struck fire, artificial light came as well as warmth, and from that day to this we have witnessed a long succession of improvements in the production of artificial light. But in none of these has man rid himself of the association of heat with light. Every device for illumination that has been put forward yields more heat than light. Our ordinary gas flame yields between one and two per cent. of light and the remaining ninety-eight or -nine per cent. is lost in heat. No wonder that the modern gas corporation is advertising itself as a convenient source of heat and power. Many of us who serve it as consumers have come to regard this by-product as the most important part of its output. We can at least feel what we are paying for, if we can not see it. But the electric lights far outrun the gas lights in efficiency. An ordinary carbon incandescent lamp yields about six per cent. of light to ninety-four per cent. of heat, the arc lamp about ten per cent. of light, while the mercury arc has climbed to the enormous efficiency of almost half light to half heat. This indeed is prodigious compared with the means of illumination of a few years ago.

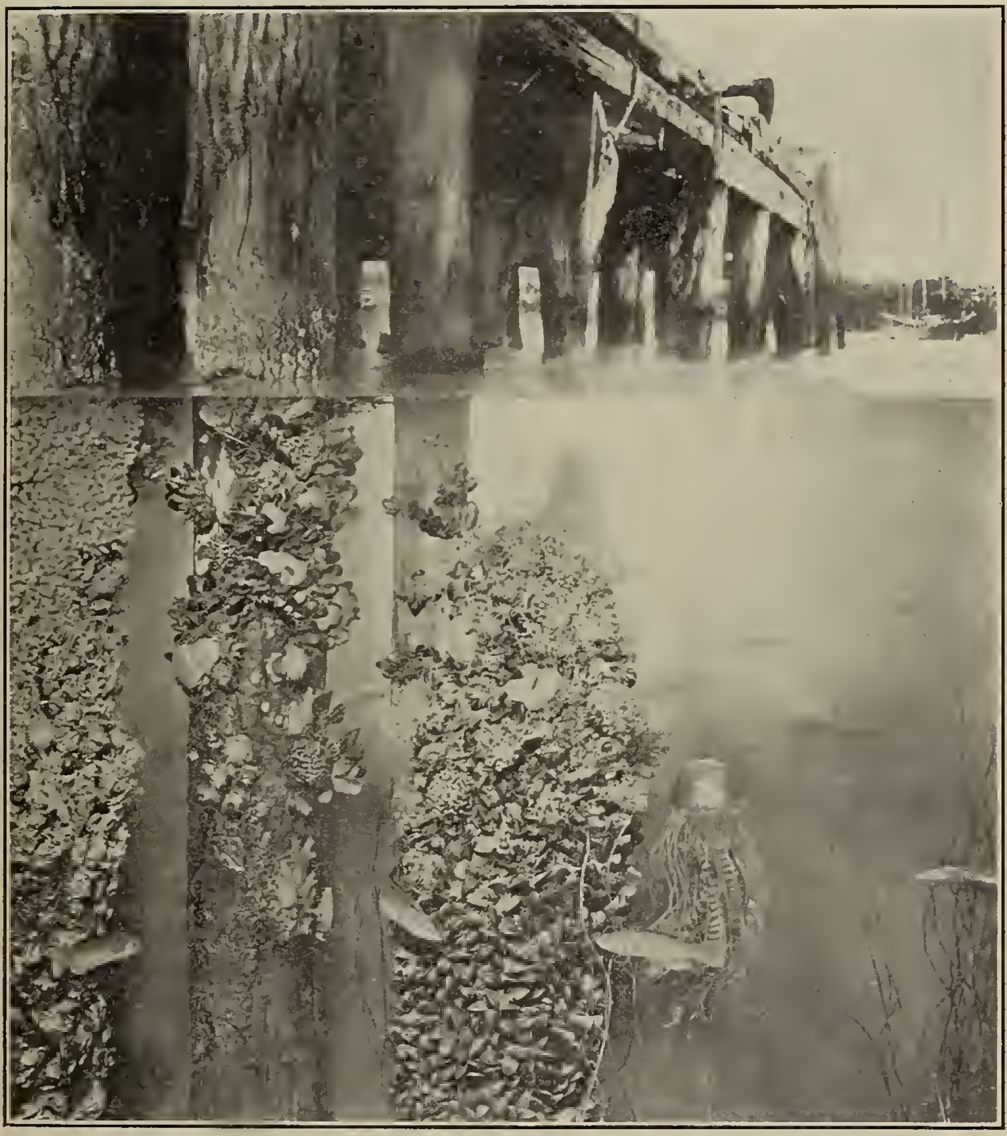
But what have the organisms to teach us in this respect? Many animals and plants are luminous. The simple one-celled animals, jelly fishes, worms, clams, insects and common fishes all have luminous representatives. But who ever heard of the sea being appreciably warmed by its phosphorescence or of a child who burned his finger with a firefly? Animal light is produced without heat, it is immensely the most economical form of light. Repeated and recent study of the firefly light has shown that all of its energy lies within the visible spectrum, that it contains not a measurable vestige of heat. Its efficiency is complete and could we discover, as we shall some day, the secret of the firefly light, the only occupation that would be left for our municipal illuminating plants would be that of heat generators.

By this time you must surely have caught the drift of my idea. For ages past animals and plants have been slowly evolving processes on some of which we have come to be absolutely dependent. Biology has now advanced to that stage where the study of these processes is beginning to be seriously undertaken. In my opinion the operations of plants and animals will serve as models on which to build up industry on a scale that human endeavor has never dreamed of before. Our modern industrial world supplies man's wants by means of what I may call inorganic devices. The future industrial world will draw more and more from organic models. In my opinion we are on the verge of an enormous expansion in applied biology. A century from to-day and our work will look as small and insignificant in comparison with the biology of that period as Franklin's electrical experiments do when brought face to face with the enormous electrical expansion of modern times. He saw in nature a few manifestations of a gigantic power which the modern man of science has brought under control. It is vouchsafed us in this early day to see dimly and indistinctly the powerful forces of organic nature and to receive the conviction that in the not distant future, these too are to be bridled and led by man. Such to my mind is the forecast of biology.

THE PROGRESS OF SCIENCE

WHARF-PILE FAUNA IN A MUSEUM GROUP

THE oceanic waters that lap our shores conceal beneath their tidal margin a wealth of animal and plant life that is surprisingly unfamiliar to those who are not actually students of marine biology. As terrestrial animals ourselves we live and move in the midst of a world of air-breathing creatures with which most of us have become tolerably familiar. Beasts, birds, reptiles and insects have for us an economic or esthetic bearing that gives them a



THE VINEYARD HAVEN WHARF PILE GROUP.

The upper background is made up of enlarged photographic transparencies showing the actual locality. Below the water line, the animals and plants of the wharf piles are represented largely by models. The submarine background effect is produced by five successive sheets of plate-glass through which daylight filters from a window behind.

The broken pile in the foreground of the group with its colonies of mollusks, hydroids, sponges and ascidians.

place in the daily life of every one. The same is true of our terrestrial plants. But while the sea is familiar to us in its outward aspects, while certain of its creatures are well known to us because of their food value or for other reasons, yet the vast majority of the life that crowds that watery atmosphere has been effectually concealed from the generality of mankind by the density of the medium in which it lives. This is true not only of the animals of the deeper waters but of those that people the very margin of the sea as well. Here in the shallows life abounds. Here the struggle for existence is fiercest, and it is here that the closest adaptations to environment may be seen. These ocean margins were doubtless the theater of much of that tremendous evolutionary progress which in Archean times laid down the foundations of the great phyletic groups of the animal kingdom.

In order to give a picture not only of the abundance, variety and beauty of the sea life of our littoral waters, but also of the delicately balanced and interlocking associations of the animals and plants composing it, the American Museum of Natural History in New York has been installing a series of groups representing the actual conditions under which this life occurs at certain definite localities on the Atlantic coast. Photographic and painted transparencies are arranged to show the surroundings at the locality in question while the animals and seaweeds are represented partly by actual specimens and partly by models colored from life. The latest of these groups, as shown in the accompanying photographs, reproduces the animal and plant colonies to be found living below the low-water mark on the wharf piles in the neighborhood of Vineyard Haven, Massachusetts. The upper part of the group represents an old abandoned wharf between the piles of which may be seen

The pile to the left is covered with the tubes of serpulid worms, overhung by the yellowish masses of the ascidian, *Molgula*. Starfishes, mollusks, barnacles, sponges, sea-anemones and six species of ascidians are seen on the central pile.

glimpses of the cottages on the further shore of the harbor. In the foreground the water is shown as though sectioned to disclose the submarine portions of the wharf piles with their bewildering display of living forms. In the center of the foreground a broken pile is completely covered by a colony of edible mussels (*Mytilus edulis*) over which has spread the pink and saffron clusters of a delicate hydroid (*Tubularia crocea*). Other species of hydroids are interspersed with fleshy masses of rosy-pink "sea-pork" (*Amaroucium pellucidum*), while glowing dully in the center is an orange-red colony of the beautiful red-beard sponge (*Microciona prolifera*). A graceful yellow and pink-tinted jellyfish (*Dactylometra quinquecirra*) with frilled mouth and fringed umbrella floats near the pile, and a school of squid (*Loligo pealii*) swims back and forth among the long thread-like filaments of the alga known as the "devil's shoe-string" (*Chorda filum*). The pile to the left is encrusted with the tubes of serpulid worms (*Hydroides dianthus*), whose many-colored gill circlets are protruded flower-like from all parts of the pile, and overhanging these are the yellow masses of the ascidian *Molgula manhattensis*. On this and the neighboring piles are also scattered in wild profusion sea-anemones, starfishes, moss-animals and several species of ascidians besides those already mentioned. Most of these are sessile animals and form an admirable illustration of adaptation to an inactive life and a diet of microorganisms, as contrasted with the swiftly moving and voracious fishes and squid shown elsewhere in the group.

Other groups which have been completed in this series are the "shore mollusk group," showing the animals of a sand-spit at Cold Spring Harbor, Long Island, and the "Woods Hole marine worm group." A group to illustrate the invertebrate animals of a Nahant rock tide-pool is under construction.

THE INTERNATIONAL MEDICAL CONGRESS

Three important international congresses were arranged for the month of August, two of them on this continent. The Congress of School Hygiene meets at Buffalo just after the issue of the present number of the Monthly. The Geological Congress met at Toronto, and the International Medical Congress at London earlier in the month, but only the cabled accounts of the latter congress are at hand in daily papers. It is gratifying that these should be somewhat full, *The Boston Transcript*, for example, devoting as much space as two columns in a single issue to cabled despatches. The proceedings of a medical congress, more especially those parts relating to public hygiene, can with advantage be brought to the attention of the widest possible public.

International medical congresses were organized in Paris in 1867 and have since been held at four-year periods. The second congress was held in London thirty-two years ago under the presidency of Sir James Paget. Among those who took part in its proceedings were Pasteur, Virchow, Charcot, Koch, Huxley and Lister. Since that time vast progress has been made in the medical sciences and in their application, but it may be that a generation hence none of those taking part in the present congress will be so widely distinguished.

The general sessions of the congress were held in Albert Hall. The address in medicine was given by Professor Schauffard, the distinguished French physician; the address in surgery by Dr. Harvey Cushing, recently called from the Johns Hopkins University to Harvard University, and the address in pathology by Professor Ehrlich, of Frankfort. The general addresses were continued on the two following days, when Professor William Bateson spoke on heredity and Mr. John Burns, president of the British Local Government Board, gave an address on public

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Professor Charles F. Marvin,

Professor of Meteorology in the U. S. Weather Bureau since 1891, Chief of the Instrument Division, appointed Chief of the Weather Bureau, to succeed Mr. Willis L. Moore. Mr. Marvin is here photographed with the barograph, which is among the important meteorological instruments which he has invented.

health. There were on the program the titles of some 600 papers and some hundred formal discussions distributed among 23 sections. Among the great number of subjects included in the program there may be mentioned almost at random a discussion on tropical sanitation by Sir Ronald Ross, who advocated a separate department of state to deal with the health of the community; an account by Surgeon General Sir David Bruce of his investigation of sleeping sickness in Nyassa Land, where he found half of the wild animals to be infected; Dr. Van Logham, of Amsterdam, foretold the spread of yellow fever to Asia and Australasia through the opening of the Panama Canal; Dr. Ehrlich explained the mechanics of his laboratory, through which he had obtained his 606 different combinations, of which the last had become so important; Dr. S. Kitasato, of Japan, presented a report on the plague, and Dr. Shirayama on the cause of beri beri; Dr. George W. Crile, of Cleveland, spoke on the surgical effects of shock; Dr. Clarence M. Blake, of Boston, on climatic and occupational influences in diseases of the ear; Dr. K. F. Wenkelbach, of Strassburg, on the pathology of heart failure. Sir Thomas Barlow, the president of the congress, made an address at the general session and other English representatives made addresses before the sections over which they presided. Sir E. A. Schafer made the address on physiology; Sir Anderson Crichett, on ophthalmology; Sir Malcolm Morris, on dermatology; Sir J. Mackenzie Davidson, on radiology; Sir Lauder Brunton, on therapeutics, and Sir David Ferrier, on neuropathology.

There were three prizes awarded by the congress, one established at Moscow was given to Professor Ch. Richet for his work on anaphylaxis; the prize established at the meeting in Hungary, to Professor Wright for his work in the same subject, and the Paris prize to Professor A. von Wassermann, the newly appointed head of the Kaiser Wilhelm Institute for Experimental Therapy, for his work on immunity.

The congress passed a resolution to the effect that "It is our conviction that experiments on living animals have proved of the utmost service to medicine in the past and are indispensable to its future progress." The seven thousand members were entertained at dinners, garden parties and other functions in the manner which is only possible in the well-organized system of English society. The meeting of 1917 will be in Munich. Four years later it might well be in the United States.

SCIENTIFIC ITEMS

We record with regret the death of Professor John Milne, distinguished for his work in seismology, and Dr. Robert von Lenderfeld, professor of zoology in Prague.

M. Pierre Boutroux has accepted a professorship of mathematics at Princeton University, and will assume his duties in the autumn. M. Boutroux is a son of the distinguished professor of philosophy, M. Emile Boutroux, and is closely related to the Poincaré family. —Dr. J. S. Kingsley, professor of zoology in Tufts College since 1892, has accepted a chair of zoology in the University of Illinois.

The Kelvin memorial window in Westminster Abbey was dedicated on July 15. The dean of Westminster made the address and the ceremonies were attended by many distinguished scientific men. The window, which was designed by Mr. J. N. Comper, is in the east bay of the nave on the north side. The light from it falls upon the graves of Kelvin and Isaac Newton, and immediately beneath it are the graves of Darwin and Herschel.

The Popular Science Monthly

Entered in the Post Office in Lancaster, Pa., as second-class matter.

CONTENTS OF THE JULY NUMBER

CONTENTS OF THE AUGUST NUMBER

PRESS OF THE NEW ERA PRINTING COMPANY

Vol. LXXXIII, No. 4 OCTOBER, 1913

THE POPULAR SCIENCE MONTHLY

EDITED BY J. McKEEN CATTELL

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THE SCIENCE PRESS

LANCASTER, PA. GARRISON, N. Y.

NEW YORK: Sub-Station 84

Single Number, 30 Cents Yearly Subscription, $3.00

THE
POPULAR SCIENCE
MONTHLY.

OCTOBER, 1913

IMMIGRATION AND THE PUBLIC HEALTH

By Dr. ALFRED C. REED
NEW YORK CITY

I. The Nature of Public Health

THE age has happily passed when patriotism is measured in terms of human life sacrificed, and weighed in the balance of territorial or financial advantage. War has its heroes and mighty men who, fighting for man or cause, regardless of victory are accounted great. But the heroes and mighty men of peace who, for man and man's cause, fight the more terrible foes of ignorance, disease and public wrong, are coming to be accounted infinitely greater. No soldier opposing foreign foe was a truer patriot or died more nobly than did Dr. Thomas B. McClintic who, with no panoply of militarism, quietly and unfalteringly with his own life helped pay the price of the conquest of Rocky Mountain spotted fever last summer in the Bitter Root Valley of Montana.

Truly it is sweet to die for one's country. But even in the battles of peace the need of this sacrifice is rare. Greater is the need and grander the opportunity to live for one's country, and wage war against the powers of ignorance, indifference, disease and degeneracy. And this is the essence of the newer patriotism, which in no way removes or lessens the ancient duty of defending the land and honor of one's country, but at once idealizes and transcends that duty. If this be true, it follows that the man who is awake to his civic responsibility and who appreciates the honor of his American heritage will be in hearty sympathy with all agencies engaged in this distinctly modern line of endeavor. He will take part in, and aid to his utmost ability, those influences making for a cleaner and better America, because he realizes that this is not only his opportunity but his patriotic duty.

It appears therefore that the subject of the public health must not

Landing Stage for Immigrant Barges at Ellis Island.

only interest, but must engage the loyal support of every good American. Yet the name itself means the same to no two people, and there exists an equally diverse opinion respecting the relative importance of the component elements of the public health, and the causal influences controlling it. However, it is unnecessary to bring up disputed points and impractical discussions when there are issues of the most vital concern involved in this question.

The public health, or the health of people en masse, in groups or communities, is more than an adding together of the conditions of health in which each person in the group finds himself. Just as the mob-sense, the group consciousness, or the dominant spirit of the mass, as one chooses to call it, differs from the individual personalities which compose it, so the public health differs from the individual health of each single person. The public health is intangible, though none the less real. It is not a static condition, which can be moved and delimited from without, but it is full of dynamic potentialities, and pregnant with unforeseen complications and denouements. The study of it leads into a bewildering array of intimately related subjects which at first glance seem to bear but a meager relation to it. A survey of its field must begin with an understanding of what is included in the term public health itself.

Public health may be considered to present itself in three phases, as physical, mental and social health. Each is influenced by many factors.

Certain features of the public health are most prominent from the social standpoint. The development of industrial life has brought many problems of most pertinent concern. Among them are industrial diseases, such as arsenic, lead and phosphorus poisoning, child labor, hours of labor, the employment of women in certain industries, sanitation of working quarters, and the responsibility of employers for the life and activities of employees outside of the workroom. The rapid growth of facilities for travel and the enormous number of travelers on railroads and steamships presents some unexpected problems in the sanitation of common carriers. Several instances are recorded of smallpox spreading in Pullman coaches. Mosquitoes, fleas, bedbugs and flies may easily carry an infection over long distances by aid of the railroad. A typhoid carrier can infect every water supply traversed by his train between Los Angeles and New York. The prevention of accidents in mines, and other industries, improved methods of controlling epidemics, and preventable diseases, and of saving the victims of common accidents like drowning, prevention of overcrowding in cities, proper housing of the poor; these are but a few of the numberless problems in the new science of public hygiene, from the standpoint of social public health.

The physical public health is concerned with communicable disease and its direct results, as in epidemics, while mental public health considers the prevalence, prevention and care of mental disorders, and the new science of mental hygiene.

One of the most important of the factors having to do with the public health is immigration. Not in the world's history has so vast an ethnic movement been recorded as that from Europe to America. The tribal migrations of ancient Europe are puny indeed compared to the great tide of a million and a quarter souls coming every year to the

BOARDING CUTTER "IMMIGRANT," ELLIS ISLAND.

Immigrant Hospital, Ellis Island.

United States. The tremendous bulk of this movement, together with the fact that it is drawn from such diverse and often mutually antagonistic races and nations, produces problems which not only are unique but whose proper solution is a matter of the gravest concern for the welfare and continuance of this country. The population of New York and of many sections elsewhere increases faster by immigration than by birth. These immigrants at best are only imperfectly and superficially sifted, and many enter to whom the privilege should be denied. The reason for this lies in the extreme difficulty of recognizing many physical and mental affections in their incipiency, in the shrewdness so often exhibited by the immigrant in concealing such defects, and in the loopholes that exist in the administration and interpretation of the law whereby many defectives who are detected are nevertheless admitted.

It goes without saying that the development of American ideas and standards in an immigrant foreign population will be inversely proportional to the density and homogeneity of that population in any section. Intermixture is the secret of assimilation. And assimilation is the test of desirable immigration. But not alone is the social and economic advance of the immigrant determined by his relations with Americans, for it is just as true that the immigrant will affect the standards and ideals of the American. This influence of the immigrant on the native population becomes operative in many ways, but none of these is so important and yet so complicated as the influence on the physical, mental and social health of the general population.

The medical inspection of immigrants is the first, most comprehensive and most effectual line of defense against the introduction of disease or taint from without. It is properly a feature of quarantine, and the two systems, immigrant inspection and national quarantine, might well be combined and condensed to their mutual advantage. Especially is this true since both systems have the same object, require a somewhat similar plant, and are both operated by the federal Public Health Service.

The influence of immigration on the public health thus constitutes perhaps the most serious feature of this vexing and much-discussed problem. Disease or defectiveness of mind or body in the immigrant must be considered from two standpoints. First is the immediate result on those with whom the immigrant comes in contact. Second is the effect on the descendants of the immigrant, and indirectly on the general public; in short, the eugenic aspect.

II. Direct Relations of Immigration to the Public Health

Certain diseases have been considered so dangerous to the individual or to the public as to be included in a list of conditions which are absolutely excluded by the immigration law. Among these are venereal and other dangerous or loathsome contagious diseases, including tuberculosis, trachoma, filariasis, and hookworm infection. Insanity, epilepsy and mental defectiveness are likewise excluded.

There is a growing recognition of the wide prevalence of venereal disease in this country, and of the insidious danger from it. But no

Medical Officers at Ellis Island.

Italian, Alpine Type.

matter how prevalent it may be, and regardless of the few cases that may be found among immigrants as compared with the huge number already existing, the exclusion of those few is a matter of deepest moment. It is extremely difficult to detect venereal disease in the routine examination of immigrants; even with the greatest possible vigilance, it is probable that many cases are not identified.

Acute diseases, including the ordinary contagious diseases, are stopped at the immigration station and kept in an isolation hospital until recovery has occurred. There is no serious danger from these because acute disease is easily recognized and ordinary quarantine precautions serve to prevent local epidemics.

Certain parasitic skin diseases such as favus and tinea tonsurans are excluded. These diseases are caused by a minute fungus which in itself is not dangerous to life or necessarily to health. But the lesions produced by these fungi are disfiguring and loathsome, and the disease is easily transmitted by contact, either directly from the patient or through the medium of domestic animals as cats and dogs, or of common hairbrushes, towels or linen. If the fungus invades the hair follicles and roots of the hairs, its eradication is a matter of the greatest difficulty and often impossible. It is this feature that makes favus and ringworm of the scalp practically incurable. The classification of loathsome and dangerous contagious diseases includes a large group, but the desirability of excluding immigrants possessing any of them rests on a few common principles. These diseases are all communicable and therefore may spread through an ever-widening circle. They are detrimental to the health and usually to the life and normal activity of the host. Occurring in the ordinary immigrant class, they decrease his productivity and power of self-support, consequently laying an additional and undeserved burden on the rest of the community. Many of them result in the transmission of hereditary taint or predisposition or actual disease to posterity. And finally their admission into this country simply means a gratuitous and unnecessary assumption by this country of a burden belonging properly to the countries from which these persons come, and encourages those countries, as in the past, to unload their decrepit, worn-out and encumbering human stock on us.

Little is heard as to the bearing that immigration may have on the prevalence of tuberculosis. The status of tuberculosis is influenced by immigration in several ways. The disease in its pulmonary form is usually chronic and marked by a slow and insidious onset. Hence only a careful physical examination, often combined with a suggestive clinical history, will reveal the affection in its early stages, that is, in the first three to six months of its course. It must be borne in mind that the medical officer examining immigrants encounters the shrewdest evasion and concealment. Only too often the diseased immigrant is carefully coached by persons having knowledge of the methods of the medical examination. Altogether the task of the medical examiner is most difficult. It is estimated that 150,000 persons die each year in the United States from tuberculosis, and statistics put the death rate from tuberculosis at 10 per cent. of the total death rate. Yet in the fiscal year 1911, but 0.015 per cent. of the immigrants examined were certified for tuberculosis. This may be explained in no small measure by the fact that in the administration of the law excluding tuberculosis it is the rule to diagnose the pulmonary disease only when the tubercle

Italian, Sicilian Type.

bacilli have been found in the sputum. Moreover a microscopical preparation showing the stained bacilli must be submitted in substantiation of the diagnosis. The tubercle bacillus rarely appears in the sputum until the disease is well advanced and there has been a certain degree of destruction of lung tissue. To limit the diagnosis to such cases alone as show the bacillus allows numerous cases to pass free in which the clinical diagnosis is practically certain.

In this connection it is to be recalled that many deportation cases diagnosed as tuberculosis are referred to the medical officers for examination to determine if the disease existed or was due to causes existing

ITALIANS.

at the time of landing. In these cases it is customary for the certificate of tuberculosis to be based on a clinical diagnosis alone with no demonstration of bacilli in the sputum. This is the case even though the deportation of a tuberculous alien is a far more severe and radical procedure than to exclude such an alien at first.

It would be more effective to hold for hospital observation all cases presenting clinical evidence of pulmonary lesions, and to allow diagnosis in such cases as after careful and repeated examination showed a definite lesion, perhaps using the tuberculin reaction as an aid in selected cases. In other words, if the diagnosis of pulmonary tuberculosis could be made by a competent and careful physician, even though there were no bacilli in the sputum, the case should be certified as tuberculosis.

In the administration of the law excluding tuberculosis, only tuberculosis of the lungs, genito-urinary tract or gastro-intestinal tract is considered to be indicated. It would seem that an arbitrary limitation of the scope of the law to these three forms leaves out of account the serious nature of tuberculosis of the bones and glands at least. There is no doubt that the widespread popular interest and agitation against tuberculosis has overemphasized the importance of the tubercle bacillus, and the diagnosis and care of tuberculous patients. But equally or even more important is the prevention of the disease by sanitation, personal hygiene and increase of individual resistance to it. The bacilli, as Osler says, are ubiquitous, and practically every person is exposed at some time to infection. One of the very best reasons for placing tuberculous patients in sanitaria, and for scrupulous sanitary care of those who can not be so placed, is that each case, especially in the humbler walks of life, tends to become a constant focus of infection, spreading the germs broadcast. This is prevented by proper care. Linked with this consideration is the fact that the tuberculous patient tends to produce feeble offspring, predisposed to this and other diseases and defects. It is no small advantage to the community to have tuberculous cases in proper institutions where these dangers are averted. The advantages of removing tuberculous patients from contact with the general public in the ordinary activities of life are at least no greater than the advantages of preventing the entrance into the country of tuberculous aliens.

Another consideration which increases the danger of admitting immigrants who are subject to tuberculosis or other communicable diseases is based on the nature of the present-day immigration. More than four fifths of the immigrants entering the United States come from southern and southeastern Europe. As a type these peoples are ignorant of hygiene and sanitation. They live on a low plane. Overcrowding, disregard of privacy, cleanliness and authority, their gregariousness and tendency to congestion along racial lines in cities, are all important factors in the spread of disease among them and by them.

Among the diseases whose prevalence, manner of spread and results constitute a national health problem, trachoma must be reckoned. Trachoma is an inflammatory communicable disease of the eyelids, of unknown causation, having most serious sequelæ of deformity of the eyelids, impairment of vision and blindness. In Europe and Asia it is a terrible scourge. "Egyptian ophthalmia" has a long and famous history. The wide prevalence of trachoma in the United States and its importance in decreasing economic efficiency are only now beginning to be fully realized. It is stated that half of the 64,000 registered blind persons in the United States are needlessly blind and that the maintenance of one blind person for life by the community costs an average of $10,000. Sixty-seven per cent. of the blindness in the Ohio State Institution for the Blind was found to be due to trachoma. In the Kentucky Institute for the Blind, a year ago, 45 per cent. of the blindness followed trachoma.

It is known that trachoma is a common disease of the American Indians, and its ravages are only equalled in seriousness by tuberculosis. In some sections of the southwest, from 65 per cent. to 95 per cent. of the Indians are trachomatous. Over 800 cases of the disease were operated upon and treated at the trachoma hospital of the Indian Service in Phœnix, Arizona, alone, according to the report of the Commissioner of Indian Affairs for 1911. A recent investigation covering 39,231 Indians in 25 states, one eighth of the total Indian population, showed 8,940 or 22.7 per cent. to have trachoma. At this rate there are 72,000 trachomatous Indians in the United States.

Italians.

Italian.

In 1911 Surgeon M. H. Foster, of the U. S. Public Health Service, made a survey of conditions of health and sanitation among the natives of Alaska. Of 1,364 Alaskan Indians examined over 7 per cent. suffered from trachoma, and nearly 3 per cent. were blind largely as a result of trachoma. The disease ranked with syphilis and tuberculosis as one of the most destructive to which the natives are subject. Recently Surgeon John McMullen, of the Public Health Service, has conducted a careful investigation as to the prevalence and seriousness of trachoma among the mountaineers of Kentucky. Of about 4,000 persons examined, 500 or $12\frac{1}{2}$ per cent. had trachoma. From 3 per cent. to 18 per cent. of the school children examined suffered from trachoma. At the semi-annual clinic held by Dr. J. A. Stucky at Hindman, Kentucky, in September, 1912, 374 patients were examined, of whom 113 had trachoma. Over 11 per cent. of the resident pupils of the settlement school at Hindman, and 16 per cent. of the day pupils suffered from trachoma. About one half of all those applying for relief to this clinic suffered from trachoma or its sequelæ.

The management of this newly recognized public health problem includes two features. First is the treatment and cure of existing cases of trachoma, and popular education in the hygienic and sanitary measures which will prevent its spread. Second, and equally important, is the prevention of the development of new cases. Probably the prevention of the introduction of new cases in immigrants is the most important single factor in the prevention of new cases and new foci of contagion. In 1911 a total of 2,504 cases of trachoma were certified in immigrants. Many of these were admitted, however, in spite of the medical certificate. At New York, for instance, where 1,167 cases were certified, 63 cases were landed. In 1912 of the 718 cases certified at New York, 64 were landed. If no inspection were made for trachoma, the victims of the disease would flock to the United States in hordes. We have a weighty and difficult problem in handling the trachoma already existent in this country. Every consideration demands its absolute exclusion in immigrants.

One other disease of national importance for the public health, and which has an intimate relation to immigration, is hookworm infection. The economic and social significance of this disease is well known. The Rockefeller Sanitary Commission for the Eradication of Hookworm Disease in its second annual report shows that a heavy infection exists in Arkansas, Virginia, Tennessee, Alabama, Mississippi, Louisiana, North and South Carolina and Georgia, and that a lighter infection exists in California, Nevada, Oklahoma, West Virginia, Kentucky, Texas and Florida. Maryland is probably also infected. The report states that hookworm disease belts the earth in a zone 66 degrees wide, extending from 36 degrees north to 30 south latitude. Practically no country within these boundaries is exempt.

It is a subtle disease with a chronic course, and it attacks the health and efficiency of its victims insidiously. It is beginning to do in the United States what it has already done in Egypt, China and India. It will be impossible to control the spread of hookworm in the United States as long as any considerable number of new cases are admitted in immigrants. The law rates it now as a dangerous contagious disease, subject to exclusion. The exclusion of Hindus at San Francisco on the certificate of uncinariasis practically stopped the immigration of

Orthodox Greek Catholic Armenian Clergyman.

East Indians through that port. The Rockefeller Commission estimated the rate of infection in India at from 60 to 80 per cent. of the population, and at San Francisco in 1911 65.6 per cent. of the Hindus were found infected. No immigrant should be admitted who is infected with hookworm. He should be treated until cured in an immigrant hospital or excluded at once.

Hebrew from Galicia.

Armenian.

These few diseases are selected merely as types to show the serious nature of the importation of actual diseases by immigrants. The list is far from exhausted by the instances we have discussed.

The phase of public health which may be termed mental health is susceptible to many influences. There is no doubt that successive ages of inbreeding, "racial incest," as Dr. H. M. Friedman calls it, results in a racial tendency toward, or characteristic of, mental instability and predisposition to a neurotic and psychopathic constitution. This is illustrated in the case of the Jews, where their highly developed emotional nature and predisposition to functional insanities may be laid to absence of fresh blood and to close racial inbreeding for many centuries. New blood is essential for racial or individual development.

If the tide of immigration brought to us only the good blood that this country needs, no restrictive examination would be required. But the mentally diseased and defective come in large numbers, and if the vigilance of the nation's sentries were relaxed ever so little, these numbers would swell to an overwhelming flood. Insanity and mental defectiveness are of grave concern from the standpoint of public health. The individual victim is predisposed to crime, is very likely to be not self-supporting, tends to become a complete public charge and, most serious of all, transmits a tainted heredity or actual mental disease to his descendants. Moreover, where physical disease or defect tends toward extinction, mental disease or defect is prolific and both insidious and far-reaching in its ramifications.

Dr. H. H. Goddard has recently made a complete hereditary study of the descendants of an Englishman of good ancestry who contracted an illegitimate union with a feeble-minded girl. A feeble-minded son married a normal woman and from this pair were descended 480 persons. Of these 480 persons, 36 were illegitimate, 24 were chronic alcoholics, 3 were epileptics, 33 were immoral, 8 kept houses of ill-fame and 3 were criminals; 143 were feeble-minded. In all that family only 46 were apparently normal. The legal union of the same ancestor with a normal woman resulted in 496 descendants, of whom but two showed abnormal mentality. Comment on this record is unnecesary. Its lesson should be kept in mind in considering the fact that the alien population of the United States is furnishing considerably more than its proportionate number of feebleminded and insane persons.

More accurate statistics are available for New York state than elsewhere in the country. But while New York is chiefly concerned with the problem of the alien insane and mentally defective, every other state has or will have the same problem in varying degree. It is authentically reported that about one per cent. of the school population of New York City, or about 7,000 children, are distinctly feeble-minded. In addition to these is an equal number of idiots and imbeciles, and the large class of morally defective children and border-line types. Census statistics show that the parents of 30 per cent. of the feeble-minded children in the country at large are aliens or naturalized citizens. In the first line of defence and prevention lies in a rigid primary exam-

CROATIAN.

ination of all applicants for entry. To put this mental examination of this ratio at least 3,000 of New York's 10,000 feeble-minded children are the progeny of the 9,000,000 immigrants of the last ten years.

Dr. T. W. Salmon writes that New York State is the destination of 26 per cent. of all immigrants coming to the United States, but that more than 80 per cent. of the immigrants found on arrival to be mentally defective or insane are headed for that state. He found more than 8,000 aliens in the New York State hospitals for the insane. The New York State Lunacy Commission reported to the legislature on February 14, 1912, that there were 33,311 committed insane cases in the state institutions. According to Dr. Salmon, more than 25 per cent. of these were aliens, who to a large extent had passed through Ellis Island. The capacity of the institutions was exceeded by 3,043.

Enough has been said to show the intimate relation obtaining between immigration and the prevalence and increase of insanity and mental defectiveness in the United States. It is recognized that these conditions are increasing to an alarming extent and the student of public health and preventive medicine must concern himself seriously with the control and eradication of the sources of this increase. So far as the immigration of the insane and mentally defective is concerned, immigrants on a thoroughly adequate basis will cost money in large amount. But it is not only a good and economic investment, it is absolutely essential in order to conserve our national mental health and to ensure a normal mentality to coming generations.

Among the important agencies operating directly to promote mental public health is the present mental hygiene movement. This is a carefully organized effort of national scope, which is being directed and promoted by the National Committee for Mental Hygiene with headquarters in New York City. The field activities of this committee are under the direction of Dr. Thomas W. Salmon, of the U. S. Public Health Service. The object of the committee is to popularize the correct knowledge of the causes of mental impairment, to supply agencies for furnishing advice to persons threatened with, or actually suffering from mental breakdown, and to furnish preventive social service for such cases. Insanity is a disease and a large proportion of the cases are due to preventable causes. The National Committee is also making a medical survey of the country with reference to methods of caring for the 200,000 insane of the country. At present there is a lamentable lack of uniformity in the different states, in the facilities and methods employed in insane hospitals, and the standards of care are very low in many.

III. Importance of the Immigration Station for the Public Health

Any discussion of the relation of immigration to the public health must take cognizance not alone of the mental and physical effect of incoming immigrants on the present population, but must concern itself very particularly with the selection and enforcement of the best methods of excluding the unfit. The relative importance of the leading ports of entry in number of immigrants examined is shown in the following table:

	1909	1910	1911	1912
New York (Ellis Island)	724,757	896,015	749,642	726,040
Boston	47,895	62,075	54,759	59,893
Baltimore	20,510	31,245	23,543	22,667
Philadelphia	15,083	39,671	46,857	47,742
Total for U. S.	944,235	1,198,037	1,093,809	1,143,234

It is seen that Ellis Island, the immigration station for New York, is by far the largest port of entry. Hence it is the most representative place to study practical methods of immigrant examination. These methods have been described elsewhere in detail.[1] Certain features only need mention at this time.

[1] Alfred C. Reed, "The Medical Side of Immigration," The Popular Science Monthly, April, 1912; and "Going through Ellis Island," The Popular Science Monthly, January, 1913.

Only aliens of the steerage class are taken to Ellis Island. Aliens in the first and second cabin of arriving vessels are examined on board by medical officers of the Public Health Service who board the vessel as it leaves the New York Quarantine at the entrance to the bay. The present force of medical officers at the Ellis Island station is hard pushed to keep abreast of their continually increasing duties and responsibilities. No definite standard has yet been found for the mental and physical examination of immigrants. It is a new and very technical field in public health work.

Magyar, showing Boots and Sheepskin Coat.

A Little Russian in a Sheepskin Coat.

Experience and practise alone will show what is best. No absolute and ironbound rules can be laid down at present as to methods of administration and examination. These features make especially difficult the task of the medical examiners at Ellis Island. Being by far the largest port of entry, Ellis Island must of necessity have most to do with the determination of the best methods of examination, and of standards of examination which can be used elsewhere after being put to the test of actual trial here and modified in the light of experience. In other words, Ellis Island is peculiarly adapted to be an experimental station in the mental and physical examination of immigrants. There is a tremendous need for such a station. The entire subject is new and, as has been pointed out, there is neither precedent nor experience to guide. It is a sophistical and beclouding argument that such work would be an injustice to the immigrant. In the strictest sense it would be an intensive study of the immigrant under the best possible surroundings to find out the best way of separating the sound and desirable alien from the unsound and undesirable.

Such work would find many definite problems in the diagnosis of disease. An instance in point is trachoma. Probably no better trachoma clinic exists in the country than at the Ellis Island hospital. So far the cause of the disease is unknown. Investigation of the etiology would naturally carry with it investigation of the best means of treatment and cure. Mention has been made of the importance of the hookworm and of its prevalence in the United States. There is a mighty host of intestinal parasites, several of which are fully as dangerous as the hookworm though not distributed so widely. An example of this is the fishworm, the *Bothriocephalus latus*. To exclude immigrants harboring these dangerous intestinal parasites or to cure them before they enter the country is very important.

Dr. M. W. Glover has noted that of 1,553 immigrants examined at San Francisco, 42.8 per cent. harbored the hookworm, not to mention numerous other parasites. He found that 29.4 per cent. of the 782 Chinese examined were infected, and notes the fact that the most marked evidences of infection were seen in Chinese boys. Dr. Glover makes the interesting suggestion that this apparently explains the puzzling observation of the discrepancy between the apparent age and the age claimed in many Chinese boys. In the fiscal year 1912, 941 cases were certified at Ellis Island for lack of physical development, in addition to 444 cases for poor muscular development and 36 for malnutrition. A large proportion of these cases were boys whose physical development did not correspond to the age claimed. Dr. Friedman notes such a disproportion as of common occurrence in the Mediterranean races and especially in the Greeks. It would be well worth while to institute an investigation to determine whether intestinal parasites or some other agency is responsible for these cases. The determination of this point would not only serve to clarify and give a more exact standard of diagnosis and certification of these aliens, but it would be of untold value in relieving similar conditions not only among our own people, but in the countries from which this class of immigrants comes.

The detection and diagnosis of mental conditions in immigrants is a matter of exceeding difficulty. This is in no small measure due to the fact that no definite standards are available by which each immigrant may be judged as to his mental development and normality. Mental defectiveness or backwardness in the Pole or Russian expresses itself in a very different manner from the same conditions in a West Indian negro or in a Basque, or an Italian. Each is accustomed to a more or less limited and different range of experience. Each has a distinctive hereditary endowment and has grown up with a distinctive training, a peculiar environment and habit of thought and action. Experience and deduction agree that each must be examined by methods peculiarly suited to his own circumstances. Such methods can only be developed from the experience of trained men in the careful examination of many cases. Numerous cases are put through a detailed mental examination and released because no definite and recognizable sign of mental impairment could be obtained. Many have latent symptoms which are indefinite, but which if kept on record for a large number of cases would make possible a more exact standard of diagnosis. If a careful stenographic record were filed

Russian Polish Girl.

Finn.

of every such examination those cases which later after landing develop some definite psychosis or show positive mental impairment could have this original examination reconsidered in the light of later developments. From a large number of such cases it would be possible to formulate definite methods of original examination and to codify new symptom complexes for different races and classes. Tabulation of such symptom complexes and from them the establishment of definite standards of mental abnormality for the various races, would be in accord with the same principle as that followed in formulating the Binet-Simon measuring scale of intelligence, now used so widely in the diagnosis of mental backwardness, which was codified from a large number of mental examinations of French school children.

A few illustrations have been picked at random to show the enormous field of usefulness of Ellis Island as an experimental station of methods and standards for the physical and mental examination of immigrants. Of course there would be great gain incidentally to the cause of science and scientific medicine, and this gain would be shared directly by the public health conditions of the country. As a suggestion of the opportunity for obtaining data on related topics, it would be feasible to make an exhaustive study of muscular anthropology, or the racial and relative physical development of the living man. Abundant material is available for this at Ellis Island from every race and nation, and that, too, with no hardship and practically no delay to the immigrant.

Space forbids more than a suggestive sketching of what Ellis Island means for the best interests of the public health. Were a larger staff of medical officers available, it would permit the fuller utilization of observation wards in the immigrant hospital in the diagnosis of diseases of the lungs, kidneys, heart, blood, intestinal tract, and others where careful observation and laboratory examinations are essential.

An efficient immigration station requires a staff of specially trained interpreters. It is hard to overestimate the need for thoroughly trained competent medical interpreters. Of course the ideal arrangement would be for the examining physician to be able to address each immigrant in his own tongue, but this is manifestly impossible. It is hard enough to discover mental symptoms ofttimes when the examiner can converse fluently and sympathetically with the patient. Lacking a skilled, intelligent and honest interpreter, his task is well-nigh hopeless.

The medical examination is the only true examination of immigrants that is provided for under the law, or that is possible or even necessary. The real center and necessary essential of an immigration station is the medical division. If an immigrant is in a broad sense the possessor of mental and physical health his entry is desirable. Whether he shall stay, having once been admitted, could well be made dependent on his meeting certain tests of education and financial self-support within a definite period. A healthy immigrant who passes such tests is the only alien who should be eligible for citizenship.

It is essential for the success of the medical examination that it be conducted in quarters especially arranged with reference to the needs of the examination. Well lighted and perfectly ventilated rooms are extremely necessary. For both the physical and mental examination a number of separate rooms are needed sufficiently large to prevent overcrowding. The immigrant is naturally frightened and nervous from

SLOVAK GIRLS.

his strange surroundings. Being detained for more complete medical examination increases his perturbation and anxiety. It is most important to allay his fears and remove the sense of strangeness, so far as possible, by avoiding overcrowding, by quiet and kind treatment, and by judicious arrangement of facilities and interpreters. These conditions are of no small importance in the conduct of the medical examination.

As has been stated, aliens in the first and second cabins of incoming vessels at New York are examined on board ship, and are not removed to Ellis Island unless such a course is required for medical attention or diagnosis, or unless the individual is held for a board of special inquiry to pass on his eligibility for admission. The conditions under which the medical examination must be conducted on board ship are most disconcerting and difficult for the medical officer. The law regards all aliens alike, and the regulations governing the medical examination of aliens expressly make no distinction between those in the cabin and in the steerage. As a matter of fact, the chances of a defective immigrant escaping detection in the cabin are far greater than in the steerage. This depends on many factors of which space forbids more than mention. The aliens of the first cabin are frequently discharged without exam-

Slovak.

Roumanian.

ination by the medical officer. In the confusion and excitement on board an arriving liner not infrequently defective aliens as well as others are passed with no medical examination.

It is not true that immigrants come only in the steerage. On many lines the second and even the first cabin brings a class of alien passengers distinctly inferior to the steerage of such lines as the Scandinavian and Scotch. In his report for 1911 of the medical examination of aliens at Boston, Dr. M. V. Safford says:

> Six per cent. of the steerage passengers arriving at Boston were United States citizens, and over three fourths of the second cabin passengers were aliens. About 25 per cent. of the aliens arriving at Boston come as cabin passengers. It appears that over 7 per cent. of the alien second cabin passengers were certified as

seriously defective or diseased, while only 4 per cent. of the alien steerage passengers were so certified.

These figures may be taken as representative, although unfortunately similar figures are not available for Ellis Island. No more is needed to show that relatively the cabin examination is at least as important if not in fact more important than the steerage examination.

Dr. Safford very aptly points out that "long-established custom dictates that the medical inspection of cabin passengers must be made somehow on shipboard whenever they may arrive, day or night, and that they can not be removed to a suitable place ashore for the purpose." This custom is pernicious when made ironclad. In some cases the examination can be conducted satisfactorily on shipboard. An exception should be made by the immigration inspectors in favor of these cases only, and the rule should be that all aliens should be examined in a satisfactory station on shore. The law designates the regular immigration station as the place of examination of all aliens, unless the commissioner of immigration expressly appoints some other.

German Swiss.

German Polak.

IV. Deportation of Unsound Landed Aliens

But the exclusion of unsound aliens includes more than a competent medical examination at entrance. Many cases of incipient disease both physical and mental are unrecognizable at the time of entry except by detailed and refined methods of diagnosis which are absolutely impracticable in the routine examination of large numbers of immigrants. Also the cleverness and cunning of defective aliens may easily conceal from the examiner some unobtrusive though important sign of defect or disease. Such cases are very apt to come to light sooner or later after landing, in hospitals or other public institutions. As Dr. Friedman says:

> The detection of mental disease among aliens offers the same difficulties in an infinitely larger degree. The goal in this work is to be able to detect from the panorama of people those who have remote or only latently present mental abnormalities. There are no signs by which an examiner can say in any given instance that an individual will develop a mental disease.

In addition it is impossible for an examination at the time of arrival to indicate how successfully a given immigrant will react to the stress and strain of American life, and whether some latent tendency or weakness may not be developed under the new conditions. In short the medical examination at entrance must be supplemented by examination at a period later in case some latent disease manifests itself.

The law takes cognizance of these circumstances by providing for the deportation of aliens who, within three years of landing, become public charges or develop any of the excludable diseases from causes existing prior to landing. An example of the need of this law and of its operation may be seen in the case of pulmonary tuberculosis, due to causes present when the alien landed but not appearing in definitely recognizable form until months later.

Even more striking is the value of this law in insanity, epilepsy and mental defectiveness. These conditions are excludable but often escape detection on the primary examination. Within the three-year limit, however, a large number of such cases develop. Many forms of insanity and epilepsy are known to be due to hereditary constitutional defect and psychopathic tendencies. Hence if one of these becomes apparent within three years after landing, the diagnosis shows that the causes must have existed prior to landing. Of course feeble-mindedness, idiocy and imbecility are congenital and one of these conditions found within three years is evidently under the law.

Feeblemindedness differs from imbecility only in degree, and in its lesser forms in turn shades off into simple backwardness of mental development. A case may have been given the benefit of the doubt on the primary examination, when later conditions indicate it to be feeble-minded. An infant or young child may show feeble-mindedness within

ALGERIAN ARABS AT ELLIS ISLAND.

three years which was not apparent at entrance. Or, especially in the cabin examination on board ship, a feeble-minded person may entirely escape detection. These instances illustrate both the need for the law and its effectiveness. It is the second line of defence against unsound aliens, augmenting and reenforcing the first line of defence at the immigration station.

Unfortunately the effect of this deportation law is nullified in many cases by decisions of the Secretary of Commerce and Labor.[1] Certain of these decisions should have the widest publicity and will be a surprise to many persons.

Decision No. 120 of the solicitor of the Department of Commerce and Labor was published on February 8, 1912, for the guidance of immigration officials and others concerned. Within the legal three-year limit, Yittel Goldfarb, a sixteen-year-old Russian Jewess, was certified to be suffering from manic-depressive insanity by a member of the New York State Board of Alienists, an officer of the Public Health Service, and officials of the Manhattan State Hospital for the Insane where she was confined. The unanimous medical opinion was that, while the insanity had developed after the girl had landed, it resulted from causes in existence before landing. These causes were stated to be constitutional psychopathic tendencies and mental instability. It is held by competent alienists that manic-depressive insanity is always based on hereditary tendencies and mental instability. The apparent or immediately pre-

[1] The newly established Department of Labor, with Secretary William B. Wilson at its head, now includes the Bureau of Immigration, and it is probable that this policy will not continue.

ceding cause acts only as an exciting agent in bringing to fruition what was previously latent. It is to be noted that this decision does not question the diagnosis, but it states the opinion of the lawyer who framed it that the existing condition of manic-depressive insanity did *not* depend on causes prior to landing. In the light of this decision a warrant was refused for the arrest and deportation of the alien in question. As a consequence deportation is impossible in a class of cases which formerly supplied about 350 deportations annually.

On February 25, 1912, Mariase Lipschutz, aged 25, arrived from Russia on the steamer *Campanello*. On February 28 she was certified by the medical officers at Ellis Island as being feeble-minded. On March 28 she was ordered landed by the Secretary of Commerce and Labor, for the avowed object of visiting a sick relative. Her visit still continues.

On June 25, 1912, Rewke Palayes, aged 11 years, arrived from Russia on the steamer *Rotterdam*. A special certificate of imbecility was issued by the medical officers at Ellis Island, this carrying with it a fine of $100 for the steamship which brought her. On July 13 she was ordered landed by the Secretary of Commerce and Labor. The immigration law declares that minor children of naturalized citizens, if these children are dwelling in the United States, shall be considered as citizens. The father of this girl was a naturalized citizen. The Secretary contended that "constructively" she became a resident when she had left her foreign domicile, even though she had not even been admitted into the United States. She was ordered landed.

An exactly parallel case was decided in an opposite manner in an

French Canadian Family entering from Montreal.

opinion of the Supreme Court handed down by Justice Day on January 7, 1907, in the case of Charles Zartirian *vs.* George B. Billings, Commissioner of Immigration at Boston. Here the Supreme Court decided that a naturalized citizen's child was not a citizen and was properly excluded because it was suffering from trachoma, a disease subject to mandatory exclusion. The opinion stated that

> The petitioner's child, having been born and remained abroad, clearly does not come under the statute. She was debarred from entering the United States by the action of the authorized officials, and, never having legally landed, of course could not have dwelt in the United States. Congress has not said that an alien child who has never dwelt in the United States coming to join a naturalized parent, may land, when afflicted with a dangerous contagious disease.

The Zartirian case and the Palayes case are just parallel. The Supreme Court decided that the Zartirian child should be excluded. The Secretary of Commerce and Labor decided that the Palayes child should be admitted.

Space is insufficient to dwell further on the loopholes in the deportation of these cases, or to discuss possible improvements in the deportation law. A factor which is far from inconsiderable is that many cases legally subject to deportation, within three years of landing, are not reported to the proper officials. It is earnestly to be hoped that a thoroughly efficient primary medical examination of arriving immigrants may be augmented and reenforced by a strict administration of the deportation laws.

Recapitulation

The subject of public health is of most pertinent and vital interest. Immigration is an influential factor in the physical, mental and social health of the United States. From the standpoint of the public health, it is absolutely essential to exclude unsound immigrants, and the second line of defence against them is a rigid administration of the deportation law. How best to exclude unsound immigrants is a new and pressing problem of the public health.

AN IRISH CHANNEL RAILWAY

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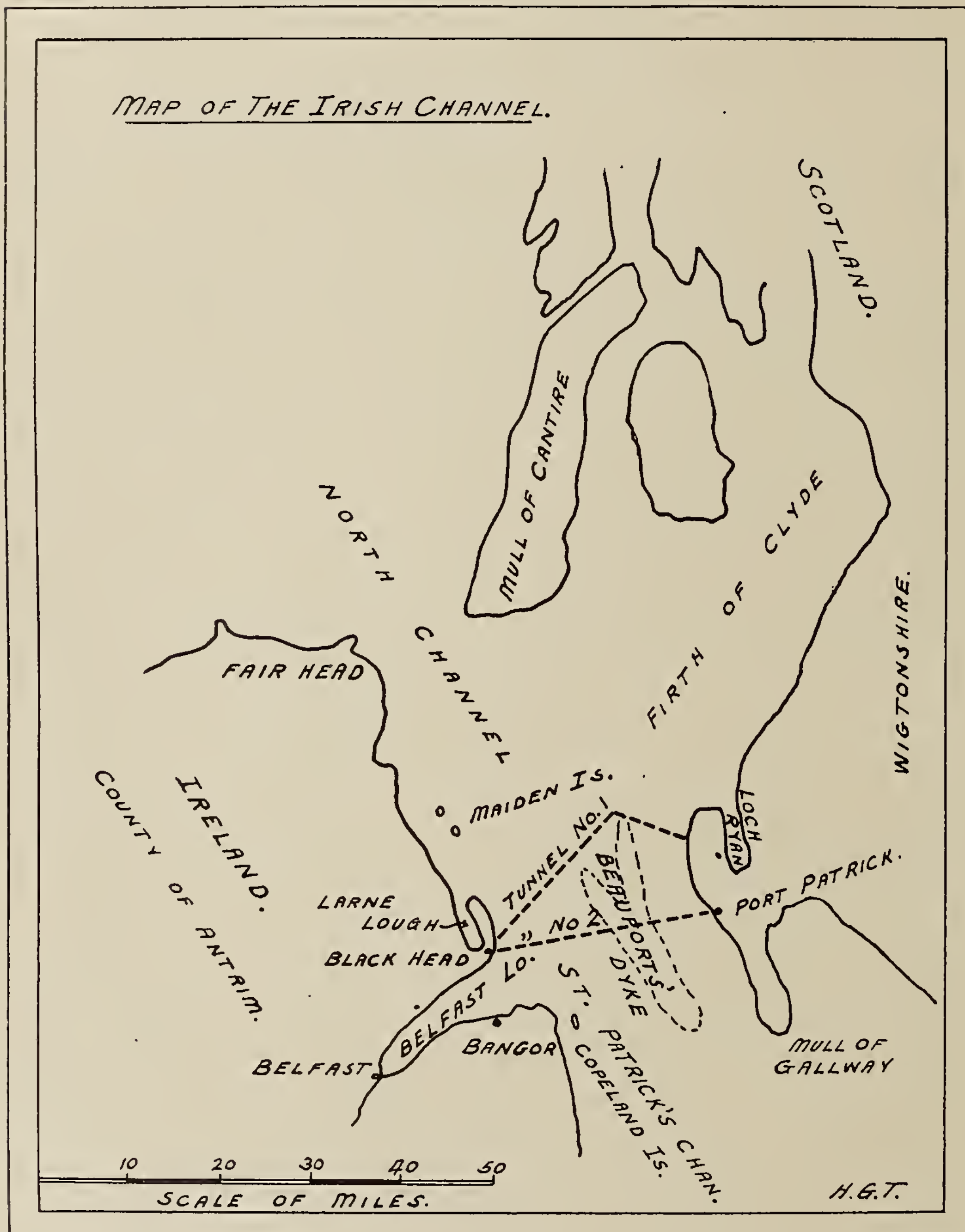
IRELAND does not seem to have ever enjoyed so great a degree of favor and prosperity as other parts of Great Britain, notwithstanding the continuous efforts which, for centuries, have been spent in its behalf. This may be due to some extent to its isolated position and the presence of the Irish Channel which unfortunately separates it from England and Scotland. Money and lives have been freely given to secure political union and better conditions, and enormous energy has been expended to improve the social and commercial standing of Ireland and its inhabitants.

In the light of modern industrial development, the question may reasonably be asked: "Are there not other and more modern and rational ways of bettering Ireland, which, for centuries, has given and is still giving to the world many of its greatest leaders?" Viewing the problem of social and commercial betterment from the standpoint of the constructor or industrial engineer, it would seem that the policies which have been so generally successful in building up and uniting parts of other countries, should also meet with success here. Since the days of the Roman Republic, the building of roads and the linking together of separated states and provinces has proved to be most efficacious, and almost essential to commercial greatness. Realizing the need of road development, the Romans introduced their great policy of highway extension as their best and surest means of developing and uniting their great dominion. It is almost needless to say that the same policy of building roads and other channels for commerce has, for a century or more, been the most successful of all the means adopted for opening up new territory in America, Africa, Australia, China and other countries. The great railway systems of Canada and the United States, the canals at Suez and Panama and the systems of roads and inland canals in Great Britain itself, are evidences of profitable commercial extension due to the opening up of highways of transportation.

Considering the problem from the viewpoint of the engineer and builder, rather than from that of the politician or statesman, it would seem that a positive railway connection between Ireland and England should be of great advantage. The western island, with its population of five million people, still remains separated from England by a sea which requires several hours to cross, and though easily navigated, trade is greatly impeded by this water barrier. The advantages of a railway connection across the Irish Channel are many and easily understood. Such a railway would shorten the time for crossing the



Atlantic from America by a day or more, and develop terminal ports on the Irish coast, thereby enormously increasing the local commerce, and offering larger chances for employment and extended opportunities to its people. The Irish railways would, in fact, become the through routes from America to India and the far east, instead of being subordinated, as they now are, for local business from Liverpool and Glasgow. Railway traffic in Ireland would be further increased if a similar line crossed the channel from England to France, making through rail connection from Great Britain to the Continent. Under present conditions, ocean traffic from Amcrica to Ireland frequently goes first to Liverpool and thence back to Dublin or Belfast, with a corresponding delay. For local commerce between Ireland and the east, the time of transportation would be shortened by only two or three hours, and yet, for improving railway facilities from England to the north, the great Forth Bridge was built at a cost of $13,000,000.

One of the difficulties in connecting the railway systems of the Islands is the difference in their gauge, which is 4 feet 8½ inches, or standard width in England, and 5 feet 3 inches in Ireland. This difficulty could be overcome in some one of several ways, such as (1) transferring cargoes at the border, (2) changing all tracks to standard gauge, or (3) laying a third rail on both systems. Any of these methods would be costly, but a change would necessarily follow the construction of a channel road.

In selecting a location for the channel road, it will be found that the shortest distance across is from Tor Point in Antrim to the Mull of Cantyre, the length of which is fourteen miles, but this course would involve other difficult water crossings in Scotland, and the line would lead far to the northwest, making the course impracticable. A better location further south is that from Whitehead on the Irish coast, northeast of Belfast, to Port Patrick, the distance being twenty-threc miles. An unfortunate feature of the latter course is the presence of a central valley or depression known as Beaufort's Dyke, the bottom of which is two or three hundred feet lower than other parts of the sea, which has a normal depth of 400 to 500 feet, making a total depth of 600 to 800 feet in this depression. Geologists declare that at one time there was no dividing sea, but only a central valley now known as Beaufort's Dyke, and during the Pleistocene period the land was submerged, forming the present Irish Sea and Channel.

There are at least four possible methods of establishing a railway across the channel: (1) a continuous embankment or causeway, (2) a submarine tunnel, (3) a submerged floating tube or viaduct and (4) a bridge.

A continuous embankment across the channel would cost at least $100,000,000, and possibly more, and it would interfere with shipping. It could be used for a double-track line of railway and for developing electric power from the strong northern current, which would be fifty times more productive of power than the whole Falls of Niagara. Such obstruction of the natural currents would, however, lower the water in the harbors of Glasgow, Liverpool, Belfast and Dublin, an objection of rather serious moment. Since the proposed causeway over to Scotland would lead in a northwesterly direction, the present water route to England and London would be shorter and quicker, and it is doubtful if the causeway would be practicable.

Investigations show that the best way of establishing a channel railway to Ireland is either by means of a submarine tunnel or a floating tube, the cost in both cases being much less than a bridge or causeway. The deep water of Beaufort's Dyke could be avoided by selecting a location from Laggan Head to Maiden Island and thence over to Antrim, or by bending the tunnel to the north around the end of this depression, and thereby increasing the tunnel length under the water to twenty-five miles, with a total length of thirty-five miles, including the approaches. A two-track bore, 150 feet below sea bottom, under water 500 feet deep, would probably cost $50,000,000 to $60,000,000 and the possibility of building it would depend wholly upon finding rock strata absolutely water-tight and impervious. Tunneling with compressed air to exclude water is possible only at depths not exceeding about 150 feet below the surface of the water, for then the atmospheric pressure reaches 75 pounds per square inch, and pressures and depths not exceeding half these amounts are usually enough for effective work. It is evident, therefore, that water could not be excluded by means of compressed air at the depth which would be necessary beneath the Irish Channel, and, as previously stated, the possibility of carrying on such work would depend entirely on finding impervious strata, the presence of which could not be definitely determined until the bore was made. The overhead thickness of rock in the Mersey tunnel is 30 feet, and in the Severn tunnel it is 40 feet.

It appears, therefore, that a tunnel would cost from $35,000,000 to $50,000,000, according to its location and other conditions, and would require from ten to twelve years for its construction.

Another method of crossing the channel is by means of floating tubes, lying either on the surface of the water or anchored far enough beneath the surface to allow ships to pass over out. While no structure of this kind has been built, somewhat similar submerged floating piers have occasionally been used, such as those under two swing bridges at Dublin, and the later one at Norwich, England. Very interesting designs for floating piers also appeared in a recent competition for a new bridge over the Hooghly River at Calcutta. The type is probably the most practical of all methods for crossing a navigable channel of so great a depth.

If the tubes were to float upon the surface, openings must be left for water travel, and this can be done by depressing occasional sections, four to five miles apart, leaving openings of 1,000 feet, the presence of the openings being indicated by signals. The depressed sections would connect with those on the surface by means of suitable grades. As the heaviest ships now afloat have a draft of about 36 feet, a depth of 40 to 45 feet in anticipation of increased draft, should be provided, as is wisely made in the Panama Canal. The roadway level would then lie about 60 feet below the surface, instead of down beneath Beaufort's Dyke, and the approaches would be proportionately shorter. In a submerged position they would not be subject to pressure from wind and wave, but would lie in comparatively quiet water. The chief objection to these tubes is their deterioration from rust, and the difficulty or impossibility of repairing them under water. When the metal is corroded through, the concrete or other lining would be the only remaining material for resisting external pressures. Since the tubes would be supported along their whole length, they would need a comparatively small section for strength, and if lying on the surface, the tubes would be proportioned like ships, to receive varying support, and to bridge the waves from one crest to another. The weight of the submerged tubes should be such as to nearly equal the weight of water displaced. If slightly less than the weight of water, there would be an upward pull on the anchors when empty, and a corresponding downward thrust under moving load, to be resisted by surface floats. If so arranged that the upward and downward pressures are equal, the forces under normal conditions would be a minimum, and the cross section of the tubes might be nearly or quite uniform throughout. The tubes would be made in convenient lengths of 200 to 400 feet, with their ends temporarily closed, and floated out into position and sunk to their desired depth, where they would be connected. The temporary dams should be 3 to 4 feet back from the ends, leaving space for the divers while bolting the sections together. A submerged viaduct of this kind across the Irish Channel could probably be built for $25,000,000 to $30,000,000, and the type is the most promising of all to put into execution.

Whether or not a channel railway would be profitable as a financial investment is uncertain, but it would accomplish a far greater purpose than merely earning dividends, for it would increase commercial activity in Ireland, and with government security for interest on the investment, it might in the end be one of the easiest means of bettering conditions there.

A high-level bridge over water of such great depth would necessarily be on floating piers, and its cost would be from $150,000,000 to $200,000,000—so great indeed as to be prohibitive.

The construction of a channel railway to Ireland, and a ship canal from Galway Bay to Dublin, the cost of which would be about $40,000,000, are of the utmost importance to the prosperity of the island and its people, for ocean ports would then be established on the west coast of Ireland, and this long neglected part of Great Britain would participate to a greater extent in the general welfare.

SCIENTIFIC STANDARDS FOR THE GOVERNMENTAL REGULATION OF FOODS

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THUS far in our attempts to regulate by law the purity of foods admitted to interstate commerce, practically no attention has been paid to the real physiological economy of foods. Questions of purity, of what constitutes an adulterant, "What is ice cream?" etc., have been much before the public and much before the courts. The bone of contention in most cases has been not how much food value does a given product contain, but is it properly labeled or is it adulterated?

From the strictly legal point of view anything is an adulterant which belies the label; but from the physiological point of view nothing is an adulterant unless it really impairs the food value. Jams made with commercial glucose instead of cane sugar might very properly be excluded from commerce under the law as it stands, unless the label states clearly the fact that glucose is contained; but such jams would have exactly as much food value as if made of ordinary sugar, for glucose yields as much energy to the body as does cane or beet sugar. Similarly, nobody likes to be defrauded even in a technical sense and get oleomargarine under the label of butter, but how does the matter stand if oleo proves to be just as nutritious as butter? Is it not time there were an adequate standard for judging of food values? Should not the food manufacturers—those who put up foods in packages and sell them under protected trade marks—be required to correctly express on the label the real physiological value of their products? If the purchaser has a choice of oleo plainly labeled at 25 cents a pound or of butter properly so designated at 40 cents a pound, what determines his choice? First of all, probably, the taste. But if it were practicable to show also the relative food value of the two parcels, would not this factor enter into his decision, and is not the purchaser entitled to this information? Similarly with other kinds of food. Take the cereal breakfast foods. Their number is legion. How is the purchaser to make an intelligent selection? At present the only way is first to buy and try the taste, the "lasting qualities," etc. But if it were possible to learn from the label its fuel value the housekeeper would be able to select from the staple articles either the most pleasing or the most nourishing foods.

According to the best scientific information to-day foods serve two main purposes in the animal economy: (1) They supply building and repair materials, and (2) they furnish energy for all the physiological activities. Let us consider the latter purpose first. Physiologists have demonstrated by numerous experiments that all the energies manifested in the body finally leave the body as heat which can be measured by an instrument known as the calorimeter. The heat unit employed in these calculations is known as a calorie, which is the amount of heat necessary to raise one kilogram of water 1° Centigrade. The quantity of heat measured agrees exactly with the quantity which may be calculated from the known amount of oxidation of foodstuffs which has taken place in the body. When muscular work is done in a calorimeter and the work is all made to take the form of heat, the increased heat production is again what it should be as judged by the increased oxidation. Similarly, the energy value of foods is determined either by analysis and computation or by burning it in oxygen. Given then foods capable of producing a certain quantity of heat, it is a fairly easy task to compute the amount of each which would be necessary to furnish the energy requirements of the body under any given set of conditions.

An engineer who wishes to supply a certain amount of power must know the heat value of certain kinds of fuel and the waste from each. From these he reckons the net cost of his power. Any one who cares to do so can make the same sort of a computation for his body. If the engineer pays $7 for a ton of coal, he sees to it that he gets $7 worth of heat. Why is it not just as reasonable when a person pays a certain price for food to expect a certain amount of food value? To demand the worth of one's money in heat units when the fuel in the house is under consideration is a plain proposition, and when housewives generally understand food values it will be a plain proposition in respect to fuel for the body. A properly educated public opinion will demand from manufacturers such information in regard to the food on which its energies depend.

Let us see if this is not a practical suggestion, and whether, after all, it may not prove a simple solution to a supposedly difficult problem. If our foods were all simple substances like sugar or olive oil, and if the energy content of the food were the only one of which we need take any account, the problem would be just as easy as calculating the yield of energy in horse-power from a ton of coal. It is because our foods are mixtures of various foodstuffs, each having a different fuel value and a different functional value, that the matter requires some study.

The simplest method yet devised for keeping account of the energy supply in one's diet is that devised by Professor Irving Fisher, of Yale University. The idea underlying this method is to do away with intricate calculation by familiarizing one's self with the amount of each article of food, as purchased or as served on the table, which yields 100 calories of energy. This he has called the "standard portion."[1]

Often it happens that the quantity required to make a standard portion is a very convenient amount to serve on a plate. One large egg, weighing 2 ounces, is almost exactly a standard portion. An ordinary serving of butter ($\frac{1}{2}$ ounce), a teaspoonful of olive oil, one large orange, one large banana, one medium thick slice of white bread—each contains very nearly 100 calories of energy. By an easy computation one can readily learn the exact weight of any kind of food whose composition is known, which will yield 100 calories. It would help greatly if some enterprising manufacturer were to place on the market standardized measures made in metal for a standard portion of sugar, milk, rice, butter, oatmeal, flour, dried beans and any other food which does not vary much in composition. The only difficulty with this method is that certain food products as purchased in the market differ considerably in composition. It would therefore be much simpler for the consumer if the food manufacturer were required to guarantee not only the purity of his product in the ordinary sense, but to guarantee also a certain energy content. If, for example, a certain brand of oatmeal bore on its label the statement, "This package is guaranteed to contain 2,000 calories of heat energy," this information would be worth many times as much to the purchaser as the statement, "This food is guaranteed to comply with the food and drugs act," etc. For he would then have some basis upon which to judge the actual economy of his purchase. Some other product likewise "guaranteed to contain 2,000 calories" might cost him only one half as much.

Such a guaranty would entail no great hardship on the part of the manufacturer, because it would involve the employment only of a competent chemist to make an occasional analysis, or a determination by combustion of the heat value. The law of many states already requires that milk admitted to the markets must not fall below a certain percentage of fat (cream). If the label on top of the bottle were required to state, "This bottle contains 650 calories of food energy," the legal requirement would mean something to the purchaser, for it would enable him to tell whether milk is or is not a cheap food as compared with, say, oatmeal or eggs.

A person *must* have a certain minimum of energy value in his food every day. There is no law of nature more inexorable than this. Certain faddists like Horace Fletcher have averred that they live on much less energy than does the average man, and yet when Mr. Fletcher was

[1] By writing to the Superintendent of Documents at Washington the careful student of the problem can have a list of publications on foods. Bulletin No. 28 of the Department of Agriculture, published in 1906, price five cents, entitled "Composition of American Foods," by Atwater and Bryant, contains nearly all the information required regarding the fuel value of the common articles of food.

put into a calorimeter at Middletown, Conn., it was found that he lost from his body nearly if not quite as much heat as the average man of his age and stature. To keep himself in an equilibrium of substance it would therefore be absolutely necessary for him to take at least this quantity of potential energy in the form of food.

A few months ago a certain New York daily widely advertised the light diet by sending on foot to Chicago a woman who claimed to be living on nuts, salads, orange juice and the like. When she arrived at Chicago it was found that she weighed some 12 pounds less than when she left New York and yet the feat was declared to be a "triumph" of the woman's regimen of light foods. As a matter of fact she had not lived on these light foods alone, but had lived largely at the expense of her own body fat. In other words, she had a large part of her fuel for the trip already in storage. If the twelve pounds which she lost were all fat, as it probably was, this alone furnished a large part of the energy of walking for the forty days (I believe it was); for every ounce of fat burned from her own tissues gave about 250 calories of energy and in 12 pounds there would be 48,000 calories or about 1,200 calories a day. If she had added 4.8 ounces of fat or a little more than twice as much starch or sugar every day to her bill of fare she would have arrived in Chicago weighing as much as when she left New York.

Cold weather raises the requirement for energy, for the body loses more heat to its environment, unless this heat is kept in by warm rooms or warm clothing. The law of energy requirement applies most severely therefore to those who can least afford to buy a large supply of food. How important it is that their money should be made to go as far as possible! The pure-food law at present operates to protect those who use more highly flavored foods and drinks rather than the poor. If every kind of food purveyed in packages, tins, bottles, etc., bore a label stating its energy value the poor and all would soon learn how to make the money go farthest.

When it comes to the actual task of calculating the body's requirements it is customary to begin with minimal conditions. A person, uses the least energy when he is resting and fasting and is kept warm—lying in bed for example. When he moves about—that is, does muscular work, when he digests a meal, or when he is exposed to cold, he uses more energy. The average utilization in twenty-four hours under minimal conditions is about fourteen calories per pound of actual body weight, or for a man of average weight (154 lbs.) 2,150 calories. We should not miss it far if we should say that a person sitting up would use one calorie per pound more (2,300). And if he digests three meals a day he uses an additional calorie per pound (2,450). If, now, he does light muscular work, like typewriting, he uses about 25 calories per hour for this work, or in eight hours 200 calories, making the total for a man of average weight 2,650 calories.

If the person's work requires him to walk about all day, instead of sitting still and using his arms, he, of course, does the work of carrying his body, to say nothing of the other things he may carry, and the allowance must be three or four times as great as in the case of typewriting. A soldier on the march, walking less than three miles an hour, has been found to use 160 calories per hour for the muscular work alone. Most occupations which involve walking are less exacting because there are frequent rest periods. So, if we allow 75 calories per hour, it will probably supply the extra energy requirement over that of complete muscular rest, for, say, a fairly active salesman. This total intake in three meals, if he is of average weight, would be some 400 calories (four standard portions) more than that of the office worker. Two sample diets constructed so as to contain the twenty-four-hour requirements for the office worker and the salesman, respectively, are given below:

TABLE I

FULL DAILY SUPPLY OF ENERGY FOR A SALESMAN OF AV. WEIGHT (154 lbs.)

Breakfast

	No. of Portions	No. of Protein Calories
1 small orange	½	3
2 shredded wheat biscuits .	2	26
Vienna roll and butter ...	2	12
1 egg, soft, fried or poached	1	32
2 thin slices bacon	1	6
Coffee, cream and sugar ..	½	2.5
Total	700 cal.	81.5

Luncheon

Ordinary serving beefstew	2	24
Tomato and beet salad with dressing	1½	15
2 slices bread and butter .	3	28
Apple tapioca pudding, large serving	2	2
Cocoa, cream and sugar ..	1	4
Total	950 cal.	73

Dinner

Cream of celery soup	½	8
Ordinary serving roast lamb	3	120
2 baked potatoes	2	22
Side dish green peas	2	50

FULL DAILY SUPPLY OF ENERGY FOR AN OFFICE WORKER OF AVERAGE WEIGHT

Breakfast

	No. of Portions	No. of Protein Calories
1 small orange	½	3
Large serving of oatmeal .	1	18
Cream and sugar	1	2.5
2 slices dry toast	2	28
Ordinary serving butter ..	1	0.5
2 eggs, soft boiled	2	64
Coffee, cream and sugar ..	½	2.5
Total	800 cal.	118.5

Luncheon

2 small tomato and lettuce sandwiches	2	28
1 large glass whole milk ..	2	38
1 ordinary piece apple pie	3	15
Total	700 cal.	81

Dinner

Plate of bouillon	0	0
Small serving rib roast ..	2	50
2 small potatoes with butter	3	20
Ordinary serving rice pud-		

Salad with mayonnaise ...	1	0
2 slices bread and butter .	3	28
Milk custard	1	26
Small piece sponge cake ..	1	7
Total	1,350 cal.	261
Grand total ....3,000 cal. with 13 per cent. protein.		

ding with cream	2½	20
Bread and butter	2	18
Demitasse black coffee ...	0	0
Total	1,150 cal.	124
Grand total .... 2,650 cal. with about 12 per cent. protein.		

It will be clear from what has been said above that the requirements of the body for muscular labor in winter will depend on whether a person works indoors or out. Lumbermen who work in the north woods in winter probably require more food than any other class of laborers. At the opposite extreme, so far as external conditions are concerned, stand the men who work in factories, beside furnaces, etc. Their muscular work may be just as heavy as that of the lumberman, but their bodies are kept warm by artificial heat. The problem for them, as for ordinary laborers outdoors in hot weather, is rather that of removing the extra heat of muscular work.

Between these two extremes, naturally, are people who are subjected to conditions of all degrees of severity. It is impossible to prescribe a day's dietary which will fit all of them. We select a teamster and a foundryman of average weight. The former we suppose not only does the heavy muscular work of lifting boxes and cases, but is exposed to cold winds and rains. The latter does heavy work but is kept warm at his task.

A person who follows his natural craving will find himself eating more meat, especially more fat meat, in winter than in summer. This is not merely because fat meat contains more energy for the same weight than starchy foods, but because foods rich in protein and fat stimulate the processes of combustion by which heat is produced. For example, a day's diet consisting of nothing but lean meat would increase the heat production by about 30 per cent. The same diet consisting exclusively of starchy foods would increase it only about 5 per cent. This is the reason why laborers in the open crave meats more than do those who work indoors.

TABLE II

Sample Diets for a Teamster and a Foundry Worker

Full Daily Supply of Energy for a Teamster of Average Weight

Breakfast

	No. of Portions	No of Protein Calories
3 wheat cakes	3	45
with maple syrup	1	0

Full Daily Supply of Energy for a Foundry Worker of Av. Weight

Breakfast

	No. of Portions	No. of Protein
Large serving oatmeal ...	1	18
Cream and sugar	1	25

2 small chops (lamb or fresh pork)	2	36
French fried potatoes	2	22
2 slices bread	1	0
with butter	2	28
1 cup coffee	0	0
Cream and sugar	½	2.5
Total	1,150 cal.	133.5

Luncheon

Plate of baked beans	3	63
with small piece fat pork	2	28
4 slices bread and butter	6	56
Rice pudding	2	16
Cup of tea with sugar	½	0
Total	1,350 cal.	163

Dinner

Large plate cream of celery soup	1	16
Large serving rump roast beef	3	180
Large serving macaroni and cheese	3	53
2 large spoonfuls creamed mashed potatoes	2	20
Side dish stewed tomatoes	2	20
Bread (2) and butter (1)	3	28
2 small baked apples	2	4
with cream and sugar	1	0
Ordinary piece sponge cake	2	14
Total	1,750 cal.	322
Grand total	4,250 cal.	618.5

with 14.5 per cent. of total in protein.

Two slices dry toast	2	26
Butter	1	0.5
Large serving ham	2	66.0
2 eggs	2	64
1 cup coffee	0	0
Cream and sugar	½	2.5
Total	950 cal.	179.5

Luncheon

3 sandwiches	6	56
with cold boiled ham (cut very thin)	1	28
2 crullers	4	24
1 pint whole milk	3	57
Total	1,400 cal.	165

Dinner

Clear tomato soup	0	0
Large serving sirloin beefsteak	2	60
Large serving rice	2	20
2 large sweet potatoes	4	24
Side dish stewed onions	1	12
3 slices bread and butter	4	42
1 dish tapioca pudding	2	1
Cup tea and sugar	½	0
Total	1,550 cal.	159
Grand total	3,900 cal.	503.5

with 13 per cent. of total in protein.

That this energy-giving quality of foods is the most important function which they serve is apparent at once when we discover that at least four fifths of the dry weight of our food serves no other purpose than that of giving heat. The heat comes from the oxidation of our food and since the temperature of the air about us is nearly always lower—in winter very much lower—than blood heat, we are practically always losing heat by radiation and conduction. Merely to keep up the body temperature to 98° F., the temperature at or near which the living substance best performs its functions in every animal, is the purpose of the great mass of fuel which we are obliged to "supply" every day of our lives. To furnish the energy for the muscular work which most of us do requires relatively little and, strangely enough, to supply brain energy—intellectual energy, alertness and other purely psychic qualities—apparently requires no energy at all in the sense in which we have been using that term thus far. Experiments have been conducted on college students while writing a very difficult examination, and it was found that no more energy was set free from the body than when they were simply writing nonsense. However, a very small part of the potential energy of the food always takes the form of electrical energy and electrical energy is manifested whenever nervous tissue (brain, nerve, etc.) is active. It is possible then that the reason no extra heat energy was given off from the body when the brain was working hard is because this electrical energy simply took the place of other forms of energy (like the secretory processes of glands, etc.), in which case it would not be correct to say that brain work is not done at the expense of potential energy. The subject requires much more study than has yet been given to it.

It will be evident from the discussion thus far that it is the energy content of the food which a person is concerned primarily to know in order to judge the economy of its use. Ordinarily if one takes care merely to supply himself enough heat energy and takes care also to eat a *variety* of food the other requirements will be automatically regulated by the appetite. Failure properly to adjust the energy supply to the actual requirements result in depletion which may subject one to disease, or, on the other hand, may lead to obesity.

But it would be a serious mistake to ignore the other chief purpose of foods—namely, their value as tissue builders and restoratives. While not more than one fifth of the dry weight of our foods find a permanent lodgment in the body, it is obvious that the functional activity of the tissues could not be kept up indefinitely without these constituents of which tissues are formed. Still less could growth of the body in early life be maintained.

Among these constituents the most important is that class of substances known to physiologists as *proteins,* exemplified by the white of egg, the casein of milk, the gluten of bread and *par excellence* the flesh of animals. The actual requirement of the body for these substances is much less than is ordinarily supposed. In starvation, when the body is living at the expense of its own substance, about 13 per cent. of its energy is derived from the breakdown of proteins or the nitrogenous substances. The remaining 87 per cent. is derived from the body fat and glycogen, which is the form in which the body stores up starches and sugars. Theoretically the body would be kept in perfect equilibrium then if the food contained 87 per cent. of the total energy in the form of carbohydrates and fats and 13 per cent. in the form of protein. In fact, many persons have found that they keep in better physical condition if they take somewhat less than 13 per cent. in the form of protein, for with a generous suply of carbohydrate in the food the waste of proteins from the body is considerably less than in starvation. The dietaries suggested above for various sorts of workers, however, have been constructed on the basis of about 13 per cent. protein calories, to be on the safe side.

It would be most desirable, therefore, if the label on packages of manufactured foods were required to give also the content of protein in addition to the total energy value. This might be done in the case of oatmeal as follows: "This parcel is guaranteed to contain 2,000 calories of heat-value, of which 14 per cent. is in the form of protein," or, in the case of milk, "700 total calories, 16 per cent. protein calories." Naturally the milk would not yield 700 calories to the bottle unless it were high in cream. The relation of total calories to protein calories might also be expressed in the form of a ratio.

A law requiring the correct labeling of foods with reference to the energy content and protein content should result in a wholesome competition among producers and manufacturers to improve the actual food value and therefore their real economic value. At present the competition runs along the line of the appearance of food and mere flavor, which, although desirable, are not the most necessary qualities to be considered in the provisioning of our people. Coal and other forms of fuel for our boilers and automobiles we must take as we find them in the earth. The only way in which we can improve their quality is by refinement, which costs nearly as much as we gain. But in the matter of fuels for our bodies there are immense possibilities of improvement without increasing the cost a particle. The fuel value of a food crop depends upon the power of the plant to utilize primarily the carbon dioxide of the air and the water of the soil in the formation of sugars, starches and oils. Under the stimulus of the sunlight the energy of the sun is stored up in roots, grains, etc., and is not lost until the food is burned in the animal body. So long as air and water and sunlight cost nothing an improved variety of corn or wheat or oats or rice which would yield more energy should be produced as cheaply as those we are now living upon, except for the extra thought and work of selection which might be involved. But the stimulus to produce more for the money for the sake of larger sales is exactly the sort of stimulus we want the food manufacturer to have.

A standard of purity in this sense ought to have the effect also of emphasizing the expensiveness of animal food *as a source of energy* as compared with vegetable food. For when the corn grown in one field is fed to an ox in another the ox dissipates fully nine tenths of the energy walking about the field and stores in his body for our use as food only the other one tenth. Hence to get our full energy requirement in the form of beef even the cheapest cuts would cost us at least ten times as much as it would if we ate the corn meal. This is assuming that the cost of *preparing* the two kinds of food for the market, and finally for the table, is the same. The illustration is used only for the purpose of emphasizing the fact that animal foods *as a source of energy* are necessarily more expensive than plant foods. *As a source of protein* the comparison would not be so much to the disadvantage of meats.

Of course it is realized that as matters now stand a great deal of our food budget is spent for pure flavor. Flavor in the broad sense is "anything which adds the element of pleasure to a meal." Chemical flavor which affects the olfactory organ or the taste buds serves a useful purpose at times in stimulating the flow of digestive secretions in anticipation of a meal and at times it serves a harmful purpose in causing us to overeat. The appearance of the food either in the parcel or on the table may serve as flavor. The kind of service, the presence of good company or even music come under the same head. If one can digest a meal only when accompanied by these latter kinds of flavors they are perhaps justifiable, but from the standpoint of the national welfare they do not deserve much consideration. Appreciation of food and the full physiological effect of flavor are obtainable by the simple device of getting thoroughly hungry before we eat.

The writer once had occasion to compare the actual food value of a dinner served at "Joe's" on Third Avenue for thirty cents and a five-course dinner served three blocks further west at a cost of three dollars. The advantage in actual food value lay with the former. The difference in cost was due entirely to "flavor."

The state universities of the wheat and corn growing sections of this country with the help and encouragement of the Department of Agriculture have already inaugurated an enthusiastic campaign for the production of better wheat, greater yield of corn per acre, and improved varieties of other food products. The classes in domestic science in public schools are learning food values as few of the present generation had any opportunity to learn them. Similar instruction has been given to working girls in the settlement houses. The time is certainly not far distant when the food manufacturer must keep pace with this rapidly increasing knowledge of food values and must make it possible for the housekeepers to know exactly what energy is stored in the food they buy. Some states, New York, for example, require cattle foods to be so labeled now. Human food may contain anything so long as it is "pure."

The government might well establish a classification of foods such as: (1) Foods which are wholly or chiefly energy-producing; (2) foods which are wholly or chiefly tissue-building and (3) foods which are of use chiefly as flavors. In the first class would belong sugar (which is usually thought of as a flavoring material), cornstarch, olive oil, butter, etc.; in the second would belong eggs, meat, cheese, etc.; and in the third would belong pickles, catsups, sauces, tomatoes. Foods which in reality belong to more than one class, as milk, oatmeal, green beans, etc., could be assigned according to their analyses and according to the judgment of a referee board of physiologists, which would then have a constructive economic function to perform instead of a reviewing function which has been discharged by the Remsen Board; for to determine the real physiologic and therefore the real economic value of certain foods would require long and careful experimentation. The regulations as to labeling would naturally be different for the different classes.

Obviously there should be no relaxation of the present vigilance of the law as to preservatives which have been proved harmful, nor as to the permission of unwholesome constitutents nor as to the presence of adulterants—meaning by that term anything which reduces or impairs the food value. But the bureau of chemistry of the Department of Agriculture should be enlarged into a bureau of food economics so that its function should become more constructive in the sense in which the bureau of plant industry and the bureau of animal husbandry is more economic. It has become a truism that the government pays more attention to the health of pigs than it does to the health of men. Unless we mistake the spirit of true progressivism this will not properly express the functions of government a generation hence. A very material advance, educative in its influence and highly economic in its results, would be the establishment of this new standard of purity in foods.

A PROBLEM IN EDUCATIONAL EUGENICS

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SYRACUSE UNIVERSITY

THE flood of current criticism which has been directed against our educational system in general and that of higher education in particular is too obvious to call for special emphasis. While much of it has been exaggerated and some even hysterical, still there is not lacking a considerable body of really sane and timely criticism to which no true friend of advanced learning dare close the eyes. The college in particular has come in for some of the sharpest arraignment of recent years. One may discount the rather indiscriminate criticism of Mr. Crane and others of similar type, but he must face frankly, and answer with equal frankness, strictures which have come from such sources as the Carnegie Foundation, ex-President Wilson and others equally capable.

It is no part of the purpose of this paper to undertake to directly review in detail this discussion; but rather to inquire into certain conditions and methods of current educational philosophy, its ideals and aims, with the hope of directing attention to possible methods of scientific betterment.

It is charged that our educational work has failed to add to earlier literary, artistic or cultural power; that no American scholars are among the recipients of the Nobel prize; that there are no modern peers in literary distinction of Emerson, Holmes, Hale, Longfellow, Lowell, *et al.* These are grave charges if true. What is the answer? Is answer or explanation forthcoming? Surely it can not be said that interest in literary matters has languished, for the multiplicity of literary activity has not only not declined, but greatly increased, as expressed in the new magazines, journals and books which issue in veritable floods. But may not these facts of multiplicity of interest and activity be a sign of the very decline or failure which is charged? Granted that such may be the case; granted that such multiplicity and intricacy of intellectual life has placed an added burden upon student and literary devotee in the added necessity of larger and more varied preparation for such a career; granted that the enormous extension of scientific, historical and philosophic activity has had a disturbing effect upon the purely artistic or literary achievement, the further query arises, is this peculiar to American conditions? Is such a handicap essentially more serious to the American student than to the European? In some degree it may be so; for one finds in the German schools, for example, that more of these preliminary or preparatory studies are disposed of before entering the professional career. Further, in the mastery of languages the foreign student seems to have, whether from inheritance or local conditions, a readier facility in rapidly acquiring usable command of these subjects. But with all this granted, is it quite sure that we have found a real cause, or merely an excuse for existing conditions? It is a condition and not a theory which confronts us and we can not afford to confuse the problem by any false lights, however alluring such a method might be.

However, it is not so much in the matter of actual difference in the relative status of these pupils in school achievement at a given age. It is rather in the matter of attitude toward things scholarly. One has not to go far into an inquiry to assure one's self on this point. Again and again has the writer heard and seen such expressions as "Don't let your studies interfere with your college duties," "fraternity is more important than scholarship," "only grinds pay any attention to marks," etc. Furthermore, it is rather evident that comparatively few give especial effort to achieving scholarship honors, such as prizes, Phi Beta Kappa, etc. Only rarely does one notice any emphasis in college papers of fellowships, research achievements, etc. One misses the eager passion for scholarship for its own sake which forms so dominant a place in the educational history of earlier days. The impression can not be escaped that the student attitude the country over is rather dominantly as intimated above, though it may be more open and avowed in certain sections than in others. "Stover at Yale" is not pure fiction!

Various attempts have been made to find some adequate explanation of this condition. For example, the dominance of commercialism has been assigned as a factor in this attitude and is involved in the scholarly decline. Let it be admitted that in this there may be a grain of truth, yet it is wholly inadequate as an explanation. We hear it over and over again that scholarly ability has a distinctly commercial value. Now if this be so then one ought to find a growing importance attaching to the highest possible standards of scholarship and educational achievement. But the obvious lack of just this is the very problem which confronts us.

Again, one finds emphasized the dominance of athletics, and the social dissipation in college affairs as responsible for divorcement of the more serious and primary considerations. And these express an undoubted element of truth; but again they are not the whole of the matter. They are but symptoms; the real trouble lies deeper and must have more critical concern.

To the mind of the writer the root of the trouble lies in our present-day educational methods. And one of these involved is what may be called *indiscrimination.* In our zeal for education we have been disposed to regard it as the one panacea for every social and civic ill. This is emphasized in such phrases as "education the foundation of democracy," "the public school the hope of our country," etc. These catch-words may have important values, *e. g.*, they may serve the campaign orator some fine phrases, but let us look a bit deeper than even these.

Perhaps as a reflex of that other half truth, "All men are created free and equal," has come the general conception that education is the common privilege of all without distinction; that it becomes a magic wand able to dispel the seeds of incapacity, imbecility, criminality or even immorality. In a word, we have been taught to regard education as *creator*, rather than helper, guide or *cultivator*. No one expects his gardener, however skillful, to supply a superior product from barren soil or defective seed. Now let it be given all possible emphasis that back of culture must be a capable brain; and that this element of capacity is rooted in the physical basis of life itself—the *germ plasm*. These are at once the soil and seed for our mental gardener to work upon.

Long ago have we learned the fundamental lesson here predicted as it relates to the school of husbandry. The breeder is first of all a *discriminator*. He knows what he wants, and he knows that in only one way may he have it, viz., by patient and persistent *selection;* and only those factors which measure up to his standard shall have any place in his school. Others may serve as bearers of burdens—as dray horse, or plodding ox; but they have no place in the stud or in that school destined for a higher product. Our husbandman has learned his lesson from that severe mistress of all progress, mother nature, whose rule is that of *fitness*. Of the product she has said "*very good.*" The price may be high, above the rubies or mere marks, but its cost is well worth while.

Education and Selection.—Fundamental in Darwinism is natural selection, the counterpart of the artificial selection of the breeder. In nature it is a process of sifting, an elimination of the unfit through the rigors of the struggle for existence. Of its reality and efficiency in a state of nature there can be no doubt; though this does not imply that it has been the only method in operation.

As in social matters, so in educational methods, we have largely disregarded nature's method of selecting the fittest. On the contrary, our standards, whether of school or college, have been adapted to *mediocrity*. There has been a leveling down whenever the poorer pupil seemed unable to keep up. To be sure, in some instances the poorest have been returned to a lower grade, but rarely the *average poor*. In technical schools there has been less of this compromise, but it has not been wholly lacking even there. The effect has been to place a premium on mediocrity, just as has been the operation of a similar method in trade-unionism, and its sequence has been to a similar end—discouragement of initiative, independence, highest efficiency, and hence highest achievement.

It may be questioned whether the glorification of our educational ideals, and the formal aspects of it in particular, has not been greatly overdone. In spite of more than a century of its trial the per cent. of illiteracy is still large. This I believe to be due to the fact that there has not been allowed to operate more freely the process of selection. Not all children are fit for formal education. They have no business in either school or college, except in the former for the merest rudiments of learning. For them the apprenticeship, the trade-school, the vocational fitting, is that through which nature may afford some chance for a place. Many a boy should never be encouraged to go to college, and would not if any pains had been taken to look into his mental pedigree. He is sent in many cases out of mere fashion, a sort of social exaction which has for him only a social significance, or value, wholly beneath the aim of a college standard of any real dignity or worth. And as in the school, only more so, his presence involves the same low and compromising standard and reaction upon all concerned.

Let the gauntlet be thrown down without hesitation or apology—Distinctly academic culture, education for scholarly ends, *is not for all.* Aye, more, the ordinary *school* is not for all. Is this akin to treason, a direct challenge of the compulsory school laws? I do not overlook the beneficent aim of these laws. No more need one shut the eyes to another code, that for prevention of cruelty to animals. To how many of us has it occurred that occasion for the latter may as often be found under the former, or in other words, that truant officers and a system which makes them necessary are as amenable to the latter code as are those who torture horses or beat helpless wives? The cruelty of which I protest is that which thoughtlessly or ignorantly grinds every intellectual grist through a common hopper. The schools do not differentiate, teachers do not discriminate between matters of quality and quantity as mental factors. An expert in nervous disorders said in a recent address before a public assembly in Syracuse that "New York State schools contribute a larger quota to the insane asylums than any other agency." This might be variously construed, but surely it should give us pause in our zeal for compulsory education. But these laws are not designedly vicious; they only express misapprehension, they fail to discriminate.

Galton has shown beyond reasonable doubt that genius follows the same laws which control other phases of development. Indeed the earlier pioneer work of Galton blazed out the path which our later experimental methods have demonstrated, over and over again, to be now almost a highway, so clear is its course, so readily followed. Concerning this very matter of discrimination and selection he made bold to declare:

I believe that if the eminent men of any period had been changelings when babies, a very large proportion of those who survived and retained health up to fifty years of age would, notwithstanding their altered circumstances, have arisen to eminence. Now if the hindrances to success were very great, we should expect all who surmounted them to be prodigies of genius. The hindrances would form a system of natural selection, by repressing all whose gifts were below a certain very high level. . . . The hindrances undoubtedly form a system of natural selection that represses mediocre men, and even men of fair powers. . . . If a man is gifted with vast intellectual ability, eagerness to work, and power of working, I can not comprehend how such a man should be repressed. (Hered. Gen., p. 38, etc.)

Eugenics.—No more fundamental and commanding factor of modern biology is current than that of *heredity*. This has been long understood in its applications to various details of husbandry. Only of late has it become fairly subject to control and direction. Nearly ten years ago in an address before the Association of Academic Principals I gave expression to its educational implications in the following words:

Of all the equipments which go to fit pupils for the larger life before them none is more fundamental and imperative than that most vital of all biological factors—generation and heredity. If the highest level of human vigor and perfection is ever to be realized it must be by critical regard for, not defiance of, those simple and fundamental laws of biology which underlie heredity in generation. How long shall we continue to look with admiration and pride upon the rich fruition of an intelligent application of these laws to the endlessly varied products of field and stable, and at the same time pretend to bewail the endless lines of human degeneracy, pauperism and imbecility? Just so long as we ignore or defy the potency of these same laws in human generation!

It was in the light of just this truth that Dr. Holmes in answer to the query "when should a child's education begin," replied, "one hundred years before it is born"! And in a somewhat facetious paraphrase of the idea a later writer has said, "In the light of science it is up to children to be extremely cautious in selecting their grandparents." Waiving all the apparent paradox of the one, or the cynicism of the other, the present message of biology to every sane and serious man or woman in relation to progeny would be similar—due attention to selection of children. If the Roman adage, "a sound mind in a sound body," has any significance for education to-day it is just in the above sense. It is strangely significant that Plato conceived a similar ideal as the basis of his Republic; and had he known as do we to-day the directing and controlling power of *heredity* that Republic, instead of an *Utopia,* might have been an abiding *reality,* as glorious as the imperishable art and literature of its golden age!

Let it not be insinuated that eugenics as a program is as utopian as Plato's unless forsooth one turn skeptic concerning all laws of life. In the language of a recent authority

We may enunciate as a law of social evolution that a race possessing social culture will be victorious in the struggle for existence over a race devoid of social culture, the physical strength of either being equal. But it would be a grievous error to suppose that social culture by itself is any guaranty of stability. Athens had social culture unequalled by any of its rivals; but Athens fell. Social culture without biological fitness is as useless as biological fitness without social culture. The law may be stated as follows: Biological fitness is to be estimated not only by the capacity of physical endurance, but by the capacity of reproduction, by the capacity of adaptation to new conditions of social life, and by the power to resist the importation of foreign vices and diseases. (Chatterton-Hill, p. 358.)

Pearson postulates two fundamental biological conditions as to human betterment:

1. That the relative weight of nature and nurture must not *a priori* be assumed but must be scientifically measured; and thus far our experience is that nature dominates nurture, and that inheritance is more vital than environment. Environment may and does modify the bodily characters of the existing generation, but not certainly the germ plasms of the next generation. At most it can provide a selection of which germ plasms among the many provided shall be potential and which shall remain latent.

2. All human characteristics are inherited in a marked and probably equal degree. If these ideas represent the substantial truth, you will see how the whole function of the eugenist is theoretically simplified. He can not hope by nurture and by education to create new germinal types. He can only hope by selective environment to obtain types most conducive to racial welfare and to national progress. The widely prevalent notion that bettered environment and improved education mean a progressive evolution of humanity is found to be without any scientific basis.

Improved conditions of life mean better health for the existing population; greater educational facilities mean greater capacity for finding and using existing ability; they do not connote that the next generation will be either physically or mentally better than its parents. Selection of parentage is the sole effective process known to science by which a race can continuously progress. The rise and fall of nations are in truth summed up in the maintenance or cessation of that process of selection. Where the battle is to the capable and thrifty, where the dull and idle have no chance to propagate their kind, there the nation will progress, even if the land be sterile, the environment unfriendly and educational facilities small.

The growth of the eugenics movement, both in Europe and America, within the recent decade is one of the most hopeful signs of the day, and far more eloquent than mere words or theories. Its intrinsic value for education is unmistakable. Herein, as I see the problem, is an open field for social betterment of the highest type, which in itself is of large promise as a basis from which it is not too much to anticipate means for augmenting any unit character of intellect as well as body. Just here is the hope for that increment of power, both innate and cultural, adequate for recovery of lost arts, and for carrying forward the race to higher achievement in every department of endeavor. If great poets, artists, statesmen and prophets are *born* not *made,* why not set into operative activity the only machinery through which such divine birth-heritages may become realities?

The problem is not occult. It is so simple that boys and girls may learn it even in the nursery, surely in the school. If a state may charter its special train in an educational propaganda to teach farmers the lesson of selecting seed corn; if a state may spend hundreds of thousands every year for exhibitions of blooded stock, the triumphs of horticulture, the fleetness of the race-horse, may it not be worth while to ask an equally serious consideration of the same state and its citizens to the no less equally important problem of how to select and improve the seed destined to yield its fruition in human brains? And on the other hand, lauding the laws which warrant the slaughter of tuberculous herds, and the common sense of the farmer who relegates his scrubs and dwarfs to the shambles, what are these same sensible people doing toward a similar process of eliminating defective and unprofitable human stock? Almost nothing. *Almost!* It is matter for note that already nearly a dozen states have taken steps to cure some of these human blights. There is not time for details, but they exist. Such are glimpses of facts all too common and dominant. They cry for attention and intelligent treatment. They constitute in a special sense an educational problem the importance of which is beyond computation. It is *our problem;* what is to be our attitude?

Educational Eugenics.—It has seemed to me for some time that there should be found an application for the principles of eugenics in the work of education in general, and for that of higher education in particular. In seeking light on the problem I have submitted certain queries to a considerable number whose work or concern in such matters I know to be great enough to warrant inquisition. For example, to Dr. Davenport I put the following:

> I have long felt that for some reason we are failing to get the best results from college training, due in part, as I believe, to the fact that instead of affording opportunity and stimulus to the capable student, to the man of brains and fitness, the dead level of mediocrity is a constant check on just the man who could profit by it. We level down to the average man or below, and the capable fellow, unless selected by individual interest, is left to drift in idleness or worse. Can there not be devised some means whereby the incapable may be deflected from a college course? Why may it not be practicable to devise a scheme of entrance tests whereby some sort of mental pedigree may be made evident? Why not include pedigree examinations as a part of the medical examination now generally exacted?

To another was asked this additional question:

> Can not a means be found for giving to eugenics a distinctly educational direction as well as the conventional physical? The crucial query is *How to get at it?*

To still another:

> American education has been recently designated as a *Proliferating mediocrity.* How can this charge be refuted? What is the way out? Is it not possible to secure some sort of family-school-pedigree record as a basis for education?

To these varied inquiries various replies have been received. Some have been extremely suggestive, others have been conservative to the point of the worse than helpless. For example, one in reply says

I am sorry that I can not be of help to you in this matter, in which I think you will find yourself a voice crying in the wilderness with very few to heed. All the same, I hope you will set up as big a cry as you can, and even if I am not able to join you in that, I shall be glad to applaud your efforts.

Another says:

My theory in outline is that there should be compulsory examination for every student in college. This examination should have reference not only to heart and lungs, to see if the man will make an athlete, but should comprehend a look into history and heredity, and determine without question the presence of any sort of infectious disease. Such an examination would, of course, exclude some students from entering college, but that would be well. . . . I am in hearty sympathy with your plan, and should urge you by all means to organize it as an integral part of your department.

In a later letter the same writer said:

I am interested in your eugenic program. No doubt there is much wasted energy in every educational direction. Perhaps there is more of it wasted in mediocre human material than in any other direction. The results, of course, are bound to be mediocre. Still it is a question with me whether any other method can be adopted. . . . However, I believe thoroughly that there should be some selective process applied to the student material that applies for admission to the freshman class.

Another response will be briefly cited. Dr. Goddard, chief of research in the Training School for Backward and Feeble-minded Children, New Jersey, writes:

I should say emphatically that such a plan as you hint at ought certainly to be developed some time. It is probably rather early to do very much at it, since the whole subject is so very new. However, some things are already visible. It is, for example, entirely practicable to eliminate all the mental defectives by means of the Binet scale and furthermore to mark those who are merely backward, those who are average and those who are precocious. We need some method of measuring intelligence beyond the period previous to adolescence, the Binet Measuring Scale reaching only to 12 years of age. You are entirely right when you say there are large numbers who should never enter college. I do not know why the inquiry into the family pedigree would not be a valuable thing in considering the admission of a child to college. While it would undoubtedly not be safe to base everything on that, yet it would contribute very materially to an understanding of the case. At present I do not believe we have enough data to enable us to interpret the results we should find.

A later word from Dr. Davenport afforded special encouragement. He says:

I hope your plan of getting pedigrees of students as a part of the medical examination would be carried out. As a teacher I always felt that I knew too little about the incipient qualities of my pupils. Why should a teacher begin in the dark when he might begin with a knowledge of the student's probable potentialities. The more I contemplate your plan it seems to me if it can be carried out that it will mark an epoch.

Enough has now been suggested to warrant the reflection that our entire educational program, its ideals, aims and methods is faulty at many points, and in not a few absolutely untrue to any consistent application of biological principles. When we reflect upon the course through which our educational philosophy has come it is not surprising that there should have been error, that something of tradition has held a sway beyond reason, and that much of existing methods are an inheritance from an outgrown past. It is not to be wondered if criticism has arisen. The wonder is that it has not come sooner and been more fierce. If one compares the civilization of even the most enlightened nation of antiquity with that of the present day; if with this survey he includes that of prevalent ideals and methods of education; if, indeed, he compares conditions in pagan Greece and Rome with the latter under the sway of the monasticism of later centuries, it will be less surprising that there arose the condition known as the "dark ages," which dominated both state and church, and school as well, for more than a thousand years. Without indifference to the good which may have endured in spite of dominant ills in the educational ideal and aim of those times it is still high time that they be estimated at their real worth and discounted according to their inadequacy in relation to present-day conditions and needs.

Through just what means the desired betterment may best be realized may still be an open question. There are those who will continue to regard it as a philosophical problem. But there are others, and their numbers are multiplying, who look upon the problem as one open to scientific and experimental solution. The writer assumes the biological point of view without hesitation or apology. He believes that whatever ideals one may assume it must be more or less evident that man, the subject of these ideals, is involved in those common relationships and laws which condition all organic nature. His growth, both physical and mental, is also conditioned by the same laws. Furthermore, it is probably beyond serious dispute that man in his entirety—body, mind or spirit—is a unity; that all his powers are so correlated that it is not possible for us to isolate them for any such artificial object as that of conventional education. The older notion of mind as an entity, distinct and independent of body or natural relations, an occupant of the "tenement of clay," may still be a fruitful theme for the metaphysician, but it is without significance in any sound philosophy or science of education. Whether one may accept the purely neurological view that all mentality is potential in the metabolism of nerve cells he can hardly doubt their intimate correlations.

Therefore, whether for better or worse, under the biological assumption, the methods of education, whether of body or mind, whether for mental or physical efficiency, must be those of the living world. In this view there is nothing essentially novel. In many of our educational processes, sometimes consciously, oftener otherwise, there has been at work these vital principles. Galton's appeal has been already cited. The whole program of eugenics is but another aspect of the application of the same conception. With this much accepted let attention be directed without further digression to the main aspect of our problem, namely, a provisional program of educational eugenics. Granted the clearly defined program of eugenics in its primary relations, may a method be devised by which the same principles may be made operative in the realm of education? In other words, can this biological method which promises so much for the race in its physical, social and other respects, afford a reasonable basis for similar hope concerning mental and spiritual betterment? May we find in it the promise and potency of a higher and better type of scholarship than that of the present or past?

I have referred above to "a *provisional program*" to be directed to these ends. In an attempt to frame a scientific hypothesis of heredity Darwin designated his attempt as "provisional." It was open to serious criticism at first, and it is hardly too much to say that it has only a historic interest to-day. With such a fate for *that* provisional hypothesis I am not vain enough to anticipate an immediate and unchallenged acceptance of views on a subject greatly more complex.

But is such a program desirable or important? Are educational conditions such as to call for an experiment of the sort which in the nature of things must be more or less an experiment? These questions are important and merit serious attention; but to my mind they must be answered in the affirmative. The program is important and worthy of whatever test or experiment may be called for in its solution. It seems rather certain that the tide of criticism already noted is such that there should be no evasion in giving to it the consideration its importance warrants. Furthermore, it is not too much to aver that existing knowledge concerning biologic laws and principles is such as to call for searching revision of existing methods of all phases of education. It is absolutely impossible to differentiate between growth or development as related to body, mind or spirit. It was once thought that such distinction was obvious as related to animals and plants. To-day such a view is impossible. The fundamentals of life are the same everywhere and always. And the growing child, in every aspect of its nature, is amenable thereto; and every phase of its development should have the same intelligent biological direction as is given to other living things. Some may be forced, while others must as certainly be restrained, or absolutely transplanted and developed under a different environment. A method applicable to the precocious would prove fatal to a mental defective. And now, that we have the ready means of differentiating these varying grades of mentality, it can hardly be short of folly to decline to utilize them thoroughly. Our school authorities have been ready to take advantage of every means by which these ends may be conserved. For example, in this state steps have only just been taken to care for any such physical defects as may impede or embarrass the pupil in the school. This has been undertaken jointly by the boards of education and health. Examinations of eyes, ears, nose, teeth, etc., will be made by special teachers under a district superintendent, and all such records will become the permanent property of the state board of health.

A School Census.—Here we have the first important step toward the establishment of a definite school census. It is admittedly only a first step; but when it shall be recognized that it is quite as important that the same critical attention be given to defects of mind as to those of teeth or eyes we shall have taken the step which more than any other can redound to educational betterment, and at the same time prove a more effective measure for prevention of cruelty to the human animal than that at present in vogue. With such a school census at command the work of the teacher becomes at once intelligent and at the same time free from the apprehension which must ever haunt one whose problem is rendered obscure by ignorance as to actualities in constitution of the pupil's mental capacity. The Binet scale has been sufficiently tested to render it a fairly trustworthy method of judging potential, as well as actual mentality, and no valid objection has been made against its use. Such a method correlated with such careful family pedigree as might readily be made an obligatory part of our official vital statistics would form a school census of the very first importance in relation to educational betterment and progress.

Difficulties.—The problem is not simple. There are difficulties, and some of them serious. But they are not insuperable. There is that associated with the ideas of family privacy, those skeleton closets where disagreeable things of body or mind are scrupulously hidden from the public view. While we may not lightly moot these objections, at the same time the state and society have rights involved which are no whit less sacred than are those of the family. As a social unit the family must not be permitted to foster conditions which may menace the larger complex of society. These rights are invaded by the board of health, by the life insurance company, by marriage permits (not as yet widely effective); why have not the guardians of mental health and efficiency an equal right to such knowledge? But let it be made clear that such a census need not be a public bureau. The school principal or superintendent is surely as trustworthy as is the city clerk or insurance agent and may be made amenable to any honorable discretion in such matters. Other difficulties may be raised, but none so far can be foreseen of serious concern; surely none more grave than the above. It is not probable that impediments, of whatever character, can long obstruct a searching inquiry into a method having even a reasonable probability of value from receiving a fair test in an impartial effort to advance educational methods by rendering them more scientific and efficient.

A Provisional Scheme.—As an outline of a method of educational eugenics the following seems both rational and workable:

1. Adequate vital statistics. These should include an authentic record of data touching (*a*) birth and parentage; (*b*) physical characteristics, health, development; (*c*) temperamental peculiarities; (*d*) mental traits, or predispositions; (*e*) moral characteristics. Critical data covering these matters should be made obligatory upon parents or guardian. Such data would be of inestimable value to the teacher at every step in the course of instruction and should cover the period from birth to school age.

2. A school census. From the time of school entrance and through the entire course of the grades there should be a permanent record of (*a*) rate and character of progress; (*b*) mental aptitudes or peculiarities; (*c*) temperamental or moral traits. During this time there would be ample opportunity for application of the Binet tests of mental capacity. Such a record would afford a real insight into the mental pedigree, which, compared with that of the nursery period, should afford some insight into hereditary antecedents.

3. A high school census. Upon entry into the high school its staff would have at command a body of fairly trustworthy data as to the general character and capacity of every pupil. It would thus become practicable from the first to advise intelligently each one as to the type and character of course to be pursued, *i. e.*, whether academic or vocational, literary or scientific, or whether discouraged concerning either. At any rate, both principal and teacher would be advised in advance as to prospects and probabilities, and thus forearmed to meet the issues. Thus qualified we should be saved from an expedient recently invoked of lowering the passing grade of the high school in order to encourage (?) dull pupils against truancy or abandoning the course, and then defending the method by the assertion that the apparent lowering of the standard was only such in form, that examinations would be made correspondingly more difficult! Such a subterfuge calls for no special comment! As in the grades, so in the high school, a similar record should be as rigidly kept, adding such data as the advanced age of the pupil might naturally afford, *e. g.*, as to prospective vocation, peculiarities, moral traits, etc.

4. A college census. Already there is much available data touching various aspects of actual progress and subsequent history. Much more is needed along these lines. There has been far too much boasting concerning subsequent capacity of college-bred people. This has lent itself effectively to the college agent or president in his endless appeal for resources, for students, etc. Let there be developed a thoroughly reliable body of facts touching every aspect of college or university pretension. Let it include data no less critical concerning social, athletic, fraternity affairs, and followed later by equally critical details as to subsequent professional distinction.

The scholastic pedigree furnished by the applicant for admission to college which the high school affords would serve quite as useful a purpose to the entrance board as is now served by the examination or certificate; indeed, in most respects a much higher credential than the latter. But beyond this ordinary entrance tribunal there should be one of still deeper importance. If the earlier school life has been largely one of grounding and discipline the college should be distinctively one of discrimination and selection. There is no more expensive and important institution in human society than the college and university. It is obviously unfair to add to the constantly increasing burden for supporting these social institutions by adding to their obligations the thankless task of educating the uneducable; cultivating a defective soil; producing a superior fruit from degenerate seed. Yet such is the present program.

Let there be added to the entrance examination already in vogue an inquiry into the eugenic pedigree of every entering freshman. This will involve no additional machinery; simply a better type of medical inspection; one which will not stop short with a test of lungs or heart or musculature; but will inquire into antecedents touching mental and moral as well as physical traits. That such is not so radical a matter as might at first sight appear, note the following recommendation made to the board of trustees of a state university only a year ago.

"A Chair of Individual Attention."—This sounds a bit vague, or worse, and it is not quite clear as to just what was involved in such a chair, but the following will afford some clue:

> To ascertain everything possible as to the antecedents of every student entering college, he (the professor) should know from pastor, teachers, parents and all qualified to testify concerning him, what his life has been from infancy through the kindergarten, the grades and the high school up to the time of his entrance to college. It would be possible for such an expert to learn something of the causes that have contributed to the previous failure or successes of the student. (*Miami Bull.*, 1911.)

Without attempting a discussion of this particular suggestion, or an inquiry as to just what might have been the aim, it seems fairly evident that *one* feature concerned was a more intimate personal relation with the student. The program herein proposed involves this and much in addition. That the personal concern is important is beyond all question; but that much more is imperative and fundamental is equally certain. It matters little just what *name* may be attached to such a chair. It might be designated the professorship of educational eugenics; or it might be called the chair of hygiene and physical culture; or any other of a dozen such. The point of real importance is that such a chair be created and placed on the same basis of dignity and independence as that of history or economics, and given opportunity and facilities essential to efficiency. To the writer no departure in educational progress is more imperative than that here proposed, and he earnestly anticipates its early realization.

THE PSYCHOLOGICAL FACTOR IN SOUTHERN RACE PROBLEMS

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WITH the increasing complexity of society in the southern states, the Negro problem is taking on a correspondingly complex character, and is coming more and more into the foreground of southern consciousness. Immediately after the civil war—in fact, during the entire epoch in which the south was in the grip of reconstruction—the Negro did not give rise to the same problems that he does to-day; that is to say, the fact that he was a Negro was not the fundamental element in the situation; at that time, the problem most in the minds of southerners was the presence of the reconstructionists and the reconstruction governments, and the Negro was feared only because he was the tool and the weapon of the latter. But with the gradual rehabilitation of southern political liberties and the reestablishment of stable local governments, the period of economic and social expansion began in the south, and southern men, freed from the necessity of combating ceaselessly for political life and social integrity, set about developing the long neglected natural resources of the country. With this change in conditions and this alteration of profound interests there came a change in the status of the various groups forming the southern social organism. And the Negro, no longer a political bête noire, began to come to attention in a more normal way as an organic member of society; and southerners, secure in their hard-won political and social ascendancy, began to be interested in him as a Negro and to attempt to bring about his better adaptation to southern social institutions. This attempt on the part of southerners to help the Negro adapt himself to southern social conditions has a peculiar significance to the average southern man; it implies an attempt to increase the social efficiency and the economic value of the Negro rather than his elevation to a higher social rank. Thus, in the thought of the average southerner, the uplift of the Negro has a radically different significance, usually, from that which it has in the thought of those living outside the south, who do not altogether understand southern social conditions.

First and foremost, the southern man is interested in raising the economic value of the Negro. To accomplish this various means have been adopted, all designed to train the Negro in things of practical usefulness. Concomitantly, the churches and philanthropical institutions are working toward the same end by attempting to teach the Negroes how to live better, and thus increase their efficiency and insure their status as self-supporting, independent members of society. The Negroes themselves are working to accomplish this end in practically every institution maintained by them throughout the south. This view of the Negro problem, practical in the extreme, is the one generally held at present in the south. The ideal seems to be to force the Negro to earn a better place in society and political life by the sweat of his brow and the toil of his hands; which toil, it is confidently hoped, will be guided by a constantly increasing intelligence, itself the indirect fruit of his labor.

On the other hand, outside the south the Negro problem is generally viewed as not primarily an economic, but as a political and "social rights" problem. The aim of many, if not most, of those living outside the south who take an active interest in the Negro is to secure for him fuller political rights and wider social opportunities, believing that as restrictions are removed, the Negro's position will improve in every respect, and he will ultimately take his place side by side with the whites, on an equal footing and possessing an identical cultural equipment.

Whatever be the theoretical merit of these views, whatever be the results of their trial, whatever be the advantage of one over the other ethically, it can easily be seen that although they advocate almost exactly opposite methods, those who advocate them are striving to reach the same goal. Each group is attempting to help the Negro to attain a more complete civilization; and each is attempting to do this by trying to make the Negro absorb the white man's civilization and come into complete accord with the profound moving-springs of the white man's social sanctions.

Many writers have contributed to the elaboration of these prevailing views of the problem. Admittedly, all of them have as their ideal the creation through evolutionary processes of a state in which the whites and the Negroes live side by side, each group partaking of the same civilization on a basis of ethical equality, and each playing its part in government and society according to its ability. This bi-racial state, theoretically, should have a single civilization, common to and understood similarly by both peoples; this civilization—and here is the vital point—will be the civilization of the whites, which, it is assumed, will be inculcated into the Negroes and which the Negroes will absorb without sufficiently modifying it to impair its usefulness as a foundation for a complex, though organically homogeneous, society.

Underlying the conception of a state such as has just been described lies a more fundamental conception which is seldom formulated, but upon which the whole structure of theory about southern race problems is based. This conception may be stated in various ways; its boldest, most general, and most erroneous form is the hypothesis that "all men are equal"; a more moderate form is "equal opportunity for all, special privilege for none"; but the most comprehensive form, which contains by implication very nearly all that is included in our thought upon the matter, is that "all men, when normal, possess the same capacity for intelligence and the same ability to absorb culture and to become civilized"; in other words, that all men are essentially alike mentally and morally, when viewed in the large, notwithstanding physical and physiological differences. The culture of any group of men, it is assumed, may be adopted by, or forced upon any other group of men, without effecting any revolutionary change in the culture. It is tacitly thought that while the processes of evolution have given one race a white skin and another race a black skin, have made one race relatively resistant to tuberculosis and the other relatively susceptible, and so on, the minds of both are alike—have not diverged as their bodies have in the evolutionary series—and that the mental processes of one may become, by proper direction, the mental processes of the other.

On conventional ethical grounds, the hypothesis of human equality can not be assailed. The Christian world, particularly that part of it which really thinks, is essentially altruistic, and this altruism demands that all men be given the fullest and most equal opportunities to get the best out of life. But it is seldom realized that this is an ideal, not a working formula; that it is, further, an ethical ideal, not a scientific one. Out of this misconception of the ideal of human equality have sprung many grievous and oftentimes dangerous fallacies, chief among which are two: (1) that all men possess the same potentialities for culture; and (2) that a so-called "higher culture" may and ethically should be substituted for a so-called "lower culture" whenever opportunity presents itself.

As has been said, each of these ideas has a basis in ethical principles. But both are fallacious when scientifically considered. Each assumes too much, and each tries to make out of an ethical ideal the scientific working formula for the uplifting of backward peoples. Neither takes into account that culture and civilization are as much the products of evolution as a white skin or a black skin.

Culture, in its broadest sense, is a phenomenon of race. Even in our more or less homogeneous western European and American culture, racial differences are to be observed; if this were not true, why should we take the trouble to call some people Germans and others Spaniards, some Danes and others Italians? Yet, despite these evident differences, western European and American culture is a definite, characteristic thing, and underlying it we recognize a common stock of traditions and general ideas which have come down through the ages "in the blood," so to speak. The white-skinned peoples of western Europe and America all have approximately the same origin, in that through the remote mixing of a few strains of blood the modern racial types were set; and since then the peoples of western Europe have given evidence of their biological kinship by displaying approximately similar reactions to similar environmental conditions and to the influence of general ideas and movements of thought. Whatever variations have appeared in the physical and psychical types among the various peoples are due to differences in the mixtures of the original strains of blood, with the accompanying differences in the contributions of hereditary mental predispositions received by the respective peoples, plus subsequent adaptations to environmental conditions. But behind all the differences lies a common kinship of blood and of tradition, which has operated to produce the unit we call western European culture; and this racial kinship is the principal reason why it is not difficult for one group of western Europeans to adopt without revolutionizing it the culture of another group. Furthermore, as a powerful factor assisting in the formation and growth of this western European culture, and aiding constantly in keeping it homogeneous, is the fact that the several strains of blood, particularly in the higher levels of society where most of the productive thinking is done, are incessantly mixing, and there are being interchanged incessantly, through heredity, the mental predispositions peculiar to the groups thus crossing. The people of western Europe and the white portion of American population, for the most part, are a sort of "blend" of similar racial stocks, presenting similar though not identical biological characteristics; and the varieties of this "blend," expressed in such terms as "English," "Dutch," and so forth, are due to differences in the numerical relationships of the contributing stocks forming these peoples. So, too, western European culture is a sort of "blend" of cultures, and the varieties of this "blend" parallel the varieties in the physical characteristics of the various peoples.

The same statements apply to any other group of people presenting a special, characteristic type of culture. The Chinese are an example; they differ among themselves in certain respects; they are a "blend" of races and their present culture is a "blend" of cultures. Yet Chinese culture is definite, peculiar and recognizable, and it is essentially Mongolian, just as our culture is essentially European. Behind the differences among the various groups in China lie their common Mongolian blood and their common store of traditions, the influences of which have moulded them into what they are to-day. Exactly the same statements apply to the Negroes. They have, physically and mentally, definite and easily recognizable characteristics, indicative of a common origin different from our own, and expressed in a similarity of Negro cultures throughout the world.

The fact of race as a physical and mental phenomenon is evident to every one. The peoples of the world differ, and often differ fundamentally; and these differences are ineradicable as long as the strain of blood remains unimpaired. On the physical side, this principle has long been an axiom. "Can the Ethiopian change his skin?" asks Jeremiah. We can not, do what we will with environment, change to any appreciable extent our anatomical make-up. A Chinaman's skin will remain yellow, a Negro's skin will remain black, no matter what we may do to alter them, so long as the races remain pure. The only way we can modify the color of the skin or the facial angle or the texture of the hair in any great number of individuals is by crossing with another race. And the product of this crossing, should it become permanent, is a different race.

From the point of view of psychology, on the other hand, we have assumed that this principle is not true. We know that we can not change a Negro's physical characteristics, so as to make him like ourselves, by bringing him to live among us. But we believe we can change his mental characteristics. In other words, while we are certain that we can not change the Negro's facial angle, we are equally certain that we can change his mental angle and make it like our own; while we consider it absurd to think that we can do anything to make the Negro's physical skin become white, we believe firmly that we can make the psychical analogue of his skin exactly like our own.

But is this a fact? Racial psychology says no. Mental characteristics are as distinctly and as organically a part of a race as its physical characteristics, and for the same reason: both depend ultimately upon anatomical structure. Racial mental-set, racial ways of thinking, racial reactions to the influence of ideas, are as characteristic and as recognizable as racial skin-color and racial skull-conformation. This does not mean that mental characteristics and superficial anatomical characteristics necessarily bear any relationship to each other, as has sometimes been assumed; that is to say, the shape of the head, the weight of the brain, the cranial capacity, the length of the arms, the arrangement of the muscles in the calf of the leg, do not determine mental characteristics: physical and mental characteristics are, however, parallel expressions of the particular evolutionary process which has resulted in the formation of a race; each set of characters is the specific result, in different structures, of the evolutionary process. Ultimately, mental differences must depend upon anatomical and physiological differences; but these differences are differences in the structure of the brain itself. If we are to assume any relationship whatsoever between brain and mind (and such a relationship, whatever it may be, certainly exists), we must assume some anatomical and physiological differences in brains if we are to account for mental differences.

The more the races of men are studied, the more certain becomes the evidence to show that races have characteristic mental peculiarities, which would serve to distinguish species and varieties almost as well as physical characteristics. In practical life, in jurisprudence, in language itself, we empirically allow for these racial mental differences. But we have never taken the trouble to study them nor to understand their nature from a scientific point of view, and almost nothing is known about their potentialities.

Taking as a fact these mental differences, let us for a moment consider the possibility of their modification. It has been pointed out that mental differences must ultimately depend upon material anatomical differences in brain-structure; if we deny this, we instantly remove racial psychology from the field of science to that of metaphysics, and controvert all the observed data of physiological psychology; there must be some structural differences between the brain of a Negro and that of a white man, though such differences are admittedly very hard to detect by present methods. We know that it is impossible for us to modify anatomical structures at will; we can undoubtedly change them (within narrow limits, by selection of characters already present and the accentuation of these), but we can not make any two differing anatomical characters become exactly alike. Why, then, should we assume that we can modify at will the mental processes of a race, since these mental processes are expressions of a certain definite anatomical and physiological organization, which we know can not be altered save by the crossing of bloods or by the laborious and infinitely slow processes of evolution?

Yet, north and south, we wish to do this very thing, and to do it in its extreme form. For we are not merely trying to change the direction of the Negro's peculiar mental characteristics, and to improve them by selection among the elements already present—we are trying, on the contrary, to deprive the Negro of his own racial mental characteristics, and to substitute our own in their place, *at the same time keeping him anatomically a Negro.* That this is an impossibility follows after the former argument.

It will undoubtedly be said, by way of refutation, that the Negroes of the southern states have advanced and advanced considerably since they have been in this country. This is unreservedly true. But it is often forgotten that they have advanced as Negroes, not as anything else. They have adopted the form of our civilization and to a certain extent (due principally to the influence of language), the mould of our thought. But however much the form of the civilization and the mould of the thought resemble our own, the substance of both is different. The Negro has received much from us, and has profited greatly therefrom; but all that he has received he has modified in accordance with his racial mental-set, and his psychical reactions to the influences of our civilization are entirely different from our own, and will necessarily remain so as long as the Negro is a Negro. No matter how much we educate him, no matter how much we better his position in society, he will remain a Negro psychically as long as he remains a Negro physically. We may cause him to absorb the full, rich store of our cultural elements, but by the time these elements have gone through the channels of his thought they will be profoundly modified, and they will take on a different meaning in the Negro's consciousness from what they have in the white man's consciousness. Concomitantly, these cultural elements will modify the brain of the Negro; but this modification will not follow the same pathways and will not give the same results as it would in the untutored brain, say, of a white child. The modifying forces acting upon the Negro's brain will have to start with an anatomical structure already formed and set by heredity, an anatomical structure different from that of the white race, which produced the modifying forces in question, and the final result in the Negro's brain will be determined and directed by this preexistent anatomical make-up. So that the brain and the consciousness resulting from the absorption of our culture by the Negroes will be a brain and a consciousness different from our own to the same extent that the Negro differs from us in other respects, and both will be characteristically Negroid in nature, not European.

It follows, therefore, that present ideals in regard to the "solution" of our Negro problem (ideals, as has been pointed out and which it is well to reiterate, resulting from the confusion of ethical and scientific principles) are biologically fallacious, and impossible of attainment. We can never make the Negro like the white man mentally. We can never have a bi-racial state based upon an identity of ideas and political philosophies in both races.

The Negroes will continue to progress, undoubtedly. But they will progress along the lines laid down by their evolutionary history. They will take our cultural elements and make them part of themselves; but they will modify these elements according to their nature, and when they have assimilated them, they will be our cultural elements no longer, but will be profoundly and permanently modified. The two races will continue to develop side by side, but the development can never be parallel—it must be divergent, even though its successive steps may perchance maintain approximately the same level, as long as the races remain pure. It will be like two men, thrown together by fortuitous circumstances, who start walking up the same slope toward the same hill-top; but because of differences in the nature of their interests, one goes east while the other goes northeast; each step will carry them closer to the top of the hill, but further and further apart.

This fact, rather than ethical theory, should form the foundation of American thought in regard to the Negroes and the Negro problem. The Negro as an intellectual being should be studied as a Negro—not as a potential white-man; and if we wish to help him, we should at least try to be sure that he is allowed to develop as a Negro in the freest, broadest manner possible, and to the full extent of his racial potentialities.

WOMEN IN INDUSTRY

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The Physical Effects of Wage Work

WOMEN'S efforts to obtain a vote have directed attention to other problems which confront members of their sex. Long hours of work in factories and stores and the evils of the sweat shop have been investigated, but little has been written upon the effect that working may have on women's ability to bear children.

It is said that the hue and cry over the work of women in industry is misplaced and overemphasized. Women have always been employed at the very same things for which they now draw wages. Since history has been recorded they have woven cloth, prepared food and borne burdens. The only difference between former times and the present is that most of this work was once done individually in the home, whereas now it is carried on collectively in a factory. Women are not doing men's work. They can not, for they are smaller, less agile, less strong. Rather it is true that men in spinning, weaving and sewing are invading women's sphere and crowding out the women. It is claimed that the work in mills is for no longer hours, nor under worse sanitary and hygienic conditions, than women's tasks have always been. A parallel argument is that scarlet fever is not a dangerous disease because it is no worse than smallpox. If it is true that there are 156 women sick for every 100 sick men in the cotton mills; if the sick-insurance societies of England, Switzerland, Germany, Austria and France report that women are ill oftener and for a longer duration than men; if medical authorities report that 40 per cent. of married women who have been factory girls are treated for pelvic disorders before they are thirty years old; then it must also be true that factory work has in it something that is more injurious to health than similar employment at home. When the labor is performed away from the domestic hearth new elements enter into it that make it dangerous. In the home the woman prepared the raw material for spinning, twisted it into thread and then wove the cloth. Each of these operations called for a change of position. In the factory the whole task has been so subdivided that each woman does only a very small share of it, and so she must stand or sit continually in one place. Such intense specialization permits no variety in the motions of the work, thus producing a monotony that is deadening. Furthermore, the number of machines to which a woman must attend, and the speed at which the machines are driven are constantly being increased. Coupled with piece-work wages, the "speeding up" results in a nervous tension and strain almost wholly lacking in the domestic system.

Although a woman might work for long hours at home, she could stop when it was necessary to attend to her natural bodily needs. In the factory she has not that freedom, and the result is a whole train of ills.

As a quadruped the female suffered little handicap because of the functions peculiar to sex, except when actually carrying or nursing the young. But after mankind had learned to stand erect, her support was far from ideal. The bones of the ankle and feet are too small to sustain great weight. A woman's knee is not so well adapted as a man's to form part of a sustaining column. The muscles of the leg, too, have a shorter purchase than a man's, hence the leverage between the trunk and the extremities is less. The strain of support is transferred to the back. Thus any work which requires long standing for a woman is injurious. All the pressure of the body's weight is brought to bear upon a portion where the sex organs and others are crowded together, and produces a dragging feeling above and about the hips. Women performing such work are especially liable to congestion of all the organs enclosed by the hip bones, because standing and the habit of resting on one leg only, causes a narrowing of the hips. This narrowing is especially apt to occur because the greater proportion of women workers are too young to have become securely and permanently established physiologically before going to work. The average age for men at work is between 25 and 30, whereas the average age for women is between 16 and 20. In 1900 49.3 per cent. of the women were under 25 years of age. In the silk, knitting and hosiery mills there are as many girls between 16 and 20 years as all women over 21 years. By far the greater number of girls do not break down while they are at work, but after leaving the work for matrimony the deformities caused by the work become apparent. Specifically the uterus is very apt to be crowded out of place, or to be congested. Menstruation is made irregular and difficult. Factory women frequently stand at their work to within a few hours before giving birth to a child, with the result of premature labor. Miscarriages occur oftener among factory wives than in the general population. It is more frequently necessary to use instruments in childbirth among such women.

The mill hands are not the only women who suffer from long standing. The girl clerks in department stores are subject to the same conditions. Although 37 states require seats to be placed for clerks, there is no law enforcing their use. Many stores have a rule that clerks must stand at all times, because they look less alert when seated. Clerks on the first floor are seldom allowed to sit down. When sitting is permitted at all, the number of seats is inadequate for the sales force. In addition to standing, clerks suffer from lack of space behind counters, which increases the strain of lifting and puts a further burden upon the pelvic organs. The secondary effects of long standing, among which are broken arches in the feet and enlarged veins in the legs, is to add to the nerve strain, and indirectly affects other functions.

Sitting in one position has an action similar to long-continued standing. Lack of exercise reduces the capacity of the lungs, and so they do not eliminate certain poisons from the body. Because the lungs fail to act the kidneys are forced to do extra work, adding to the congestion of the abdominal organs. Sitting augments constipation, a minor ailment in itself, but one which breeds more bodily ills than any other single cause that might be mentioned. This condition is very prevalent among working women because of their lack of careful personal attention. In mills and stores the toilets are often too few in number, unsanitary in condition and inconveniently placed. In many cases there is no separation for the sexes. In some stores and factories no employee can leave her work for more than five minutes. When in a many-storied building the toilets are not on the same floor with the worker this rule amounts to a prohibition. In other places girls must ask permission of men foremen or floor walkers to leave their work, a thing which many hesitate to do. When a store closes at 6 o'clock clerks frequently may not be absent from their posts after 4:30 P.M. Such conditions cause a partial paralysis of the alimentary canal, and abnormalities in the secretions, which puts an undue and constant strain upon the whole body. In women this strain is most apparent in functional abnormalities, hysteria and general anemic conditions. In addition to the restraint of sitting the indirect pressure against the abdominal organs by leaning over a sewing machine or against a desk augments the tendency to chronic inflammatory disease in the pelvis. The total result of long standing, or sitting in one attitude, is either absolute sterility or such organic disturbances as make child-bearing dangerous.

The second new element in modern industry is the monotony of the work, the unending recurrence of unavailing effort. It is difficult to trace any direct effect of monotony upon the more vital organs of the body. Monotony is a mental rather than a physical phenomenon. Modern factory work demands no feeling, no personal interest, no responsibility, nor inventive genius on the part of the worker. She does one thing endlessly, automatically. Work which demands nothing of the intelligence costs the intelligence more than work which demands too much. When only one brain center is employed the brain is more fatigued than if all the centers were worked harder. The result is either a stunting of mentality or an inordinate craving for excitement. The intimate association of the nervous system with the other functions of the body insures the reflection of injuries to the brain centers in the disturbance of all other organs.

The monotony of work is linked to the strain under which it is carried on. In the knitting industry a girl now has to watch from two to ten needles instead of one. In sewing shops the needles make 4,400 stitches a minute. The operator can tell when a needle or a thread is broken or a stitch misplaced only by a variation in a beam of light thrown on the needle. Constant attention to so minute a detail puts a fearful strain on the eyes and nerves. In textile mills the number of machines has so increased that the operator is kept always at the highest rate of speed. In a large publishing house girls who bind the magazine must handle 25,000 copies, each weighing three fourths of a pound, in ten hours. Piece work aggravates the evil of keeping up with a machine. In the millinery trade "rush work" is of a similar character. This speed coupled with the monotony of doing the same operation repeatedly brings about nervous exhaustion. The monotony of the work exercises only little patches of the nervous system. Mental and physical fatigue are closely bound together. A muscle in contracting uses nitrogen and liberates a poison or toxin. Under normal conditions this toxin is carried out of the body by way of the kidneys and lungs, and is neutralized by an antitoxin. If the muscle is exercised too frequently the toxins multiply faster than the ability to eradicate them. The poison accumulates and the muscle becomes fatigued. Further work is performed at the expense of the will, which puts a drain on the nervous system. Fatigue may go to the point of exhaustion, and result in death by chemical self-poisoning. Normally the tired body throws off the toxins during sleep and is then ready for another full day's work. But if the body does not get rest, the fatigued muscles on the second day can do only one half the normal amount of work before again becoming fatigued. At the beginning the overwork may pass unnoticed, but since fatigue is accumulative it eventually results in a complete nervous breakdown, because fatigue really weakens the brain centers that control the muscles, although the feeling of being tired is primarily felt in the muscles themselves. Women are predisposed to nervous trouble, and their nerves are weakened by the various sex functions. Nervous tension exaggerates any bad tendencies already present. The industrial woman works to the point of over-fatigue and then goes home to do housework, or seeks excitement in dances and shows, thus adding nerve strain to nerve strain. Sleeplessness and loss of appetite follow; succeeding days of work pile up fatigue until the brain cells and nerves collapse. A usual accompaniment of nerve exhaustion is menstrual irregularities and poverty of the blood. The constant vibration in a mill may help bring about organic troubles, particularly if the organs have been weakened by other causes. The vibrations plus noise act on the nerves as a continual light tapping does on steel. Both steel and nerves disintegrate. One girl said that when her machine stopped at night she always felt like screaming, which proved that her nervous energy was being too greatly sapped by the day's work.

The effect of the strain of industry then is to add mental to physical fatigue, destroying the recuperative power of the body. Since the sexual organs and the nervous system both take the same food elements from the blood and are delicately adjusted to each other, the toll industry takes of the nerves is sooner or later reflected in organic maladjustments.

As with monotonous work, so with industrial diseases no direct result on the fecundity of women can be pointed out. The harm comes indirectly through a lowering of general vitality and nerve strain. Lead poisoning seems to attack women more readily than men. It is a most potent producer of abortion, for it is rare for a woman working in lead fumes to give birth to a healthy child at term. Often the poisoning results in sterility. At first, the odor of carbon bisulphide in a rubber factory makes girls excitable, but it is followed by headache and nervous lassitude, with a loathing for food. As with morphine and cocaine, the cause has the semblance of a cure, a feeling of normality only when drugged. This produces the vicious circle, of poisoning, lassitude and repoisoning. The excitement causes undue fatigue, while malnutrition culminates in poverty of the blood, general debility and organic disturbances. The eating of the hands by acids in pickling factories, bleacheries and soap works tortures the workers and exhausts the nerves. Dust dries the throat. The effort to cough produces asthma or an inflammation which is a good seeding ground for tuberculosis. A hot, damp workroom weakens the body by excessive perspiration, and renders it liable to rheumatism, bronchitis and tuberculosis. Lifting heavy weights or running foot-power machines so injure the sex organs as to induce sterility. This list might be lengthened, but enough has already been written to make the point.

Malnutrition plays a part in lessening the vitality of working women. When a mother has to prepare a breakfast for a family before hurrying away to a shop, that breakfast is to be commended for the speed of its preparation rather than for its adherence to principles of proper diet. Bread and butter, coffee or tea and greasy meat, with the addition of a pickle as a stimulant, is the usual bill of fare, varied but little in the three meals of the day. There is not enough of cooked food and vegetables are lacking. The mother's body is not sufficiently nourished to withstand the double tax of factory work and house work, and if a child comes, the mother is sometimes too impoverished physically to nourish it. A baby should be fed every two hours, but a factory mother sees her infant once in six or ten hours only. Drugs are given to children only two weeks old to keep them quiet while the mother is away from home. Interference with lactation is injurious to the mother and fatal to the baby. The survivors of this heroic treatment grow up never having had sufficient nourishment. When it comes their turn to go to work, they do so not equipped with full vigor to meet the increasing stress of such work, but in a weakened condition, and are susceptible to all the ills before mentioned. Lifelong malnutrition added to pelvic deformities acquired by work is a serious drawback to the motherhood of working women.

Because children are a handicap, in calling for time and attention that is needed for other work, they are unwelcome or impossible to certain groups of women workers. A woman reporter or school teacher can not afford to have the demands of a child interfere with the requirements of her work, so in some branches of industry it can not be stated whether the women engaged in it are physically incapacitated for bearing children, or whether they have none because they do not wish them. All the social and economic factors which are causing a world-wide decline in the birth-rate operate in the various groups of working women and complicate any general conclusions that might be drawn as to the injury done by the work itself.

A hundred and fifty years ago the man who ventured to predict that no women would be allowed to work in mines, bar rooms, buffing or polishing metals or as public messengers would have been laughed at in scorn, but we to-day look upon such occupations for women with horror. May not our children's children think of a time when women worked in factories as a barbarous age? Lawmakers may some day forbid such labor on the grounds of the injury to the future race. We may not have to wait for such laws, however. Working conditions are usually the worst in the smaller concerns. The country is tending toward large-scale production, therefore conditions are slowly improving. But with large-scale production machines are larger, work heavier, speed and number of machines greater, so much so that men must be employed to do the work formerly done by women. The task a woman performs is largely of a mechanical nature, hence with large-scale production unreliable labor is replaced by a reliable automatic machine. The development of the loom from hand power to power driven, and from female to male attendance, and to final automatic action is an illustration in point. The more efficient machine may drive the less efficient woman out of the shop. In stores, offices and schools they must be more adequately protected by law, for it is evident that working, sooner or later, is reflected in fecundity.

THE FOURTH DIMENSION

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I. Non-Euclidean Geometry

AS non-Euclidean geometry has not become popular enough to find a place in the ordinary college curriculum, and as its discovery preceded any serious consideration of space of more dimensions than three, it seems to me that, before taking up hyperspace proper, it would be well at least to mention the non-Euclidean geometries.

The mathematics of the college student is largely deductive, and he but faintly realizes the important part played by intuition, observation, induction and even imagination in the realms of higher mathematics. For instance, nothing surprises the layman—I use the word layman as including all who have not made some special study of higher mathematics—so much as to hear for the first time that the famous axiom of Euclid, namely: *If two lines are cut by a third, and the sum of the interior angles on the same side of the cutting line is less than two right angles, the lines will meet on that side when sufficiently produced,* is not necessarily true. And yet in very early times mathematicians began to doubt the truth of this axiom as it did not seem to be, like the rest, a simple elementary fact. The great geometer Legendre and other mathematicians attempted to give a proof of this so-called axiom, but without success. At last, to make a long story short, some mathematicians began to believe that this proposition was not only not self-evident, but was not capable of proof, and moreover that an equally consistent geometry could be built up on the supposition that it is not always true. Thus, out of various endeavors to prove Euclid's "parallel" axiom, arose non-Euclidean geometry, the beginning of which is sometimes attributed to Gauss; but as he did not publish anything on the subject, it is impossible to say what his ideas were. In the greatness of his heart, he generously gave full credit to Bolyai for his independent discoveries.

All honor, however, is due to two remarkable men, the Russian Lobatchevsky and the Hungarian Bolyai, who, about 1830, independently of each other, showed the denial of Euclid's parallel axiom led to a system of two-dimensional geometry as self-consistent as Euclid's. This new geometry is based on the assumption that through a given point a number of straight lines can be drawn parallel to a given straight line.

In 1854, the German Riemann[1] discovered another geometry. This geometry is based on the hypothesis that through a given point *no* straight line can be drawn parallel to a given straight line. Thus we have the three geometries: Euclid's (or the parabolic geometry), in which the "parallel axiom" holds, Lobatchevsky's (or the hyperbolic geometry), Riemann's (or the elliptic geometry). As is now well established, all three geometries are consistent with reality: Euclid's is true for a plane (a surface of zero curvature); Riemann's is true for a spherical surface (a two-dimensional space of constant positive curvature); Lobatchevsky's is true on the so-called pseudo-spherical surface of indefinite extent (a two-dimensional space of constant negative curvature). This pseudo-spherical surface is a saddle-shaped surface, like the inner surface of a solid ring.

It is to be noted that the straight line of one geometry is not the straight line of another, but in all three geometries it is the *shortest* distance between two points. Such straightest lines are "geodetic" lines. It will perhaps be evident now why in a sense the discovery of the non-Euclidean geometries was a stepping-stone to the consideration of hyperspace; though we should bear in mind that the two conceptions are entirely distinct, neither one being dependent upon the other. The logical conception of non-Euclidean geometry is far more difficult than the abstract notion of the fourth dimension. The study of the results arrived at by Lobatchevsky, Bolyai, Riemann, Beltrami and others forced men to think of "spaces," and it is hardly too much to say that the stimulus thus given to "high thinking" of this nature gave rise to the hypothetical acceptance of a fourth (or any higher) dimensional space.[2]

II. The Fourth Dimension

I come now to the consideration of hyperspace, which is space of any dimension above three, but for convenience and simplicity I shall confine myself mainly to fourth dimensional space.

To get any clear notion of the fourth dimension, one must make up his mind to exercise much patience, perhaps reading and re-reading many times articles by various authors. In this exposition of the subject, I would warn the reader against supposing that any attempt is here made to convince him of the possibility of the existence of fourth dimensional space. He is not even asked to *believe in* a material space

[1] Riemann, "Ueber die Hypothesen welche der Geometrie zu Grunde liegen," first read in 1854.

[2] Lobatschevsky's "The Theory of Parallels" and Bolyai's "The Science Absolute of Space" were translated into English by George Bruce Halsted and first appeared in *Scientiæ Baccalaureus*, a journal published for a short time by the Missouri School of Mines. By this and other publications Professor Halsted did much to popularize non-Euclidean geometry. Perhaps the most available short treatise on the subject in America is Professor Henry P. Manning's "Non-Euclidean Geometry."

other than our common, every day three-space. Fortunately a comparison with lower dimensional geometries furnishes so many analogies that the subject can be very fully explained in a non-mathematical way. Only let me say just here that the geometry of the fourth dimension is a perfectly logical system of theorems and proofs entirely independent of these analogies.

We, the dwellers in 3-space, can best realize the reasonableness of *conceiving* of a fourth or higher dimensional space by considering as best we may what would take place in lower-dimensional space did such exist.

Consider a pipe of indefinite length with a bore of diameter as small as you please, and suppose that there dwell within this pipe "worms" of such diameter that they just fill the pipe. We can not conceive of anything with no breadth or thickness, but let us consider for sake of the illustration that this one-dimensional animal (which for brevity I shall call a *unodim*) has only length. Of course these unodims may vary in length according to age or family traits, perhaps. Now it is evident that a unodim can never turn around. He may move forward or backward, but one unodim can never pass another. If he possesses an eye in front or behind he can see a neighboring unodim as a mere point. His world is a very limited one.

Again, we might imagine a two-dimensional animal, taking hold

Fig. 1.

of a *unodim,* turning him around in his (two-dimensional) space and putting him back with his "tail" where his "head" was before. Evidently the *unodim* would be ignorant of the cause of his reversion, for he has no knowledge of a two-dimensional space, and the two-dimensional animal is invisible to him. In other words, if AB and $A'B'$ in the figure are equal in length but running in opposite directions, it is impossible to put $A'B'$ in the place of AB, that is, A' where A is and B' where B is. To accomplish this, it would be necessary to take $A'B'$ into 2-space and turn it around. While this would be an impossible feat for a unodim, a two-space animal could readily do it.

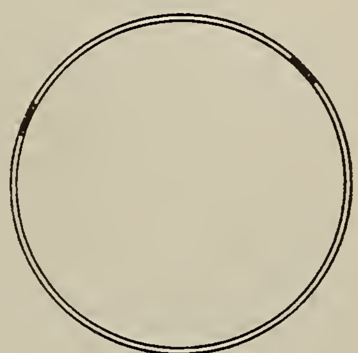

Fig. 2.

Now this one-dimensional space may not be "straight" (that is, of zero curvature); but it may be the space that we should get by bending the pipe around in the form of a circle, as in Fig. 2. In such a case, as his body would be constantly bent in the same direction and by the same degree, we may suppose that the unodim is totally unconscious of any curvature. It is well to note that in an exactly similar way our space may be curved without our being conscious of it. So he might feel just as certain that his space is "straight-line" space as we, the high and mighty 3-space beings, do that our space is Euclidean (or space of zero curvature).

Again, suppose the tube to be bent in an egg-shaped curve where the curvature is not constant. Here the unodim's world would still be one-dimensional, but as his body would be bent a little more in one part of his world than in another, it is possible that he may feel that there is some variety in his space. He may walk a little straighter at times and less straight at others. Whether his 1-space is straight or curved, and, if curved, whatever may be the variety of its convolutions, the unodim can not know of the existence of a world of 2-space or 3-space.

If a 2-space body, say a square, passes through his 1-space world, he sees only the 1-space section of the square.

In Fig. 3, *xy*, the 1-space world, is represented as being in the same

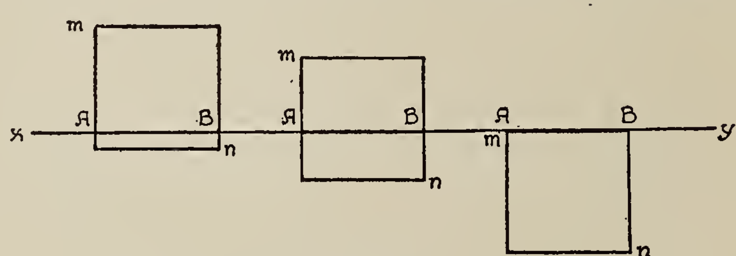

Fig. 3.

plane with the square *mn*. The square may cut *xy* at right angles or obliquely. In any case the *unodim* sees at any moment only the part of the square common to his world and is not conscious that there is any more to the square.

Two-space

Next let us consider 2-space.

Assume a 2-space being, which we shall call a *duodim,* that is, a *flat* being (theoretically with no thickness) with length and breadth and confined to a surface having length and breadth but no thickness. Such a being could move to the right or left or forward or backward, we will say, but neither up nor down from the surface. In fact, he knows neither *up* nor *down*: the surface is his world.

His position in his world is easily located by the Cartesian system of coordinates, that is, with reference to its distance from, say, two straight lines at right angles to each other. For illustration, define his world as the geometrical plane formed by the two lines *xx′, yy′* intersecting each other at right angles. Employing the usual notation, we consider distances measured perpendicular to the *Y*-axis as positive if measured to the right, and negative if to the left of the *Y*-axis. Such a distance is called the *abscissa* of the given point. Similarly, distances measured perpendicular to the X-axis are positive if measured above and negative if below the X-axis, such a distance being called the *ordinate* of the given point.

Thus it is evident that a point is fully determined in the plane if its *abscissa* and *ordinate* are given. Every school boy has met with this principle in the location of a place on the earth's surface by latitude and longitude, where the axes of reference are great circles of the globe.

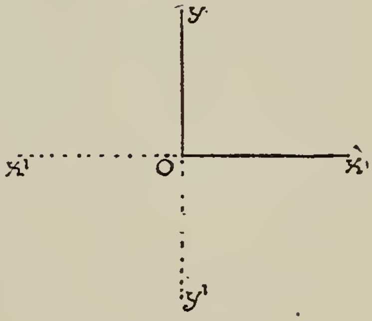

Fig. 4.

Now our *duodim* has a far more extended space than the *unodim*, and can do many things that the unodim is totally ignorant of. His space may not necessarily be one of zero curvature,—for it is perfectly consistent with our definition of 2-space for it to be the surface of a sphere, of an ellipsoid, of an egg-shaped figure, or what not. It is to be noticed that if the space has constant curvature (including no curvature), a body may be moved from any place to any other place on the surface *without changing its shape.*

If there are (Fig. 5) two triangles like E and F in which the sides

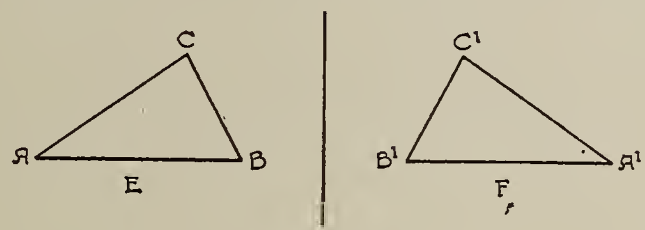

Fig. 5.

are equal each to each, but are arranged in reversed order, it is impossible in 2-space for F to be made to take the position of E. Here E is the reflection of F in a mirror. An inhabitant of 3-space has no difficulty, however, in taking up F, turning it over and putting it on the position E.

A three-dimensional body as such is of course invisible to a 2-space being. If a 3-space body, say a cube, crosses a 2-space, the 2-space being is conscious only of its section with his world.

Fig. 6 represents the effect of a 3-space body, a cube, passing through the 2-space pictured by the plane "*mn.*" The section $ABCD$ of the plane mn with the cube G is all that a *duodim* would be conscious of. As G passes through mn, this section, certainly if G is a homogeneous body, will appear the same until suddenly it vanishes as G passes beyond mn.

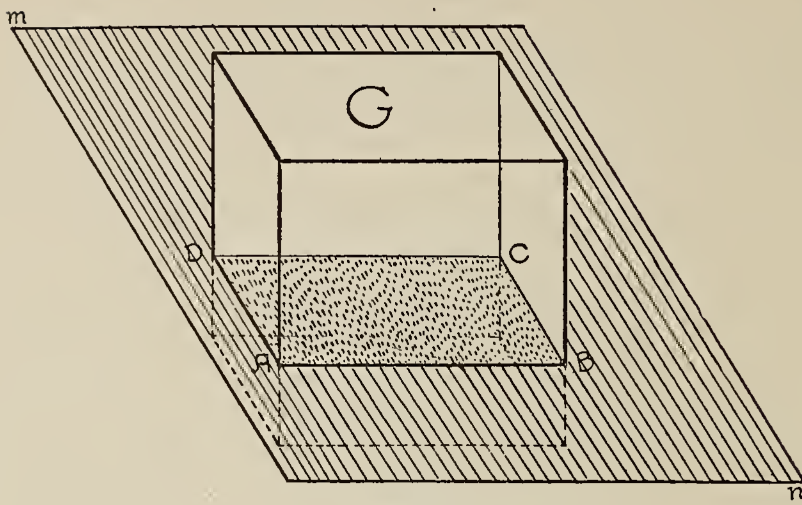

FIG. 6.

Three-space

Let us next direct our attention to 3-space, an inhabitant of which we might call an animal, but which, to continue the nomenclature adopted, we shall sometimes in a general way speak of as a *tridim.* Here freedom of life is much more augmented, even more so than in passing from 1-space to 2-space. For here we have added the up-and-down motion to the right-and-left and the forward-and-backward motions. Here any point is located by means of its distances from three mutually perpendicular planes, each plane being formed by two of the three lines that can be drawn mutually perpendicular to one another. In Fig. 7, *Ox, Oy, Oz*—representing directions to the right, hitherward and upward, respectively—are the axes of reference, each being perpendicular to the other two, forming the mutually perpendicular planes, *xOy, yOz, zOx.*

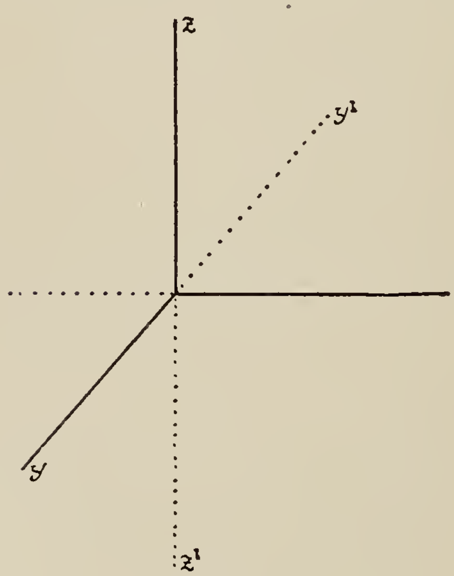

FIG. 7.

We saw that in 2-space the axes *xx′, yy′* divided the space into four equal parts of indefinite extent. A straight line in 2-space divides that space into two parts. In 3-space, it is evident that the coordinate planes divide space into eight equal parts of indefinite extent. Any point in 3-space is definitely determined when its distances from the three planes of reference is known. Distances perpendicular to the *yz* plane, denoted by *x*, are positive if measured to the right, *negative* if measured to the *left;* distances perpendicular to the *xz* plane, denoted by *y*, are *positive* if measured *towards* us, *negative* if measured *away from* us;

distances perpendicular to the *xy* plane are *positive* if measured *above, negative* if measured *below.* This notation enables us to locate any point in our space.

Now we know of 2-space only as a section of 3-space, and a *duodim* is purely an imaginary being to us; and we know of 1-space only as a section of 2-space (and therefore of 3-space), and the *unodim* is imaginary. We have seen that a duodim might interfere with life in 1-space, but the unodim would not know at all what had caused the interference. We have also seen that a tridim might in a similar way interfere with life in 2-space. The important point to observe is that in either case the inhabitant of the lower space would not understand what had caused the change.

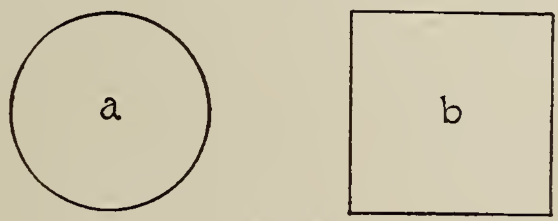

FIG. 8.

A duodim could lock up his treasure in circular or polygonal vaults, such as "*a*" or "*b*," safe from 2-space intruders, but a tridim could help himself to anything he pleased without breaking the sides of the vault. By analogy, a 4-space being could do many things in 3-space impossible to man and entirely inexplicable to him. No 3-space safe or vault would be secure from a 4-space burglar. He could get a ball out of a hollow shell without breaking the surface, he could get out the contents of an egg without cracking the shell and enjoy the kernel of a nut without the use of a nut-cracker.

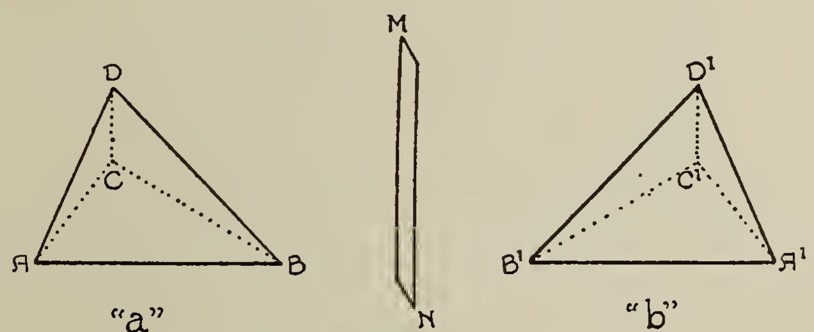

FIG. 9.

A geometrical illustration similar to those already given is found in Fig. 9. Here "*a*" and "*b*" are symmetrical tetrahedrons,[3] in length

[3] A model of "*a*" and "*b*" can be readily constructed as follows: Cut out the figure (Fig. 10) from a piece of cardboard, perforated along the lines *AB, BC, CA,* and having $AF = AE$, $CE = CD$ and $BD = BF$. Fold over the triangle *ABF, ACE, CBD* till the points *F, E* and *D* meet in a point, thus making one tetrahedron: fold the triangles in the opposite direction and the symmetrical tetrahedron will be formed. The one corresponds to the image of the other in a mirror.

$AB = A'B'$, $AC = A'C'$, $BC = B'C'$, $AD = A'D'$, $BD = B'D'$, $CD = C'D'$. It is evidently impossible in 3-space to put "*b*" in the position "*a*," or *vice versa*. It would be possible to make "*b*" coincide with the image of "*a*" in a mirror. In fact it is obvious that "*b*" is the image of "*a*" as seen in a mirror.

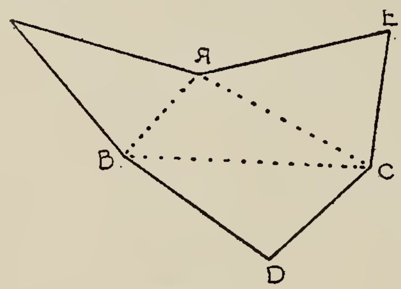

FIG. 10.

Readers of that classic nonsense book by Lewis Carroll (Rev. C. L. Dodgson), "Alice Behind the Looking-Glass," will be interested in the fact that Mr. Dodgson, himself a mathematician of no mean note, is poking fun at the fourth-dimension students.

Now, while it is impossible for a tridim to make "*b*" take the position "*a*," there would be no difficulty in a fourth-dimensional animal interchanging "*a*" and "*b*." In other words, to make "*a*" and "*b*" coincide, one must be taken up into 4-space, turned over and put down on the other.

It is easy now to see that, while there is no proof of the material existence of 4-space or space of any dimension higher than three, and while we can not even say that there is any likelihood that such exists, yet the *conception* of hyperspace is a perfectly real and logical conception; moreover, it is by no means an idle question or a useless idea. Assuming hyperspace, mathematicians have built up a perfectly consistent geometry which throws much light upon problems of 3-space.

We have seen that by many analogies it is a simple matter to *conceive* of hyperspace. Let us next observe how algebra invites us to consider the possible existence of higher space.

The solution of two simultaneous equations in two variables x, y, gives us a point in a plane. The solution of three simultaneous equations in three variables x, y, z, gives us a point in 3-space. The solution of four simultaneous equations in four variables, x, y, z, w, which is easily performed, gives what? Is there a geometrical equivalent here? Can the values of x, y, z, w be represented graphically? The answer to both questions is *No*, at least not in our space. Four-space is necessary if we are to give a geometrical representation to the solution of four simultaneous equations, such as:

$$a_1x + b_1y + c_1z + d_1w = e_1,$$
$$a_2x + b_2y + c_2z + d_2w = e_2,$$
$$a_3x + b_3y + c_3z + d_3w = e_3,$$
$$a_4x + b_4y + c_4z + d_4w = e_4,$$

Again,

$$x = a$$

represent a point in 1-space. [Incidentally it would also denote a line in 2-space and a plane in 3-space.]

The equation

$$ax + by = c$$

represents a line in 2-space, but has no meaning in 1-space.

The equation

$$ax + by + cz = d$$

represents a plane in 3-space, but has no meaning in 2-space or 1-space.

So, by analogy, the equation

$$ax + by + cz + dw = e$$

would have a meaning in 4-space,—say a 3-space section of 4-space—but has no meaning in 3-space.

In general, an algebraic equation of k variables has no meaning in a space of lower dimension than k, but has a meaning in n-space, where $n \gtreqless k$.

Discarding experience and reasoning wholly from analogy, we introduce some properties of the fourth dimension as follows.

Four-dimensional measure depends upon length, breadth, height and a fourth dimension all multiplied together. In the graphical representation of 3-space, points are referred to three mutually perpendicular planes formed by three lines mutually at right angles. In a similar way, to represent 4-space we must assume another axis at right angles to each of the other three. In the present development of human thought, this is purely subjective, a mere mental conception, and it is upon this conception that the theory of hyperspace is built.

The position of a point in a plane may be determined, as we have seen, by its distance from each of two perpendicular right lines; in 3-space, by its distance from each of three mutually perpendicular planes; and in 4-space, by its distance from each of four mutually perpendicular 3-spaces, for there are four arrangements of the four axes taken *three* at a time, and each independent set of three perpendicular axes define a 3-space, for example, wxy, wxz, wyz, xyz. Just as in our space it requires at least three points to determine a plane (2-space), so in 4-space four points are necessary to determine a 3-space.

As portions of our space are bounded by surfaces, plane or curved, so portions of 4-space are bounded by hyperspace (three-dimensional).

In our space, a point moving in an unchanging direction generates a straight line.

This straight line (say of a units in length), moving perpendicular to its initial position through the distance a, generates a square.

This square, moving perpendicular to its initial position through the distance a, generates a cube.

This cube, we will suppose, moving perpendicular to our space for a distance equal to one of its sides (that is, equal to a), will generate a hypercube.

Now the line contains a units, the square a^2 units, the cube a^3 units, the hypercube a^4 units.

Again, to repeat in words slightly different from the foregoing (Fig. 11) considering the a units as a points (an indefinite number), the square *ABCD* is derived from the line *AB*, which for convenience suppose to be one foot in length, by letting *AB* with its a points move through a distance of one foot in a direction perpendicular to itself, that is, perpendicular to the one dimension of *AB*, every point of *AB* describes a line, and *ABCD* contains therefore a lines and a^2 points.

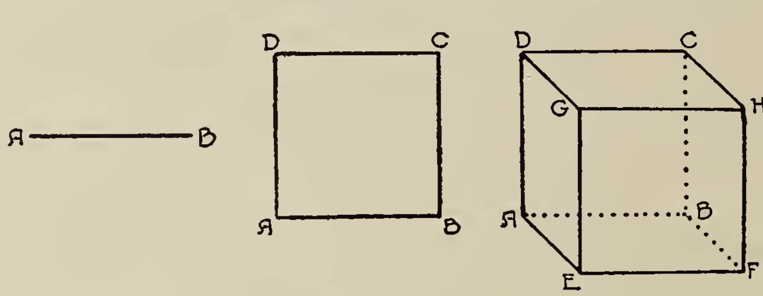

FIG. 11.

The cube *ABCD–G* is derived from the square *ABCD* which moves one foot in a direction perpendicular to its two dimensions, its a lines and a^2 points describing a squares and a^2 lines respectively. The cube *ABCD–G* therefore contains a squares, a^2 lines and a^3 points.

Similarly, the four-dimensional unit is derived from the cube, *ABCD–G*, by letting that cube move one foot in a direction perpendicular to each of its three dimensions, that is, in the direction of the fourth dimension; its a squares, a^2 lines, and a^3 points describing respectively a cubes, a^2 squares, a^3 lines. The hypercube, therefore, contains a cubes, a^2 squares, a^3 lines and a^4 points.

Boundaries

Now, as to the boundaries of the units, *AB* has two bounding points, *ABCD* has four, two each from the initial and the final position of the moving line, *ABCD–G* has eight,—four each from the initial and the final position of the moving square,—and the hypercube[4] has sixteen,—eight each from the initial and the final position of the moving cube.

Bounding Lines.—Of bounding *lines*, *AB* has one (or is itself one), *ABCD* has 4, one each from the initial and the final position of the moving line and 2 generated by the 2 bounding points of that line; *ABCD–G* has 12,—4 each from the initial and the final position of the moving square and 4 generated by the 4 bounding points of that square; and the hypercube has 32,—12 each from the initial and the final position of the moving cube and 8 generated by the 8 bounding points of that cube.

Bounding Squares.—Of bounding *squares*, *ABCD* has one (itself); *ABCD–G* has 6,—one each from the initial and the final position of

[4] This four-dimension unit is often called the "tesseract."

ABCD, and 4 described by the bounding lines of the moving square; and the hypercube has 24,—6 each from the initial and the final position of the moving cube, and 12 described by the bounding lines of the moving cube.

Bounding Cubes.—Finally, of bounding *cubes, ABCD–G* has one (itself); and the hypercube has 8,—one each from the initial and the final position of the moving cube, and 6 described by the bounding squares of the moving cube.

The results obtained for the boundaries may be conveniently exhibited by the following table:

BOUNDARIES

	Points	Lines	Squares	Cubes
One-dimensional unit..........	2	1	0	0
Two-dimensional unit..........	4	4	1	0
Three-dimensional unit........	8	12	6	1
Four-dimensional unit.........	16	32	24	8

Freedom of movement is greater in hyperspace than in our space. The degrees of freedom of a rigid body in our space are 6, namely, 3 translations along and 3 rotations about 3 axes, while the fixing of 3 of its points, not in a straight line, prevents all movement. In hyperspace, however, with 3 of its points fixed, it could still rotate about the plane of those 3 points. A rigid body has 10 possible different movements in hyperspace, namely, 4 translations along 4 axes, and 6 rotations about 6 planes, while at least 4 of its points must be fixed to prevent all movement.

In hyperspace, a sphere of flexible material could without stretching or tearing be turned inside out. Two links of a chain could be separated without breaking them. Our knots would be useless. In hyperspace, as we have seen, it would be entirely possible to pass in and out of a sphere

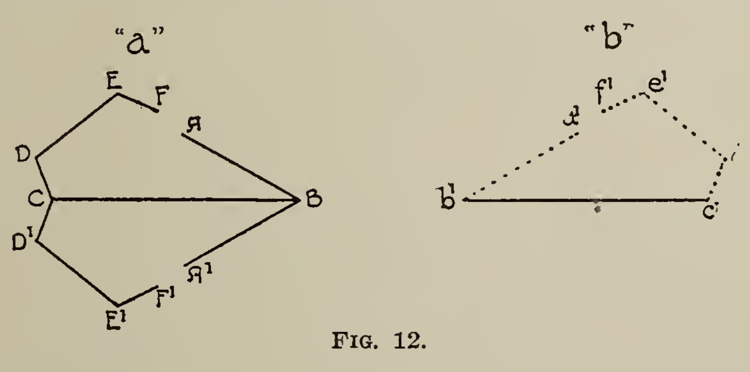

FIG. 12.

(or other enclosed space). A right glove turned over through space of four dimensions becomes a left glove, but notice that when the glove is *turned over,* it is *not turned inside out.*[5] This may be made clear by analogy. Suppose we have in a plane (Fig. 12) a nearly closed polygon

[5] A right glove turned inside out in *our* space becomes a left glove.

ABCDEF. This can be turned into its symmetrical form *A′ BCD′ E′ F′*, the lower half of (*a*), by opening it out straight and bending it over the other way so that it is turned inside out. This process takes place entirely in the plane and can be performed by a two-dimensional being. The polygon may also be changed into its symmetrical form (*b*), Fig. 12, by being turned over, in 3-space, but in this process it is not turned inside out at all. On the other hand, if it is sufficiently flexible, it may be turned inside out by twisting each part upon itself through 180 degrees, and in this process it is not changed into its symmetrical form.

When mathematicians began to talk of higher space, the spiritualists seized upon the idea as affording a habitation for their spirits. These men, naturally wanting a home for their spirits, were rather too eager to believe in the actual existence of the fourth dimension. It is astonishing with what avidity the advocates of spirit rappings and occult demonstrations appropriated the fourth dimension for the abiding place of their unearthly beings. This was, of course, unwarranted as are perhaps most of the claims of such people. While somewhat interesting, it is too trivial to claim our serious attention.

In conclusion, we have no material evidence of a fourth dimension. Our knowledge of the phenomena of 3-space is empirical. Our experience tells us nothing of 4-space, if it exists. But the *conception,* not being dependent upon experience or experiment, is not unreasonable. As a working hypothesis it is not without decided value, as it throws light upon many propositions of our (3-space) geometry.

The existence of 4-space might explain certain phenomena in physics and chemistry; for instance, rotation in hyperspace would explain the changes of a body producing a right-handed polarization of light into one giving a left-handed.

A few months ago an article appeared in the *Scientific American* by E. L. DuPuy setting forth the use of four dimensions in representing certain chemical compounds graphically. He took as an example a "special steel" consisting of iron, carbon, silicon-manganese and nickel-vanadium.

In this short sketch of what is meant by the fourth dimension, it must be borne in mind that the mathematical investigation of the geometry of the fourth dimension has been omitted altogether. It is hardly necessary to add that all arguments for the existence of a fourth dimension apply equally well for the existence of 5, 6, or *n* dimensional space. The geometry of *n*-space, where *n* is any number, is just as logical as that of 4-space.

[In this paper the author claims no originality, except to some extent in the mode of presentation and in the manner of introducing the illustrations; but he has not knowingly made use of any ideas that have not now become public property. The following are some of the works that he has consulted: "Non-Euclidean Geometry," by Henry P. Manning; "The Elements of Non-Euclidean Geometry," by L. L. Coolidge; "The Fourth Dimension Simply Explained—a collection of Popular Essays with an Introduction and Editorial Notes by the Editor," Henry P. Manning, editor (published by the *Scientific American*); "The Fourth Dimension," by C. H. Hinton; "The Fourth Dimension," in "Mathematical Essays and Recreations," by Hermann Schubert, translated by T. J. McCormack.]

SOME PSYCHOLOGICAL PROBLEMS EMPHASIZED BY PRAGMATISM

By Professor JOSIAH ROYCE

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IT is not my purpose upon this occasion to enter into the philosophical aspect of the discussion regarding pragmatism, excepting in so far as may be necessary to call attention to the psychological problems that I now have in mind. I presuppose, of course, a familiarity on the part of all of you with the main outlines of the recent discussions concerning the problem of truth. But I shall not try with any exactness to define what the term pragmatism means. I recognize that the word as now used refers to a considerable variety of opinions, and that the comparison of a "holding company," which Professor Dewey has, I believe, on one occasion employed, is not altogether inapt. It is enough for our present purpose that by the name pragmatism we all of us mean a certain set of tendencies in recent discussion which lay stress upon the importance of defining the truth of propositions or judgments or ideas in terms of those empirical facts and relations of facts which are said to constitute the "workings" of the propositions, or judgments, or ideas which are in question. The favorite summary of pragmatism, to the effect that from the point of view of pragmatism a proposition, or judgment, or idea is true "if it works," is sufficient to serve as a general indication of the tendencies of opinion which are here in question.

What pragmatism asserts about truth may be considered from the point of view of a general theory of knowledge, or of a metaphysic. But pragmatism itself especially emphasizes its relation to psychology, on the one hand, and to the recognized methods of empirical science, on the other. As Mr. Schiller said to me during the Philosophical Congress of 1908 at Heidelberg, "What is most essential to pragmatism is that it insists that the relations and values of the thinking process must be estimated in psychological terms. Success tests truth, and success is itself a matter of experience that can best be understood when it is defined psychologically." Another way of stating the essence of pragmatism is to insist, as Professor Dewey has so often done, upon the fact that the method which pragmatism proposes to apply to all problems is the method already used by the various sciences of experience. They employ "working hypotheses." They test these working hypotheses by comparison with experience. Pragmatism consists in the assertion that all propositions should be tested as the hypotheses of science are tested.

These two points of view are, of course, very closely connected. Students of the physical sciences often take little account of the psychology of their own processes. But the processes of science obviously have their psychology, and this psychology conforms in its types to those laws of mental activity which have interested psychologists ever since the apperceptive process was formulated by Herbart,—yes, ever since the doctrine of association was so widely applied by the English psychologists, and still more since the modern so-called "functional" psychology has connected the apperceptive processes and the associative linkages with the physical processes whereby an organism is adjusted to its environment. The psychology of the apperceptive process, and the work of the scientific finding and testing of hypotheses, have a close relation, and since common sense also is interested in successful verifications, although this interest is less precise than is the interest of the student of the more exact sciences of observation in the criteria to which they submit their more careful tests,—common sense and science and psychology join in contributing their various shares to the modern general theory of truth.

But now to come to the matter to which I wish especially to attract your attention. Since pragmatism is thus especially interested in the psychology of the thinking process, it has emphasized this psychological problem in recent literature. A general psychology of thought, on a pragmatic basis, has been worked out by Professor Pillsbury. The psychological text-books of the Chicago school, and in particular the contributions of Professor Dewey, have familiarized us with other accounts of the psychology of thought. The psychological problems to which attention is thus especially attracted may be, of course, studied apart from their relations to the theory of truth. These problems are threefold. (1) There are the problems regarding the processes whereby hypotheses are invented, or, in common-sense terms, the processes whereby people get their ideas; (2) there are problems regarding the processes whereby ideas, once in hand, are made sufficiently clear to be a proper subject for testing; and (3) a psychological problem arises as to what happens when an idea is tested. To all these problems the pragmatists as psychologists have contributed. I wish to illustrate in the course of my discussion a certain dissatisfaction which I feel with the present state of some of their contributions to these purely psychological issues, when viewed apart from the other issues of the pragmatist philosophy.

Yet I admit that when you hear me you will say that my psychological dissatisfactions are due to certain philosophical dissatisfactions, and that the pragmatist psychology appears to me inadequate partly because I do not wholly accept the pragmatist theory of truth. I recognize the connection in my own mind between the two dissatisfactions. I do not wish to pretend that I can wholly dissociate my interest in psychology from my interest in the other aspects of the pragmatist controversy and in the very nature of pragmatism itself. My pragmatist friends least of all would desire me to do this. And so I shall aid you in following my further inquiries if I first briefly state one ground of my dissatisfaction as a student of logic and of general philosophy, with the pragamtist's theory of truth. This statement I make not as if it were here important for the psychological purpose of this discussion, but because by confessing my own state of mind I may help you to fix your attention upon matters that will more directly interest you. For my dissatisfaction as a student of logic, with the pragmatist theory regarding truth, will call attention to the way in which I should approach precisely those psychological problems which pragmatism has most emphasized.

I

When pragmatism asserts that the truth of a proposition is tested by the "workings" of the ideas that the proposition expresses, a student of logic very naturally raises the question as to *what* workings are meant. A man who hears a proposition and who more or less completely understands its meaning, and who hereupon more or less believes the proposition, has certain mental attitudes aroused in him, and these mental attitudes have their physical expression. They tend to lead to action. The action may well be accompained by expectations of various sorts, and the expectations may remain throughout more or less identical with those that the utterance of the proposition first arouses in the mind of the inquirer. Thus ideas may lead to actions. These actions may gratify or in a measure satisfy expectations. In this case the ideas which the proposition expressed are said to "work." But now consider the contrast between what this decidedly general statement expresses and what a student of any more exact empirical science is likely to have in mind when he thinks of testing the truth of a definite assertion. One familiar process of testing the truth of hypotheses in scientific regions is to trace the consequences that must be true if those hypotheses are true, and then to see whether these consequences can be found verified by particular experiences. An essential part of this process is the deduction of certain consequences from one's hypothesis. How extensive this deductive process may be, a glance at any textbook of theoretical physics, in particular of theoretical astronomy of the classic type, will show.

Now what happens when one deduces the consequences of an hypothesis? Does one simply let one's ideas work? Are the consequences of hypotheses simply ideas that are as a fact aroused in the mind of a man who begins with the hypothesis itself in mind? Certainly the usual taste and purpose of the student of any more exact science is *not* sufficiently expressed by saying that he looks merely for such "workings" as may happen to be suggested to his mind. *He is looking for what must be true if the hypothesis is true.* He is making use of those mental processes whose nature is sometimes discussed in text-books of deductive logic. But when we are dealing merely with the world of common sense, ideas that have been suggested or propositions that have been uttered, frequently arouse in our minds expectations which are not directly called for by the logical meaning of the propositions, but which through various processes of association or various reminders of past experience are more or less casually aroused. Such resulting expectations may be said in a given mind to follow from the utterance of the proposition that arouses them. But they are not logical consequences of the proposition in the sense which the student of the more exact sciences has in mind.

Again, when the student of an exact science has made his deductions and proceeds to verify them, he may find his hypothesis confirmed or refuted by the results of experience. In this case his hypothesis may be said to "work," but what sort of working is in question in the more exact sciences? I answer, in any more exact science the confirmations or refutations which experience is able to furnish to the hypothesis whose logical consequences are to be tested, are required to be so exact that we can define them in definite *affirmations* and *denials.* The very essence of precise confirmation or refutation is that if it is as successful as the requirements of an exact science demand, we are able to say as the result of our process of confirmation, "So and so, thus and thus defined, happens or does not happen, is found or is not found." Or again, we sometimes say of the failing hypothesis, "It is *contradicted* by the facts." Somewhat different however is the situation in the world of common sense, where one's expectation may often be met or disappointed with very various degrees of definiteness. In the world of common sense a man may say, "This more or less meets my expectations." In the world of an exact science the investigator is interested in seeing within what precise limits a definite experienced measurement agrees with the prediction. *Precision,* in other words, characterizes the confirmations or refutations which experience furnishes in the more advanced sciences. And the concept of precision has characters which are studied in text-books of logic, although, as I admit, in most text-books of logic the concept of precision is very inadequately studied.

In consequence of all this the student of logic is likely to object to the ordinary formulation of pragmatism, (1) that pragmatism seems not to be interested in the distinction between merely arousing an expectation, and deducing a consequence; (2) that it takes comparatively little account of the distinction between feeling more or less personal satisfaction in partial agreements between experience and our expectations, and precisely confirming or refuting a determinate hypothesis, in so far as that can be done by a certain group of experiences.

And finally the student of logic finds a certain difficulty in the usual statements of pragmatism regarding the sense in which empirical verifications are said to lead to a certain "belief" that the ideas which we have been trying to verify are true. In ordinary life beliefs exist in all sorts of vague degrees of intensity. But when the student of a science formulates his results, considerable stress is laid upon the assertion that, by virtue of a given group of confirmations, a hypothesis has received a somewhat determinate degree of what is called *objective probability.* Now into the theory of probability this is no place to go. But most of you who have dealt with statistical probabilities will admit that our subjective confidence is somewhat different in its nature from that objective or statistically estimated probability which most students of an inductive science prefer to be able to define if they can. The whole modern development of the theory of probability has been in the direction of separating the concept of objective probability from the concept of subjective belief or confidence. From the objective point of view a proposition has a certain probability P in case it belongs to the class of propositions of which in the long run a proportion P are true. The difficulty of defining such probability with genuine exactness is great, and the whole subject of probability is too complex to be here discussed, but the student of logic feels dissatisfied with the fact that his pragmatist brethren take little interest in defining the difference between the vague confidence which in the world of common sense confirmed expectations may arouse, and the scientific measure of probability in exact and relatively objective terms which the students of an inductive science are commonly seeking.

II

So much for my general statement of logical scruples concerning the adequacy of pragmatistic formulations. Into the merits of these logical scruples I have no wish to go on this occasion. I have stated them merely in order to formulate the problems of a psychological nature to which I wish to attract attention. Pragmatism has emphasized these problems, has undertaken to solve them, has contributed a great deal to their study, but in my opinion has failed to satisfy all the requirements that it might satisfy, just because it is not sufficiently interested in the very logical problems that I have just outlined. These logical problems, however, have their psychological aspects. If one does not deal with them in an exact fashion from the logical point of view, one is not likely to have one's attention attracted to their psychological complexity. On the other hand, if I can do anything to awaken your interest in the psychological character of these problems, perhaps I may indirectly help to awaken interest in their logical aspect.

Let me repeat the list of the problems to which I have called attention, emphasizing the sense in which each one of them is a psychological problem. I mention the fact that a science which is testing hypotheses *deduces the logical consequences of these hypotheses.* The process may be an extended one. *What is the psychology of deduction?* What happens when a process of deduction takes place? In some respects this problem has indeed been repeatedly dealt with from the psychological point of view. I do not wish in the least to deny that the analyses of Professor Pillsbury and others have contributed to this problem, but just because these psychologists have been so little interested in the logic of the deductive process they have failed, in my opinion, to emphasize some of its most important psychological aspects. Yet their own discussions emphasize the need of such a psychology. Here lies the first of the problems to which I now call attention.

Secondly, the pragmatists in speaking of the working hypothesis have emphasized, as Professor Moore has recently done, the fact that the agreement of an assertion or idea with its expected workings constitutes the test of its truth so far as up to a certain point in our investigations we may happen to have gone. I have called attention to the difference between an expectation and an assertion or a denial. One goes to the play expecting amusement. At the end of the play, have his expectations been met or not? The question may be unanswerable in any definite way. The play was amusing, and yet perhaps not so very amusing, or not so amusing as one could have wished it to be. One goes away partially disappointed, partially pleased. One is not so disappointed but that one continues to go to plays over and over again. One is not so pleased that he expresses himself very enthusiastically. What ideas with regard to the amusing character of plays have been precisely tested, so long as one remains in this state of mind? On the other hand, through a deductive process the occurrence of an eclipse is precisely predicted. The eclipse is observed, its beginning is noted with an accuracy as great as the errors of observation permit. A precise assertion is made as to the agreement between the prediction and the observation. When the assertion has received its proper qualifications with regard to probable error and the rest, the assertion appears in the records as true or false. In this case an issue is met and something is tested, yes or no. I now ask, what is the psychology of assertion and denial, of the difference between yes and no? In what way does this difference, namely that between yes and no, differ from any other kind of difference? This problem I mention, without hoping in this paper to do more than mention it. I called attention to this psychological problem some years since in an address that I was permitted to give before the Psychological Association. I venture to emphasize this problem afresh and to declare that it is a problem which the whole pragmatist controversy has itself especially emphasized and has not yet adequately solved.

Again I have called attention to the difference between vaguely estimated confidence and objective probability. Here is a problem that once more presents psychological aspects. I shall have no time to discuss them upon this occasion. The psychology of probability is, however, to my mind one full of very interesting problems.

III

I have thus enumerated three of the psychological problems which to my mind are emphasized by the course of the pragmatistic discussion. That these problems come to my mind with a special force because of my logical interest, you see. It is now my purpose to appeal to you as psychologists or as students interested in the subject, to follow for a few moments some further characterization especially of the first of these psychological problems. I am dissatisfied in the recent discussions of the psychology of reasoning with what seems to be a failure to understand what takes place in exact deductive procedure. The current prejudices as well as the hoary traditions on this subject seem to conspire to call the attention of students away from the center of the problem. Without attempting to give any adequate summary of Professor Pillsbury's account of the reasoning process in his recent "Psychology of Reasoning," I may attempt by a few references to indicate how inadequate some current views are to take account of what the deductive process actually is. In Professor Pillsbury's "Psychology of Reasoning," he distinguishes pretty sharply between the two processes of *inference* and *proof*. By inference, if I understand him, he means the process whereby a conclusion is suggested in such wise as to arouse more or less belief. By proof he means a process whereby this belief is more or less adequately tested. Now logicians are accustomed to use the word inference in a somewhat different way from that which Professor Pillsbury emphasizes. And what this way is I shall try to point out in a moment. But laying inference aside for the moment, and passing to the other side of the reasoning process as Professor Pillsbury defines it, namely to the process of proof, the only form of deductive proof which Professor Pillsbury seems to emphasize is the one that has received its traditional description in the doctrine of the syllogism. The essence of the traditional syllogism is, according to Professor Pillsbury, that the general major premise is supposed to aid us in testing our belief in the conclusion, by virtue of the fact that in the minor premise something has been brought under this major premise as a particular case of the principle. Professor Pillsbury consequently points out how comparatively insignificant both from the logical and from the psychological point of view the syllogism is as an expression of the nature of the concrete process of reasoning. To bring cases under major premises is to do little to confirm our belief except in so far as one thus emphasizes in a somewhat formal way the tendency of every new or questionable fact to find its place by being brought into conformity with the habits, or better with the principles of action, which have been formulated on the basis of previous experience. Deductive proof appears therefore to be, as Professor Pillsbury says, not so different from induction as is usually supposed, and to be in any case of comparatively minor importance. The business of proof, according to Professor Pillsbury, is to produce belief. Belief in general is not produced by formulating major premises. It is produced by a more complex process whose general nature he sets forth.

Other familiar discussions of the reasoning process, such as one finds in the text-books of recent pragmatists, agree with Professor Pillsbury in assuming that it is of the essence of deduction or of deductive proof to proceed from the general to the particular, and that the significance of deductive proof lies in the fact that one hereby formulates, often somewhat uselessly, the general process by which an adjustment to the environment in cases of initial doubt or difficulty is attained. Apart from these statements more characteristic of pragmatists, a wide-spread tradition, which unfortunately is supported by the older logical text-books themselves, maintains that it is of the essence of deductive reasoning to bring nothing out of the premises except what was already in them, so that the essence of the deduction is "analysis." From this point of view it is supposed that when you engage in deduction you solemnly draw out of the bag the cat which you have already hidden in it. You declare, for instance, that all the *A*'s that are *B* are indeed *B*, and solemnly demonstrate that all the white mice must be both white and mice. It is unquestionable that many of the logicians of the past as well as the psychologists of recent times have conspired to give this impression of the deductive process. But whatever the psychology of deduction may be, any fair examination of the work of the exact deductive operations of science, and especially any examination of the work of mathematics, shows that deduction as it exists in real life is simply not this fiction of the older logical text-books. And yet to the psychological analysis of this fiction, with the natural result that such a process is not of very great importance, Professor Pillsbury, as I understand him, devotes himself in his discussion of the place of the syllogism in life.

But anybody who undertakes to deal with the psychology of reasoning ought, I think, to take account of the fact that there is nowadays a new logic, that this new logic is in considerable part the work of men whose attention has been attracted to the nature of the deductive process by a wide experience of mathematical procedure, and that this new logic shows us with regard to the syllogism, for instance, two things, first that the essence of the syllogism does not consist in the fact that a particular case is brought under a general principle; and secondly, that the syllogism is by no means the only form of deductive reasoning. From the point of view of the new logic, the student has upon his hands the problem that Poincaré has so well stated at the outset of his book, "Science and Hypothesis." This is the problem presented by the enormous *Fecundity of the Deductive Process.* Our own American logician, Charles Peirce, long since called attention to this fecundity. It is a fact of much philosophical importance. What I mean by the fecundity of deduction as a logical fact can be suggested by what Poincaré mentioned, and also by a summary of the matters to which Peirce has frequently called attention. Poincaré states the case thus: From the point of view of the older interpretation of the nature of the syllogism it would seem impossible that a deductive science such as mathematics could do anything but draw out of premises what it had already more or less overtly or secretly put into them. Nothing novel could result. And in fact if the reasoning of mathematics were all of the kind that Professor Pillsbury supposes to be the typical deductive reasoning, mathematical science would consist in a process as stupid and monotonous as the process of taking the major premise, All men are mortal, and then looking up all the names in a directory and solemnly concluding to write opposite to each name the fact that since this person is a man he is mortal. But now as a fact mathematical science consists of nothing of the kind. The situation is actually this: you can write upon a few sheets of paper an accurate statement of a set of principles from which the whole science of the quantities of ordinary algebra can be deduced. That is to say, the principles of the ordinary mathematical analysis are capable of such a brief statement as this. But the consequences of these principles are such that novel results in vast numbers are annually discovered. These results are not stowed away in the premises in any such way as that in which the mortality of this man is stowed away in the assertion of the mortality of all men.

Poincaré, in the passage to which I have referred, suggests his own theory to account for the fecundity of mathematical analysis. His theory may as a logical theory be questioned. But the fecundity to which he attracts attention ought to be a commonplace to any one who has looked into any branch of mathematics with care. Peirce has called attention to this fact, and speaking as a logician has gone further. Following a lead of De Morgan's, Peirce has shown that any proposition whatever which has a definite meaning permits you to draw from it an infinite number of deductive inferences, all of which are possible without formulating any other basis for the deductions in question than the assertion of the original proposition and the synthetic power which one indeed has in his hands who is capable of understanding certain simple processes of the construction of relations. Let me mention the instance, famous in modern logic, which De Morgan first formulated; and which as it stands may appear trivial enough. If a horse is an animal, you can deduce from that hypothesis the conclusion that the owner of a horse is the owner of an animal, that the friend of the owner of a horse is the friend of the owner of an animal, and so on. Such deductions in an individual case such as that of the assertion about a horse may seem and are trivial enough. *But they have the character of novelty:* That is, the conclusion does not follow from the premises by the process of first stuffing a vast number of cases into a bag and then pulling them out one by one. But the process of deduction thus illustrated can be used and is used as an instrument of enormous power in those branches of mathematics in which one builds one system of relations upon another system. The number of ways whereby such deductive processes can be accomplished is presumably very great. And it is because such processes are possible that mathematical reasoning possesses its great fecundity.

And now since such fecundity, such proof of novelties, is the essence of the live process of deduction as it exists in the deductive sciences, why should not psychologists study that live process instead of studying the dead body which some text-books have called the syllogism? And if they must study the syllogism as the supposed typical example of deductive reasoning, why should they confine their attention to considering the most traditional and trivial aspect of it?

As modern logic has shown, the really essential feature of the syllogism lies in the fact that what the logicians call the Illative Relation (that is, the relation which is in mind when you consider one proposition as true in case another is true) is a relation which has the property of so-called *transitivity*. That is, the essence of the syllogism may be stated by saying that from the pair of propositions "*A* implies *B*," and "*B* implies *C*" taken together you can deduce the conclusion "*A* implies *C*." In other words, it is of the nature of the illative relation that it permits the use of what James called the principle or axiom of skipped intermediaries. I can not pause to show why this account of the essence of the syllogism is logically correct. But the mere mention of this fact shows that those who analyze the process of deduction, supposing it to be represented by the traditional syllogism, and interpreting the traditional syllogism in the way in which Professor Pillsbury interprets it, simply miss the most interesting feature of syllogistic reasoning.

Nor is the aspect of the syllogistic reasoning which this emphasizes, the only one to which modern logic calls attention. Mrs. Ladd-Franklin long ago pointed out that the entire theory of the syllogism could be stated as a sort of comment upon the fact that a triad of propositions which she called "a triadic inconsistency" has, when considered as a triad, a certain set of logical properties. These logical properties, belonging to such a triad of propositions, can be observed by a process which is of the nature widely illustrated throughout the whole realm of mathematics; but this is certainly *not* the synthesis that Professor Pillsbury has in mind when he analyzes what he supposes to be a typical process of deductive reasoning.

Still more unfortunate for the study of the psychology of the reasoning process is that misunderstanding of the nature of deduction which supposes that the principal use of a deduction is to bring to pass a belief in a certain conclusion by virtue of an appeal to a belief in certain premises. This assumption, common in the recent literature of pragmatism, is false to the most essential use of deduction in the exact sciences. Mr. Russell has well emphasized the fact that, in mathematical science, just in so far as it is pure mathematics, you are not concerned with producing belief in the conclusions themselves. Your interest in pure mathematics, that is to say in that science which deals with deduction proper, lies simply in showing that *certain premises do imply certain conclusions*. That is, you show that "p implies q," where p and q are propositions. The importance of mathematics for the empirical sciences is due to the fact that it gives you a means for testing the hypotheses by first finding out what are their logical consequences. Now it is essential for the fair and unprejudiced testing of an hypothesis, that you should *not* be too much disposed to believe in it before you test it. It is very important, when you do not believe an hypothesis, or when your mind is still perfectly open upon the subject, *to find out with exactness what would be true if the hypothesis were true*. Your purpose in deduction is therefore not to establish belief in certain consequences by virtue of a previous belief in the hypothesis upon which they depend. Your great interest is to produce *no belief whatever either in the hypothesis or in the conclusions from the hypothesis, until the logical issues are precisely defined* for empirical confirmation; and then you are *ready* to appeal to the confirming or refuting experience. It is a strange misunderstanding of the nature of the deductive process to suppose that its principal interest is an interest in producing belief in consequences. The sole logical interest of the deductive inquirer lies in his discovery that certain premises imply certain conclusions.

To sum up, then, this sketch: I assert that in the recent psychology of reasoning, *the nature of the deductive process and its principal purpose have been equally misunderstood.* Deduction in its more developed forms simply does *not* consist in an analysis of the premises. Nor is it intended to make you believe the conclusion. The true interest of deduction lies in the fact (1) that it is a process possessing an inexhaustible fecundity, and (2) that this fruitfulness results in giving you a knowledge that certain premises imply certain conclusions.

IV

But now let me briefly put before you some genuine deductive processes, and point out what problems with regard to their psychology can be aroused. Let me begin with the instance with which I have often wearied my friends, so that some of you who are here present will have heard me mention it. Raise the question whether a strip of paper can exist which shall have only one side. One would be disposed to settle the question empirically by observing that every strip of paper in one's ordinary experience obviously has two sides. If one passes from a consideration of strips of paper that have two ends, to the consideration of endless strips of paper, that is strips of paper made in ring shape, one sees that in an ordinary ring the two-sidedness of strips of paper still holds good. But if one takes an ordinary strip of paper, say two inches wide and eight or ten inches long, first twists one end of it 180 degrees, and then brings the two ends together, one has the resulting geometrical form of the one-sided ring. The first discovery that such a ring is possible was of course an empirical discovery. But the geometers (I believe it was Möbius who first noticed one-sided surfaces) had their attention at once attracted to the mathematically interesting properties of this form. Now when such a form is viewed as a mathematical object, any one with mathematical interest naturally proceeds to an undertaking of the sort which is characteristic of mathematical science in general. One endeavors to deduce some of these properties from others, or to discover, as the ordinary mind would say, why these properties belong to any one-sided surface. Hereupon let me mention a problem that can be studied as soon as you have once taken note of the one-sided surface and have begun to make a study of the real sense or connection of its structure. Suppose a one-sided surface, a ring strip of the sort that I have described, to be cut down the middle, midway between what appear to be the two edges of the strip, and suppose the cut continued until it returns into itself, what will be the result? There are two ways of answering the question. One is the directly empirical one of making the cut. The other method is to endeavor to see before making the strip what must be the result in view of the one-sidedness of the strip. I once proposed the question to a class, and found a member of the class, who although not a student of mathematics, possessed a relatively clear visual imagination, was ingenious, became interested in the problem, solved it without cutting the strip, then tested his solution by an actual cut, and then brought me written out the process of reasoning whereby he had solved the problem.

The process of reasoning in question, or any process of reasoning by which the problem could be solved in advance of actually cutting the strip, is in part a genuine instance of deductive reasoning. Just because of the intimate mingling of empirical data and of exactly definable relationships, the case in question forms an admirable instance of the study of the genuine psychology of the deductive process; but I confess that no psychologist would make much of the study who was not fairly well acquainted with deductive processes of a certain complexity,—processes which in their more exact forms you will find anywhere in pure mathematics, where a symbolic language with an exact definition is used, as the only means of presenting data to the imagination.

Let me mention another instance of a deductive process of some complexity, but of great ingenuity and of interesting psychological relationships. We know that about 500 B. C. a member of the Pythagorean school discovered that granting the ordinary principles of metrical geometry as they were then and ever since have been used, the diagonal of a square could not be commensurate with the side of the square. The strictly deductive portion of this proof can be with fair ease distinguished from that portion of the proof in question which is indeed empirical and not deductive. That figures resembling squares exist is a matter of experience. That if you make a square exactly enough and large enough, and measure carefully enough you will discover that by no rule you seem to be certain of stating the ratio of diagonal to side exactly in terms of whole numbers: this again is so far empirical. And the ordinary so-called axioms of metrical geometry, considered as principles about the constitution of the physical world, are of course generalizations from physical experience. On the other hand, the purely mathematical portion of geometry, that is, the purely deductive portion, consists in the discovery, not that the geometrical axioms are self-evident or otherwise certain, and not that the physical world has any properties whatever, but that certain assumed geometrical principles which can be stated wholly in symbols, actually imply certain geometrical conclusions. Now the early Greek geometer who discovered that the diagonal and the side of the square are from the point of view of geometrical theory incommensurable, was no doubt guided by the empirical difficulty of discovering any rule whereby a common measure for the diagonal and the side could be stated. Furthermore, he was not clear in his own mind as to the precise distinction between the deductive and the inductive part of his geometrical science. But he was possessed of the power to draw an exact deductive conclusion. And what he found out was that if certain principles of measurement and certain purely mathematical properties of whole numbers be admitted, the diagonal and side of the square are incommensurable. That is, he discovered that certain premises imply certain conclusions.

The process by which he discovered this we happen, though somewhat indirectly, to know. The instance is a remarkable one of the fecundity of the deductive process. The conclusion when the Greek reached it was a novelty. It seemed to him so novel and uncanny a conclusion that the Pythagorean school is said by a later tradition to have long regarded the whole matter as a mystery which must not be mentioned to the vulgar. It was reported that the man who revealed this mystery came to a bad end and received special penalties in the underworld, so closely in those days was exact science linked with *tabu* and with superstition. Yet no one who once goes through the little process of reasoning by which the ancient geometer established his result can remain without interest in the psychology of such a process.

V

You see throughout how my account of the whole matter is of course colored by my logical interests, and yet I freely admit that the psychological problems at issue ought to be considered without any undue reference to anybody's philosophical prejudices or concerns. I admit my own bias in the matter, merely because I am thereby enabled to call attention to what the live process of deduction is, and to point out that the recent psychology of reasoning has profoundly neglected to take account of some of the most elementary facts with regard to the nature of this process.

Charles Peirce long ago called attention to the general nature of the psychological processes which are in question in deduction. They are processes of the nature of ideal experiments. The instance of the one-sided strip of paper readily shows how many intermediate steps there may be between such ideal experiments and physical experiments with a strip of paper. On the other hand, as soon as you begin to reason, and to predict what will be true about a given strip of paper if certain hypotheses are met, with regard to its structure, you get an insight into the whole situation which you can not possibly get by cutting the strip of paper without adding the deductive process. And in general, wherever deduction is worth while, the testing of hypotheses after deductions have carefully been made whereby we predict determinate results of such hypotheses, has a wholly different value and interest from that which results from the testing of hypotheses without previous deduction.

The psychology of deduction may then well be characterized as the psychology of the *Gedanken-experiment*. The peculiarity of the experimental processes in question is that whether we use symbols, or diagrams, or mental images, our reasoning depends upon the fact that the objects in question are wholly under our control, so that in dealing with them we have no "course of experience," to use Charles Peirce's phrase, that is, no series of experiences which we have passively to await to see what they are, but are guided wholly by our own control, and are dealing wholly with objects which are what we make them. A given set of premises we construct in terms of symbols, diagrams, or figures, hereby expressing the meaning of these premises. Our deduction consists of the reading of this meaning from a new point of view. The fecundity of the process depends upon our power to combine at pleasure various constructions in various permitted orders and syntheses. The precise relation between such arbitrary objects, and the objects of ordinary experience, forms a topic of almost inexhaustible interest to the student both of logic and of the mental processes concerned.

I have thus indicated that the problems of the psychology of deduction have thus far hardly been attacked, mainly because psychologists have usually been so little interested in live deduction as it exists in mathematical science. So long as the myth still exists in text-books, that deduction is adequately to be represented by the form of the syllogism and the interpretation of that form which Professor Pillsbury cites and uses; so long as it is imagined that deduction merely lets out of the bag the cat that has already been put in it, our logic will languish and our psychology of reasoning will fail to fulfil the purposes of pragmatism or of any other doctrine of the reasoning process. So long as it is supposed that the main purpose of deduction is to produce belief in the conclusions, the psychology of certain of the most important human thinking processes must be lost. As a fact all tolerance, all considerateness in advance of action, all deliberate working out of ideal consequences of modes of behavior concerning which we deliberate,—all such processes would be impossible. A great deal of toleration depends upon seeing how my opponent's conclusions are related to his premises, although I may have no belief either in his premises or in his conclusions. The process of deduction, in case of a practical deliberation concerning what it is best to do, helps us because we thereby learn in advance what *would* be the case *if* so and so were done, even if we ourselves have no tendency whatever as yet to decide in favor of the hypothetical course of procedure.

It seems to me then that the fecundity of the deductive process, the essence of the ideal experiment, and the genuine use of deduction, where it is not intended to produce belief but to give us insight into a connection of premises and conclusion, should form the topic of psychological studies such as thus far have attracted small attention.

VI

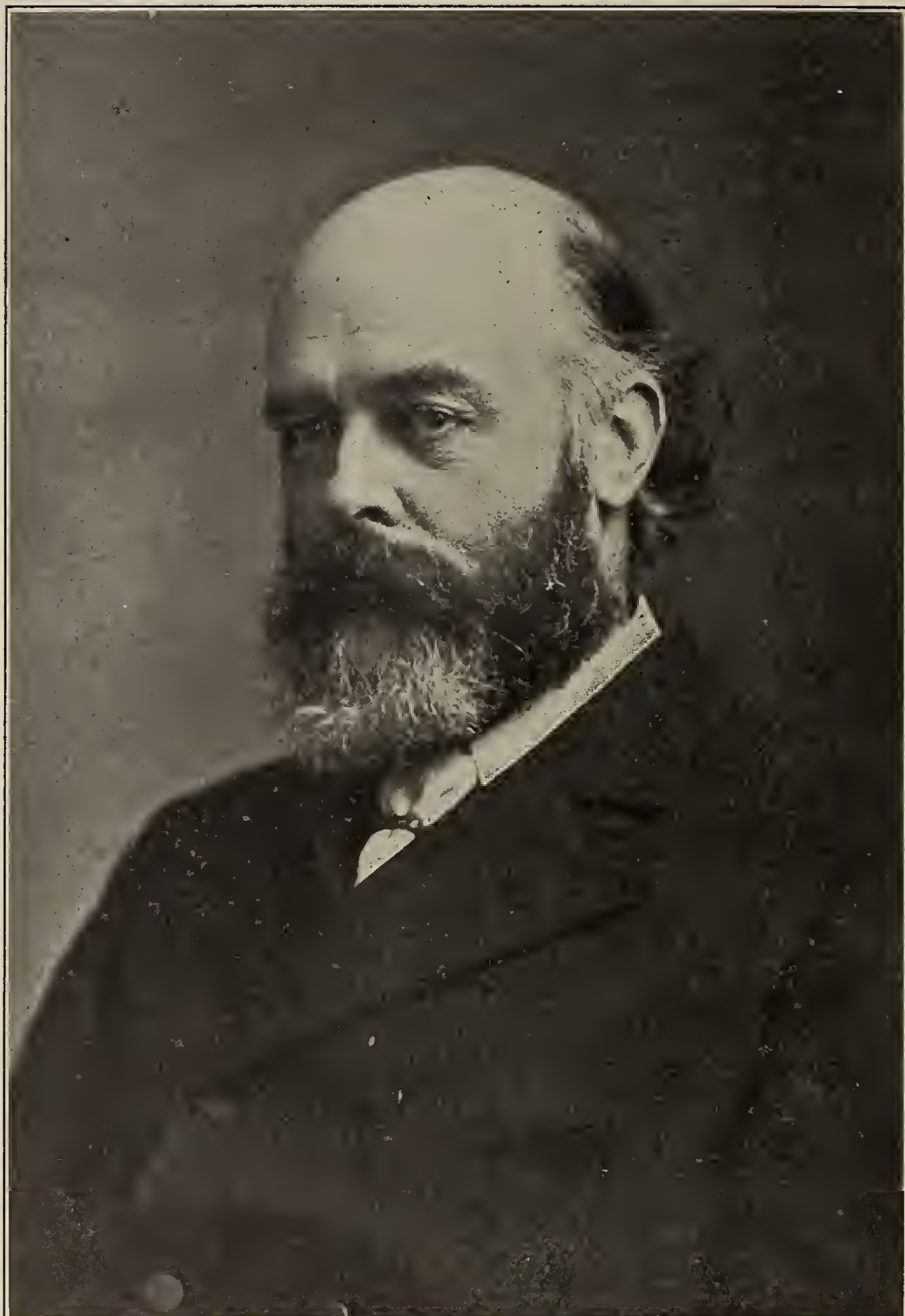
Some of the studies that I thus suggest may be of a nature to be treated by the methods of experimental psychology proper. I do not see why the psychological process of solving deductive problems that really illustrate the fecundity of deduction should not be, in certain cases, proper objects for detailed introspection. Let me mention a few possible cases. The one-sided strip of paper and a considerable number of related geometrical forms, may be made the topic of more or less direct experimental inquiry. Trained observers might undertake to solve such problems, namely, as deductive problems proper, that is, as problems of working out what conclusions follow from what premises. The deductive process proper could be separated in such cases from the special empirical materials used. And if the process is brief enough, or can be sufficiently well divided into stages to be the subject of introspection, there is much that is new to discover.

Let me mention another case of an extremely simple process of deduction of a type of which elementary mathematics is full, the process being one that involves a genuine ideal experiment, and a genuine deduction. Almost anybody knows that if the sum of the digits of a number is divisible by nine, the number is divisible by nine, and conversely. Now let the psychological student be asked, if he does not already know the solution of the problem, *Why*, granting the ordinary principles of number, the numbers expressed in any decadic system must have this property. Let the ideal construction by which the problem is solved in a given case be a topic of introspection. The result could easily throw a light upon the psychology of reasoning which no discussion of the misused syllogism could possibly produce.

But the syllogism itself does indeed involve deductive processes that have a genuine fecundity. Mrs. Ladd-Franklin's theory of the syllogism, briefly restated by her in Baldwin's "Dictionary" and elsewhere, involves a deductive use of a construction which almost any psychologist can grasp with comparatively little trouble. The nature of the proof of the identity of the ordinary syllogism with Mrs. Ladd-Franklin's reconstruction, can be grasped by a process probably too complex to admit of any strictly experimental control. Yet if one once becomes familiar with this process and with repeated operations of it under controlled conditions, he would have material for the psychology of deduction.

There is another very fascinating problem in the psychology of deduction which has been almost wholly neglected. In my address before the Psychological Association years ago I called attention to the psychology of order as a problem still awaiting discussion. So far as I know, the problem has been little considered by psychologists since that time. But here is an aspect which presents curious phenomena. The relations "such as," "greater than," "to the right of," "to the left of," are transitive. That is, they follow James's axiom of skipped intermediaries. Now all those serial relations that can be expressed in these transitive dyadic relations can also be expressed in terms of the formally triadic relation "between." Thus, let *A, B, C, D* be four objects in a row. I can say, "*B* is to the right of *A, C* is to the right of *B*." I can conclude that *C* is to the right of *A*. And then I can define the relations of order in question. Now it is very easy to see that if *B* is to the right of *A* and *C* is to the right of *B, C* must be to the right of *A* so long as one interprets the relations of right and left as we ordinarily do. But suppose I give you the premises, "*B* is between *A* and *C, C* is between *A* and *D*," and ask you what follows. The conclusion is decidedly hard for most minds to work out. In other words, the triadic relations have a psychological difficulty which we do not feel in the case of the transitive dyadic relations, although we can express equivalent facts in both terms. The difference in question is hardly due to the fact that a set of three objects is more complicated to grasp than a set of two. For a little exercise in attempting to reason in terms of "between," as the geometers often do, will show that the psychological difficulty is out of all proportion to the numerical difference between two and three. The grounds for the difference in difficulty are presumably statable only in psycho-physical terms. But the matter is one for psychological research, and should be undertaken.

Over against these problems of the psychology of deduction which are possibly capable of a more or less direct experimental research, there are vast numbers of problems of deduction which can be attacked more indirectly, some of them by following the records of formation of new habits, some of them by means of more or less exact study of social processes. There exists, for instance, an indefinite range of possibilities for the study of the psychology of the arithmetical processes by a device which, so far as I know, has still been very little used, although I have repeatedly recommended it to students of educational psychology. We hear a good deal of effort to make out the details of the process whereby a child gets control of arithmetical computations. Now it is perfectly easy for any one to put himself near to the beginning of practical arithmetic and into a place where he has to learn very many of his habits as a computer over again, under conditions that will admit of a pretty careful experimental scrutiny of the way in which the new habits get formed, and which will enable us to make precise records of the growth of the new habits. The device in question consists simply in using, instead of our decadic notation and numeration, a dyadic, triadic, or other such system. Dyadic arithmetic is the simplest of all. In this one uses two digits instead of the digits from 0 to 9, inclusive. That is, one uses only 0 and unity; 1 standing alone will mean unity. If one uses two digits, the digit on the right will stand for units, the digit on the left for twos. The symbol 10 would now stand for two, the symbol 11 would stand for three, and so on. With the triadic system the places would be used exactly as in our decadic system. In the first place would be the units, in the next place to the left the threes, the third place to the left the nines, the fourth place the twenty-sevens, and so on. Now all numbers could be written in any of these systems. In starting with a new system, one could begin to perform additions, subtractions, multiplications and divisions, as with the decadic system. The possibility of an endless range of experiments, with mature persons, who, while retaining all their present arithmetical knowledge, would be instantly reduced to the position of young children, so far as some of the computations were concerned, all this makes an inquiry into the psychology of simple deductions of this type a very attractive one. Whoever wants to study psychology by becoming a little child has here a place for a wide range of study.



Sir Oliver Lodge,

Principal of the University of Birmingham, president of the British Association for the Advancement of Science.

THE PROGRESS OF SCIENCE

THE PRESIDENTIAL ADDRESS BEFORE THE BRITISH ASSOCIATION

Great Britain is able to supply each year for the presidency of its national association for the advancement of science a scientific man of distinction, who can deliver an address in a form interesting to a large audience and likely to attract popular attention. Sir Oliver Lodge, who presided over the Birmingham meeting, was no exception. He is known for his original investigations in experimental physics and at the same time for his wide-reaching speculations. His address combined a statement of recent physical theories, likely to be of interest even to those who can not fully understand them, with some remarks on vitalism and psychical research which are sure to attract wide attention.

Sir Oliver Lodge began his address, which extended to some 20,000 words, by stating that the characteristic of the promising though perturbing period in which we live is rapid progress combined with fundamental scepticism. The subject of his address was "Continuity." He said that the remarkable feature of the present scientific era is the discovery of various kinds of atomism, but he urged that a belief in ultimate continuity is essential to science. The modern tendency is to emphasize the discontinuity or atomic character of everything. Matter has long been atomic and electricity has proved itself to be atomic. The electron is a natural unit of negative electricity, and it may not be long before the unit of positive electricity is also found. Even magnetism is suspected of being atomic and atomic theories of the ether have been invented; biology is said to be becoming atomic through modern ideas on mutation and Mendelian heredity. Sir Oliver Lodge, however, states that he is himself an upholder of ultimate continuity and a firm believer in the ether of space. The ether is a universal connecting medium which binds the universe together and makes it a coherent whole instead of a chaotic collection of independent fragments.

The lecturer then discussed the principle of relativity which had its origin in the famous experiment of two American physicists, Professor Michelson and Professor Morley, concerning the time taken by light to travel to and fro independent of the motion of the earth through space, from which such remarkable conclusions have been deduced by Dr. Einstein and others. Sir Oliver Lodge holds that the dependence of inertia and shape on speed is a genuine discovery, while the principle of relativity seeks to replace these real changes in matter by imaginary changes in time.

There is an emotional appeal in words such as electricity, ether and continuity, and this becomes even greater when we pass to life, free-will and immortality, with which Sir Oliver Lodge deals in the second part of his address. It will be remembered that last year his predecessor in the presidential chair, Professor Shäfer, who is now lecturing in America, defended the mechanistic conception of living bodies. Perhaps a physiologist is more competent than a physicist to decide on which side the weight of the evidence lies, and indeed in the course of his address Sir Oliver Lodge warns us frequently against negative generalizations. In the case of living beings he holds, however, that life introduces an incalculable element. The vagaries of a fire or of a cyclone ought to be pre-

From a photograph in the Illustrated London News.
PROFESSOR EHRLICH AND DR. HATA.

dictable by Laplace's calculator, given the initial positions, velocities and the law of acceleration of the molecules, but no mathematician could calculate the orbit of the common housefly. A spider in the galvanometer of a physicist would introduce a superphysical cause. Still the speaker did not defend vitalism as an appeal to an undefined cause. A living thing obeys the laws of physics like everything else, but it initiates processes and produces results that without it could not have occurred.

A wide public will doubtless be interested in Sir Oliver Lodge's statement of his conviction that occurrences now regarded as occult, not only can be examined and reduced to order by the methods of science, but that evidence so examined has convinced him that memory and affection are not limited to association with matter and that personality persists after bodily death, that evidence goes to prove that discarnate intelligence may interact with us on the material side and that ultimately we may hope to obtain some understanding of the nature of this larger, perhaps ethereal, existence and of the conditions regulating intercourse across the chasm. The speaker does not repeat the evidence on which he bases his faith, but it certainly has not produced similar conviction on others equally competent to judge.

CHEMIOTHERAPY AND DR. PAUL EHRLICH

In his address before the recent London International Medical Congress Dr. Paul Ehrlich, director of the Royal Institute for Experimental Therapy at Frankfort-on-Main, reviewed the problems of chemiotherapy. He said that the governing principle is that parasites are only killed by those materials to which they have a certain relationship, which substances are "parasitotropic." In the parasites and in the various organs of the body there are specific chemioreceptors which energetically attract certain fixation groups "somewhat as a magnet attracts iron." It depends on the relationship between the parasitotropism and the organotropism whether a certain disinfectant can be used as a remedy. The only substances that can be considered therapeutic agents are those of which a fraction of the tolerated dose is sufficient to bring about therapeutic effects.

This sounds rather obvious, and in fact Dr. Ehrlich, like Mr. Edison, appears to have accomplished his remarkable results by somewhat empirical methods. This procedure he defends in his address, saying at the outset that the important factors in experimental chemiotherapy are patience, skill, luck and money, and in conclusion: "Considering the enormous number of chemical combinations which must be taken into consideration in the struggle with disease, it will always be a caprice of chance or fortune or of intuition that decides which investigator gets into his hands the substances which turn out to be the best for fighting the disease."

Whether by chance or by intuition, by luck or by genius, Dr. Ehrlich, with the assistance of Dr. Hata and other fellow-workers in his Frankfort laboratory, in salvarsan, or "606," and neosalvarsan, or "914," has discovered drugs with remarkable therapeutic effects. Salvarsan is an arsenical compound with the formula $C_{12}H_{12}N_2O_2As_2$. Its effects on the spirochætes of syphilis are well known, it having already been used in perhaps a million cases in all parts of the world. Cures are sometimes effected by a single injection in the first stages of the disease. It is not so well known that even more striking results have been attained with relapsing fever, the fever immediately subsiding after the injection of salvarsan, and the patients being cured by one injection. The very rare cases of recurrence are also readily curable. Dr. Ehrlich states that it is possible by one single injection of salvarsan to cure frambœsia (yaws), which is caused by spirochætes and is a scourge of the tropics, to cure it completely except in rare cases where unimportant relapses occur. Thus in Surinam a hospital in which over three hundred patients with frambœsia were constantly under treatment was closed and turned to other uses after the introduction of the salvarsan treatment, as one single injection sufficed to cure the disease, and all the patients but two could be discharged.

In the concluding paragraph of his address Dr. Ehrlich said:

> The efforts of chemiotherapeutics must be directed as far as possible to fill up the gaps left in our defences, more especially to bring healing to diseases in which the natural powers of the organism are insufficient. And I believe that now definite and sure foundations have been laid for the scientific principles and the method of chemiotherapeutics, the way is visible before us—a way not always easy but yet practicable. In the diseases due to protozoa and spirilla extraordinarily favorable results have already been gained, as I have shown. There are many valuable indications that in a series of other diseases—small-pox, scarlatina, typhus exanthematicus, perhaps also yellow fever, and, above all,

the infectious diseases caused by invisible germs—the prospects of success are brightening. But in contradistinction to the protozoan disorders the ordinary or common bacterial diseases (diseases due to the streptococcus and staphylococcus, *B. coli,* typhoid and dysentery, and above all tuberculosis) will not be vanquished without a hard struggle. Nevertheless, I look forward with full confidence to this development also, and, without being set down as an optimist, will put forward the view that in the next five years we shall have advances of the highest importance to record in this field of research.

SCIENTIFIC ITEMS

We record with regret the death of Dr. Tempest Anderson, of York, England, known for his publications on earthquakes and volcanoes, and of Dr. Hermann Credner, professor of geology at Leipzig, and director of the Geological Survey of Saxony.

Professor William Bateson, director of the John Innes Horticultural Institute, has been elected president of the British Association for the Advancement of Science for the meeting to be held next year in Australia.—At the meeting of the section of tropical medicine and hygiene of the recent International Medical Congress, Sir Patrick Manson was presented with a gold plaque. It bears his portrait and on the other side an allegorical group representing science triumphing over disease in a tropical landscape.—In honor of Professor John Milne and to continue his work in seismology, it is proposed to collect a fund for endowment. His seismological observatory will probably be moved from the Isle of Wight to Oxford.

The Permanent International Eugenics Committee, which met in Paris on August 4, decided to hold the next International Congress in New York during September, 1915. Major Leonard Darwin presided, Mrs. Gotto acted as secretary, and the following countries were represented: England (Dr. Edgar Schuster), America (Dr. F. A. Woods), France (M. Lucien March), Germany (Professor A. Ploetz), Italy (Professor C. Gini), Denmark (Dr. S. Hansen), Norway (Dr. J. A. Mjöen).

The Popular Science Monthly

Entered in the Post Office in Lancaster, Pa., as second-class matter.

CONTENTS OF THE AUGUST NUMBER

CONTENTS OF THE SEPTEMBER NUMBER

PRESS OF THE NEW ERA PRINTING COMPANY

6413

Vol. LXXXIII, No. 5 NOVEMBER, 1913

THE POPULAR SCIENCE MONTHLY

EDITED BY J. McKEEN CATTELL

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THE HISTORY OF DIETETICS

By JOHN BENJAMIN NICHOLS, M.D.

WASHINGTON, D.C.

THE manifold diversities in diet, the articles employed as food, the manner of preparing food, customs of eating, etc., among different peoples and at different times have been the outcome of fortuitous evolution, unguided and uninfluenced by definite physiologic principles. An account of the development of such dietary practises would present much of interest and would be included in a complete history of dietetics; but it is far too large a subject to be considered here, and the present paper will be limited to a brief presentation of the development of the various lines of knowledge constituting the scientific basis of dietetics, as it exists to-day.

Inquiring and speculative minds in all ages have endeavored to trace out the principles and laws governing diet. Prior to the modern scientific era, that is, during the entire ancient and middle ages, there was very little foundation of real knowledge on which a true science of dietetics could be based. Only the crudest objective characteristics of foodstuffs could be appreciated, such as the division of animal and vegetable, liquid and solid, etc. Notwithstanding the want of any adequate basis, from the time of Hippocrates a large proportion of medical literature was devoted to the subject of dietetics, and a multitude of treatises on food were presented characterized by chimerical speculation and fine-spun theorizing. Mythical properties and dangers were ascribed to different foodstuffs; rules were laid down in minute detail as to the use or prohibition of various foods in different morbid conditions which were without rational warrant; dietetic theories and systems were propounded which in the light of modern knowledge are seen to have been grotesque; and the authorities expounded their doctrines with an emphasis and dogmatism paralleled only by their real ignorance of the subject. Of all the mass of dietetic doctrine presented in the ancient and medieval eras of medical thought, there was very little of abiding verity or value that contributed to our present rational knowledge of the subject. On the contrary, the professional mind was thoroughly indoctrinated with erroneous ideas which retarded the acceptance of correct conceptions and have not even yet been eradicated.

The science of dietetics is a composite subject, uniting a number of rather independent branches of knowledge, such as the chemistry of food, the processes of digestion, the physiology of metabolism, etc., the development of which may be separately considered. The beginnings of our scientific knowledge of these subjects may be traced back to the seventeenth century, soon after the discovery of the circulation of the blood by William Harvey (1578–1667), announced in 1628, opened the way to the development of scientific physiology. No great progress, however, was made for nearly two centuries, and the main foundations of our knowledge of these subjects were laid down in the second quarter of the nineteenth century.

The development of our knowledge of the physiology of digestion will be first considered.

A knowledge of the mechanism of glandular secretion in general is prerequisite to an understanding of the origin of the digestive fluids. No adequate conception of the structure and function of glands was possible prior to the discovery of the circulation and the use of the microscope. When these conditions were fulfilled the physiology of glandular secretion was quickly worked out. At first, for instance, it was not even known that, except for the liver and kidneys, the glands possessed ducts. The main steps in the evolution of our knowledge of glandular action were about as follows:

In 1643 the duct of the pancreas was first described by Georg Wirsung, a Bavarian (died 1643), although his pupil Maurice Hoffmann contested the honor of its discovery as his own. In 1654 Francis Glisson, an Englishman (1597–1677), published an important work on the liver, in which he touched upon the mechanism of the secretion of the bile. In 1656 Thomas Wharton, an Englishman (1610–1673), published an account of the duct of the submaxillary gland. In 1662 Lorenzo Bellini, of Florence (1643–1704), at the early age of 19 years, described certain portions of the uriniferous tubules of the kidney. In 1662 also Nicolas Stensen, or Steno, a Dane (1638–1686), described the ducts of the parotid and other glands. The names of these observers have ever since been attached to the structures which they discovered.

About this time Franciscus Sylvius, Stensen's instructor at Leyden, drew a general distinction between conglomerate glands, possessing secretory ducts, such as ordinary secreting glands, and conglobate glands, such as the lymphatic glands. Stensen, from his researches on the salivary and other glands, came close to an adequate conception of the process of glandular secretion; but as, like the other observers just mentioned, he did not employ the microscope, he was unable to work out the full details of the subject. It remained for Marcello Malpighi (1628–1694), of Bologna, a pioneer microscopist and one of the first and greatest of histologists, in 1666 to lay down finally the essential features of the minute structure and mechanism of the main glandular organs as they are accepted at the present time.

The lacteals were discovered in 1622 (published 1627) by Gaspare Aselli (1581–1626), professor at Pavia, who recognized that they conveyed the chyle away from the intestine, but regarded them as emptying into the liver, then thought to be the organ in which the food materials were converted into blood. The discovery of the receptaculum chyli and the thoracic duct, and the connection of these with the lacteals on the one hand, and the venous system on the other, was made independently by Jean Pecquet (1622–1674), of Dieppe and Paris, and Jan van Horne (1621–1670), of Leyden, whose observations were published in 1651 and 1652, respectively.

In the ancient and middle ages, the stomach was looked upon as the principal organ of digestion. The process of digestion was by some (Hippocrates and others) regarded as a coction, or πέψις (cooking), a sort of maturation effected with the aid of heat; by others it was considered as akin to putrefaction; and by still others as a mechanical process. It came to be the general doctrine that the food material absorbed from the alimentary tract was first acted upon by the liver and endowed with "natural spirits"; in the heart, by the action on the blood of the inspired air, the natural spirits were converted into "vital spirits"; finally, in the brain the vital spirits were converted into "animal spirits," which were then conveyed by the nerves to all parts of the body.

The beginnings of our modern knowledge of digestion can be traced back to the observations of the Belgian savant Jean Baptiste van Helmont (1577–1644), whose work formed a landmark in the history of chemistry. He regarded the chemical activities of the body as a form of fermentation, analogous to the familiar alcoholic or vinous fermentation; he assigned ferment action as a cause of a wide range of vital processes, thus anticipating theories that at the present time are frequently advanced. In van Helmont's view the digestion of food was accomplished by fermentative action. He recognized only two stages of digestion in the alimentary tract, namely, in the stomach and in the duodenum; the action of the salivary glands and pancreas was not yet known. Gastric digestion he regarded as being effected by a ferment derived from the spleen, associated with an acid principle which was necessary to its action. When the chyme passed into the duodenum the acid ferment was neutralized, and the second stage of digestion was effected by the bile.

The next developments in the knowledge of digestion came from

Franciscus Sylvius (François de la Boe, or Dubois, 1614–1672), the professor of medicine at Leyden, who founded the iatro-chemical school and exerted a powerful influence as a teacher and expositor of the chemical philosophy of his time. Sylvius also attributed many of the vital processes to fermentative action; but he confused effervescence (such as occurs on adding acid to carbonate) with fermentation, and looked upon effervescence as the type of these processes. Sylvius had knowledge of two secretions, salivary and pancreatic, unknown to van Helmont.

The observations of Wharton and Stensen (published 1656 and 1662) had clarified the salivary secretion. Impressed with these discoveries, Sylvius attached an exaggerated importance to the digestive action of the saliva, and held that digestion in the stomach was accomplished much more by swallowed saliva than by any ferment of gastric origin. This view persisted for a long time.

The second stage of digestion, that taking place in the duodenum, according to Sylvius was effected by the conjoint action of the bile and the recently discovered pancreatic juice. Wirsung in 1643 had described the pancreatic duct; and in 1664 Regner de Graaf (1641–1673), of Holland, published the results of investigations on the pancreatic secretion carried out while he was a student at Leyden under Sylvius. De Graaf obtained pure pancreatic juice from dogs through quills inserted into the pancreatic duct. He fell into the error, however, of regarding it as acid; and he held, in accordance with Sylvius's theory of effervescence, that the effervescence supposed to be produced by the mixture of this acid juice with the salts of the bile was in some way associated with duodenal digestion.

In 1677, Johann Conrad Peyer (1653–1712), a Swiss, published a description of certain glandular structures discovered by him and since known as Peyer's patches. He decided that these were secretory (conglomerate) rather than lymphatic (conglobate) glands, and believed their secretion had digestive properties, active in the lower ileum at a point where the pancreatic juice must become exhausted.

In 1683, Johann Conrad Brunner (1653–1727), of Germany, published the results of experiments which he had made in exsecting the pancreas and ligating the pancreatic duct in dogs. As the dogs did not manifest any disturbance of digestion or nutrition, he argued that the importance attached by Sylvius and de Graaf to pancreatic digestion was unfounded. Brunner also showed that the pancreatic juice was not acid. In 1687 he described the duodenal glands, since known by his name, and attributed digestive properties to their secretion.

In consequence of the doubt brought by the discoveries of Peyer and Brunner, belief in pancreatic digestion waned, and for a long time the view prevailed that the stomach was the chief seat of digestion. In the latter part of the seventeenth century, two opposing theories as to the mechanism of gastric digestion were held by the rival physical and chemical schools of that period. The chemical theory of digestion was that of van Helmont, Sylvius, and their followers. On the other hand, Alfonso Borelli (1608–1679), the founder of the iatro-physical school, held that gastric secretion was chiefly effected by powerful trituration of the ingested food by the muscular walls of the stomach, as appears especially in birds; and while he conceded a corrosive action of the stomach juices in some species, his followers denied all chemical digestion and regarded the whole process as purely mechanical.

During the eighteenth century the only additions to the knowledge of digestion were a few studies of the gastric juice.

René Antoine Ferchault de Reaumur (1683–1757) developed a new and fruitful method of investigation, publishing his results in 1752. He introduced metal tubes containing various food materials into the stomach of a buzzard (which, like other carnivorous birds, ejects from the mouth indigestible substances like bones, etc.) and other animals, and on examining them subsequently was able to determine the effect of the gastric juice on these materials. By using sponges in the tubes he was the first to obtain gastric juice in pure condition. He observed that meat and bone were dissolved by the gastric juice, but not grains or flour. He thus demonstrated that this secretion possessed a definite solvent power, distinct from putrefaction, and independent of trituration.

Employing Reaumur's and other similar methods, Lazaro Spallanzani (1729–1799), of Italy, continued and extended the observations, publishing his results in 1777 and subsequently. In 1777 Stevens, of Edinburgh, published a similar research. John Hunter (1728–1793) in 1772 and 1786 also published some observations on digestion.

The acidity of the gastric juice, appreciated by van Helmont and denied by his successors, was not generally recognized until the nineteenth century. Spallanzani and Hunter regarded the acidity of some of the specimens which they obtained as occasional or exceptional or abnormal only. Carminati recognized the real conditions, showing in 1785 that the gastric juice while fasting is neutral, and is acid only after taking food; his observations, however, did not gain general attention.

A contribution of interest to Americans, which, however, passed unnoticed, was the graduation thesis of John R. Young, of Maryland, at the University of Pennsylvania in 1803, in which he described experiments made on digestion in the stomachs of frogs and human subjects, and demonstrated the acidity of the gastric juice.

The foundations of our present knowledge of digestion were mainly established during the second quarter of the nineteenth century.

William Prout (1785–1850), of London, in 1824 identified the acid principle of the gastric juice as hydrochloric acid.

William Beaumont (1785–1853), an American army surgeon, from 1825 to 1833 conducted a celebrated series of observations of gastric digestion through a fistula following a gunshot wound in the case of the Canadian Alexis Saint Martin, the results being published in 1833. These observations constituted an important contribution to the subject and attracted world-wide attention.

Leuchs in 1831 discovered the starch-digesting properties of saliva. Payen and Persoz in 1833 discovered and studied the amylolytic ferment diastase in germinating barley. Mialhe in 1845 isolated ptyalin from saliva.

J. N. Eberle in a work published in 1834 was the first to note the power of an extract or artificial gastric juice prepared from the gastric mucous membrane to dissolve proteid material. He, however, erroneously attributed this solvent action to the mucus on the surface of the stomach. Theodor Schwann (1810–1882), the discoverer of animal cells, investigated the subject (partly in association with his teacher Johannes Müller) and in crude form isolated from the gastric mucosa a principle possessing intense proteolytic powers, to which he gave the name pepsin; his results were published in 1836.

In his treatise published in 1834 Eberle noted the fact that a watery extract of the pancreas would emulsify oil, and he surmised that one of the functions of the pancreatic secretion was to favor the absorption of fat. In 1836 Purkinje and Pappenheim discovered that extracts from the pancreas possess proteolytic properties. In 1844 Valentin made some observations on the starch-digesting powers of the pancreatic fluid; and in 1845 Bouchardat and Sandras definitely demonstrated the secretion of an amylolytic principle by this organ.

Following these pioneer discoveries, the elucidation of the functions of the pancreas, especially its fat-splitting action, was accomplished chiefly by the work of the French investigator Claude Bernard (1813–1878), whose researches on this subject were prosecuted about 1836–1846.

From these beginnings the chemistry and physiology of digestion have been further elaborated by numerous subsequent investigators.

The study of gastric digestion was made a simple clinical procedure by the employment of the stomach tube for obtaining samples of gastric juice. This originated with Adolph Kussmaul (1822–1902), who in 1869 reported the use of the stomach tube in the treatment of dilatation of the stomach; subsequent to which the examination of gastric juice for diagnostic purposes was elaborated by W. O. Leube, C. A. Ewald and Franz Riegel, and their associates during the seventies and eighties of the last century.

Important studies of the action of the digestive organs were not long ago made by Ivan Pyotrovich Pavloff (often transliterated, from the German, J. P. Pawlow) (born 1849), director of the Imperial Institute of Experimental Medicine in Saint Petersburg, the results of whose brilliant researches (conducted 1887–1897) were first published in collected form in 1897. For this work Pavloff received the Nobel prize in 1904.

The discovery of pancreatic secretin by William Maddock Bayliss and Ernest Henry Starling, announced in 1904, opened up an entirely new field of knowledge, that of the action of the so-called hormones as inciters of secretory activity carried to the points of action by the circulation.

The introduction of the X-ray made available a new and fertile method of studying the movements of the digestive organs; one of the earliest and most prolific workers in this field has been an American, Walter Bradford Cannon, professor of physiology at Harvard, whose contributions on this subject date from 1899.

The main basis of dietetics rests in the chemistry of food and nutrition. This knowledge could not be developed until the science of chemistry entered upon its renaissance, which occurred much later than the birth of modern anatomy, physiology and physics. The discovery of oxygen in 1774 opened the way to a rapid development of chemical knowledge, just as Harvey's discovery of the circulation a century and a half before had been the starting point for physiology.

As has been the case with many other discoveries, the effective discovery of oxygen had been anticipated long previously by work that had fallen into oblivion. In 1668 a young Englishman at Oxford, John Mayow (1645–1679), published a remarkable work in which he argued that the atmosphere contains, as he styled it, an "igneo-aereal" or "nitro-aereal" principle which by combining with combustible ("sulphureous") substances constitutes the process of combustion; that this principle is imparted to the blood by the respiratory activities; that the union of this principle, carried in the blood, with combustible material in the muscles gives rise to muscular action and is a source of animal heat. Though this theory was soon forgotten, it was a remarkable presentation of the doctrine of oxidation (including body oxidation as the source of animal energy), and anticipated by a century the discovery of oxygen.

In 1774 oxygen was independently discovered by Joseph Priestley (1733–1804), an English clergyman, and by Karl Wilhelm Scheele (1742–1786), of Sweden. It was Antoine Laurent Lavoisier (1743–1794), of Paris, however, who grasped the real significance of this discovery, and by his researches, published from 1775, overthrew the false though fruitful phlogistic theory of heat that had dominated chemistry for a century, and showed the true nature of combustion and the properties of oxygen.

Lavoisier was followed by a number of brilliant investigators, who rapidly laid down the great foundations of chemical science. The beginnings of organic chemistry may be traced to some of these early workers; Lavoisier, for instance, showed that organic compounds are composed mainly of carbon, hydrogen and oxygen, and sometimes nitrogen.

The foundation and elaboration of organic chemistry was mainly the great achievement of the illustrious chemist Justus Liebig (1803–1873). After studying chemistry at Paris under Gay-Lussac, he was professor of chemistry at Giessen 1824–1852, and at Munich from 1852 until his death in 1873. About 1837 he began epoch-making investigations of physiologic and organic chemistry, and in works published from 1840 he laid down the main lines of our knowledge of the chemistry of food and nutrition. He first, for instance, sharply differentiated the foodstuffs albumen, fat and carbohydrate, and recognized the tissue-forming function of albumins and the heat-producing properties of fats and carbohydrates.

Since the time of Liebig many workers have brought our knowledge of the chemistry of food to its present state. Among important investigations of this character now being actively prosecuted are those on the molecular structure of the complex foodstuffs, such as the studies of Emil Fischer, Emil Abderhalden and others on the proteins. Some of the sugars have been artificially synthesized, and a beginning has been made even on the proteins.

Crude attempts at food analysis date back for centuries, as in connection with governmental measures to prevent adulteration of foods and beverages. In the modern era George Pearson, of England, in 1795 reported an analysis of potatoes; in 1805, Einhoff analyses of potatoes and rye. Reliable analyses of milk were reported by Peligot in 1836, and of feeding stuffs and milk by Boussingault and Le Bel 1836–1839. From about 1840, through the work of Liebig a great impetus was given to food analysis; and with the further advances of chemistry came the development of reliable analytic methods and the accumulation of data. From about 1860 the standard methods of food analysis now employed were developed by Wilhelm Henneberg (1825–1890), of the agricultural experiment station at Weende, near Göttingen; these methods soon came into general use and have greatly facilitated and systematized this line of work.

Possibly the earliest analyses of food made in the United States were of some cereals by C. U. Shepherd published in 1844. Analyses of various foods were published by Salisbury in 1848, Beck in 1848–1849, Emmons in 1849, Jackson in 1857. One of the most prolific workers in this field in this country was Atwater, who, employing the Weende methods, made analyses of maize in 1869, and commenced an extended series of analyses of fish and other foods in 1877.

Dietary studies—investigations of the amounts of foodstuffs actually consumed by different classes of people under various conditions—furnish an important part of the data underlying the science of dietetics. Among the earliest investigations of this sort were those conducted by

Liebig in 1840; by Beneke in England in 1851; and in this country by John Stanton Gould in 1852 and Atwater in 1886. Since then many such studies have been made and a large amount of information collected.

A knowledge of the processes of metabolism forms another component of the foundations of dietetics.

Probably the earliest real metabolism studies were prosecuted by Sanctorius (1561–1636), who published his results in 1614. Sitting in a chair suspended from steelyards, he observed the changes in weight from eating and from the loss of insensible perspiration.

Theories of the source of animal heat were presented from the early days of physiology. Van Helmont held that animal heat was generated by fermentation of the blood in the heart. Sylvius believed it to be produced by the supposed effervescence resulting from the mixture of venous blood with acid chyle. Mayow in 1668 anticipated the modern view that the body energy is derived from oxidation in the tissues; but his views were soon forgotten. Toward the end of the seventeenth century these chemical theories were largely superseded by the physical view that animal heat is generated by the friction of the blood in the capillaries. It was not until after the discovery of oxygen that our present conceptions of the part played by oxidation as the source of animal energy were founded by Lavoisier.

The general outlines of our knowledge of metabolism were formulated by Liebig, the details being worked out by numerous subsequent investigators, many of them under his personal influence. In this way, chiefly since 1850, an extensive mass of data on this subject has been accumulated. The earliest metabolism study appears to have been one by Lehmann, made in 1839. The study of the metabolism of nitrogen is a comparatively simple matter, and has been an easy and frequent subject for investigation.

The determination of the exchanges of carbon and hydrogen is a much more difficult matter, involving the collection of the products of respiration and requiring elaborate apparatus and an amount of labor rarely available. Early respiration experiments with animals were made by Boussingault about 1844, Bidder and Schmidt in 1847–1850, and Regnault and Reiset in 1849; and with man by Barral in 1847–1848, and Hildesheim in 1856.

A most extensive and accurate series of investigations was conducted by Max von Pettenkofer (1818–1901) and, especially, Carl von Voit (1831–1908), in the Physiological Institute at Munich with the respiration apparatus constructed by Pettenkofer about 1860. Animals and men were made the subjects of extended observation with this apparatus from 1861 to 1867, and principles of fundamental importance were established by these classical researches.

Other important studies of metabolism were prosecuted by Pflüger and his associates in Bonn, by Zuntz in Berlin, by Tschudnovski, Pashutin, and others in St. Petersburg, by Tigerstedt in Sweden, and by many others.

The energy exchanges of the organism have a fundamental bearing in dietetics, since the heat output of the body under different conditions determines the caloric requirements of the diet. The apparatus used to investigate these exchanges, the respiration calorimeter, besides measuring the respiratory products after the manner of Pettenkofer's apparatus, determines with great accuracy the amount of heat given off by the subject. In its perfected form this mechanism is a marvel of complexity, elaborateness, and delicacy, requiring much labor and ample resources for its construction and operation.

Some imperfect calorimetric studies on animals and man were published by Russian observers from 1884. Max Rubner (1854–) was the first to conduct a successful and elaborate series of calorimetric observations on animals. He was educated at Munich under Voit; professor at Marburg 1885–1891; at Berlin from 1891, succeeding Koch as Director of the Hygienic Institute. His studies were begun about 1889, and his results published in full in 1902. He demonstrated that the law of the conservation of energy holds good for animals; and he has laid down principles fundamental in this branch of physiology and of the utmost importance in dietetics.

The most elaborate calorimetric investigations ever carried out have been those prosecuted in this country since 1892 by Wilbur Olin Atwater (1844–1907) and his associates and successors. Atwater studied at Munich under Voit, and derived some of his ideas from Rubner. Professor of chemistry at Wesleyan University, Middletown, Connecticut, from 1873 until his death, he devoted his whole life to investigations concerning food and nutrition. In 1892, with the assistance of the physicist Rosa, he began the construction at Wesleyan University of a respiration calorimeter large enough to accommodate a human subject. This apparatus underwent gradual improvement until finally direct determinations of the oxygen exchanges were, for the first time on a large scale, carried out. The work was jointly supported by Wesleyan University, the Storrs (Connecticut) Agricultural Experiment Station, the United States Department of Agriculture, and (later) the Carnegie Institution. With this apparatus an elaborate series of researches was carried out from 1892 to 1907, the results of which must stand as classical. After Atwater's death in 1907, the original apparatus was removed to Washington and installed in the Department of Agriculture, where it is now in operation; while his successor Francis Gano Benedict under a grant from the Carnegie Institution is continuing the research with an equipment constructed in Boston.

Other investigators have since taken up this line of work, and important points concerning metabolism under different conditions and in various morbid states are now in course of elucidation.

To recount all the important researches on the physiology and chemistry of dietetics would unduly prolong this historical review. I have mentioned the principal contributions that have first opened up the various lines of inquiry pertinent to the subject. By the researches of a host of investigators along these lines have been accumulated the data and developed the principles that underlie the theory of dietetics as we have it to-day. The evolution of the subject is still far from complete, and points of even fundamental importance are yet to be worked out. So elementary a standard, for example, as the optimum daily ration of protein, is even yet unsettled. The establishment of rational principles of feeding in disease has been very incompletely accomplished. The whole subject is in a transitional stage; investigation is, however, proceeding rapidly, and results with important practical bearings are being constantly gained.

American conrtibutions to the subject have been noteworthy, such as the work of Beaumont, Atwater and Cannon. Honor is especially due to the United States Department of Agriculture for the special encouragement it has since 1894 given to the study of problems relating to the food and nutrition of man; under its auspices a vast amount of research has been systematically fostered all over the country and the results published and distributed in an extensive series of bulletins.

The scientific and rational principles of dietetics have not become well assimilated into the conceptions of the public, or even of the medical profession. Dietetics is a fruitful field for fallacy, fancy and fad. There are a few diseases that have a specific dietetic treatment, such as diabetes, acidosis, scurvy, beri-beri, gout, etc., in which, as also in infant feeding, the profession follows rational principles. With many diseases the appropriate dietetic principles are ignored, or have not been as yet worked out, or do not differ from those of health. In this field the dietetic management is to a certain extent a matter of caprice, guesswork and error. Faulty practises are in vogue, such as the general use as food of meat extractives and soups, although well known to be devoid of nutritive value. Mystic potencies and occult dangers are erroneously ascribed to articles of food. The distrust of food engendered in the ancient days of medicine still lingers, and there is no doubt that countless lives have been sacrificed to the fear of feeding in disease.

The medical students and practitioners of the present and future need to be more thoroughly grounded in the scientific and rational basis of dietetics. Only by a thorough appreciation and application of its principles can this subject be raised from a position of empiricism to that scientific dignity which it is the aim of modern medicine to attain, or the powerful agency of diet be utilized in its maximum efficiency for the benefit of mankind.

JEWISH COLONIZATION IN PALESTINE

By O. F. COOK

BUREAU OF PLANT INDUSTRY

HISTORICAL and religious interest has been responsible for many investigations and explorations in Palestine, but the country has still to receive an adequate study from the biological and agricultural standpoints. What we are pleased to describe as European civilization had its rise in western Asia and was based on the cultivation of plants indigenous in that region. The agriculture and agricultural plants of western Asia were brought to Europe in prehistoric times as a part of the equipment of the ancient Mediterranean civilization. To become familiar with the primitive stocks of our cultivated plants and the primitive agricultural arts that are still practised in this cradle-land of civilization is quite as interesting as reconstructing its ruined cities or digging out its buried inscriptions. We have much more adequate knowledge of incidents of ancient history than we have of the underlying agricultural and social conditions.

Even among those who have urged the colonization of Palestine for reasons of philanthropy and national patriotism there has been rather tardy appreciation of the importance of scientific exploration and investigation of agricultural resources. It remained for American Jews who have relatively little interest in the colonization idea to undertake the investigation of the country from the broader motive of human welfare, and as a means of securing for American agriculture the advantages of better knowledge of the agriculture of western Asia, whence so many of our American crops have come. There is a special reason why this agricultural knowledge is likely to be much more valuable in the United States than in Europe, for we have in our Pacific coast and southwestern states enormous agricultural resources still undeveloped under natural conditions that are much more Asiatic than European. In other words, we have need to go back to Asia to get the remainder of the agricultural plants and agricultural knowledge that was not carried to northern Europe because the European conditions were unfavorable. Thus the establishment of colonies of European Jews in Palestine has had the entirely unexpected result of opening the country to agricultural exploration in the interest of American agriculture.

The establishment of an agricultural experiment station in Palestine was announced in *Science* in 1909.[1] The director of this station,

[1] Fairchild, David, "An American Research Institution in Palestine. The Jewish Agricultural Experiment Station at Haifa," *Science*, N. S., 31: 376.

Mr. Aaron Aaronsohn, had already been engaged for many years in an agricultural and botanical exploration of the country, some of the results of which have been published in Bulletin 180, Bureau of Plant Industry, U. S. Department of Agriculture. One of the most interesting discoveries was a wild species of wheat closely related to some of the domesticated forms, and possibly representing the long-sought ancestral form of this whole group of cereals. An opportunity of observing the habits of this plant in the region of Mt. Hermon in the summer of 1910 has left no doubt that the plant is a genuine wild species, and not an escaped form of domesticated wheat. A subsequent experiment with the wild wheat in southern California shows that it is worthy of further study from the standpoint of acclimatization in the United States.[2]

But the wild wheat is only one of many subjects that are receiving attention at the newly established experiment station. Many difficulties are being encountered, as was fully expected beforehand, including the necessity of grappling with the problem of malaria. As this disease has been one of the most serious obstacles in the establishment of the colonies, the power to control it has a direct relation to the agricultural progress of the country. Some of the most fertile districts have remained almost uninhabited on account of the prevalence of malaria, a disease that modern sanitation can easily exterminate. The recent organization of a health bureau for the scientific study of the indigenous diseases and the improvement of hygienic conditions is the first outgrowth from the establishment of an agricultural experiment station.

Thus the founding of this station has given a new aspect to the whole colonization movement, in showing that the resources of modern science are to be enlisted. It is becoming apparent that some of the problems of Palestine will yield to scientific knowledge, although they may have resisted the most devoted efforts and the most liberal expenditure of money in unscientific ways. Motives of religion, charity and patriotism have figured so largely that constructive applications of science have received little consideration. If even a part of the colonists brought with them to Palestine a knowledge of modern scientific agriculture the situation would be entirely changed. Such knowledge would be far more precious than money, so much of which has been spent to little purpose.

The tendency has been to think of Palestine as a refuge from oppression rather than as an opportunity of developing a new agricultural civilization. But if the colonization movement continues it must be only a question of time when the traditional idealism of the people will assert itself in agricultural lines, as it has in so many other forms

[2] Cook, O. F., "Wild Wheat in Palestine," Bulletin 274, Bureau of Plant Industry, U. S. Department of Agriculture, 1913.

of human activity. The factor of time is indispensable in all such movements. The ancient Hebrews of the Exodus spent forty years in the wilderness before they were ready to adopt an agricultural existence, and it is a new generation nurtured in the wilderness of modern Palestine who now appreciate the need of a more effective conquest of the art of agriculture.

The persistence of the colonists in the face of so many difficulties naturally arouses interest in what might be accomplished if a people capable of so much devotion and self-sacrifice should really face the problem of developing an agricultural civilization adapted to the local conditions. As the colonists had not been farmers in Europe, the life they undertook in Palestine broke absolutely with all their previous existence. What the previous existence must have been can best be judged, perhaps, by what the colonists are willing to accept in Palestine as an improvement. The absence of agricultural knowledge or experience means that they must work at first at the greatest possible disadvantage, and encounter all manner of unnecessary toils and hardships that people with agricultural traditions would readily avoid. But even after incredible perseverance has overcome the handicap of unskillful and inefficient labor and brought material prosperity, the lack of agricultural ideals is even more apparent, for the colonists have still to appreciate and utilize the opportunities that are within their reach, in the direction of securing the normal advantages of agricultural life. And yet in some respects the conditions appear extremely favorable for progress along new lines. The very existence of the colonies is evidence of a strong determination to escape the artificial restrictions represented by the conditions of life in the European cities whence most of the colonists have come.

In the effort to resume a simple agricultural existence the colonists may be said to have gone back about 3,000 years to the time of the ancient theocracy, before the establishment of kingly government in the persons of Saul and David. The provisions of the law of Moses evidently contemplated the development of a purely agricultural civilization, and made no provision for the control of urban populations by a permanent centralized government. The modern colonies are also free from any attempt at governmental organization and it may be this that has enabled them to develop peaceably in the midst of a population traditionally hostile, but actually much more tolerant than many European communities.

The reasons of safety that might have impelled the early colonists to crowd themselves together in small slum-like villages no longer justify the continuance of such methods at the present time. The more settled state of the country and the development of telephones and other means of communication would make it possible for each family to live on its own land under its own vines and fig trees. And even from the standpoint of safety more is to be gained by developing readier means of communication and transporation than by crowding the people into small inaccessible villages.

In spite of all that has been said of the devastation of Palestine, the country has rich possibilities of agricultural development. The prevailing notion that the Promised Land is now a hopeless desert rests largely on the impressions of travelers who confine themselves to the regular tourist route from Jaffa up to Jerusalem and then down to Jericho and the Dead Sea. The districts visited on such a trip give about as correct an idea of the country as might be obtained if a visitor to California were to land at Los Angeles or San Diego, and then travel over the mountains to Indio and the Salton Sea. Even the most recent account of Palestine, written by a professional geographer, shows a very inadequate appreciation of the factors that determine the agricultural possibilities of the country.[3]

The agricultural possibilities of Palestine are not likely to be appreciated by visitors from Europe and America until some readily accessible part of the country is developed on the basis of farm homes. People who live in crowded villages are not likely to attain any very high degree of agricultural prosperity or to make very rapid agricultural progress. What the colonists have been able to accomplish under their present methods of living affords ample evidence of a self-sacrificing determination, worthy, not of a better cause, but of a better course, more directly aimed toward agricultural improvement.

The natural conditions are undoubtedly favorable, and the desire for agricultural progress exists, but effective combination of the two elements must also be secured. The leaders among the colonists are no longer resting their hopes for the future upon securing political control of the country through purchase or diplomatic negotiations. Whatever the political status of the country the essential conditions will remain the same, in the sense that the whole resident population must be considered in any program that is to assure the permanent progress of the colonists. Thus the human problem is even more serious than the agricultural problem. The human environment of the colonists needs to be improved, no less than the agricultural environment. The only possible solution of either problem is through agricultural and

[3] See Huntington, E., ''Palestine and its Transformation,'' 1911. This author considers it very unfortunate that most of the rain comes in the winter instead of in the summer season when the crops are growing, but overlooks the further facts that nearly all of the precipitation occurs in the form of very gentle rain, and that the granular limestone soil is extremely well adapted to absorb and retain the moisture till the crop season arrives. The sesame and sorghum crops grow without any rain, on moisture stored in the soil by dry farming methods.

educational progress. The improvement of agricultural conditions is the single issue on which the highly diversified population of the country might be expected to agree.

Whether any ordinary system of formal education in schools will have any practical result in Palestine seems very doubtful. Some parts of the country are already overstocked with different kinds of charitable and religious institutions, many of them engaged in educational work, but apparently with as little relation to the requirements of actual life as similar institutions in Europe and America. Though most of the colonists are already past school age when they arrive in Palestine, yet they are acutely in need of learning how to work and live in the new country. For effective agricultural education in a country like Palestine, there must be places where men, young or old, can acquire correct habits of doing farm work, become accustomed to the atmosphere of farm life, and learn something of its possibilities. Agriculture is a habit and a method of life, not merely a science to be studied or an art to be pursued for profit alone.

Agricultural education, in the narrow sense of formal scholastic instruction in agricultural facts, commonly fails to accomplish its intended purpose of improving the life of the farm. At the same time that the boys are being instructed in agricultural knowledge they may also be losing their agricultural habits and becoming less adapted to agricultural life. After their courses in agriculture they are more likely to enter some other line of activity involving less responsibility than agriculture and more similar to the work and life of the school to which they have become thoroughly accustomed. The unintentional training in town life usually has a stronger influence than the formal instruction of the school. The event proves the boy has been educated away from agriculture rather than towards it. Whether agriculture or other subjects are studied makes little difference in a comparison with the change of habits of life. Thus the general effect of agricultural schools and colleges in the United States has been to take more of the boys away from the farm, or, in other words, to make our civilization more industrial and commercial, rather than more agricultural.

Even less can be expected in Palestine than in the United States from the establishment of agricultural schools of the ordinary sort, because of the lack of previous agricultural contacts on the part of the students. The American student who has grown up on a farm and is thoroughly familiar with farm conditions is much more likely to project some of the new facts that he learns in the school against the background of farm life, but in Palestine most of the newly arrived colonists are without agricultural experience. They need practise in farm life and farm operations even more than they need instruction in agricultural facts.

The next generation also needs to be educated without losing its contacts with the life of the family and the farm. Otherwise the young men will go to Egypt to find employment as clerks or emigrate to Europe or America in search of better commercial opportunities, as they are now beginning to do. Ordinary school conditions are in the nature of a training for commercial life, but there is no corresponding training for agricultural life. This deficiency may be a more serious hindrance to agricultural progress among the Jews because of their stronger parental instincts. The greater the stress that is laid on the formal education the stronger the tendency to develop urban habits of school life in the children. To what extent this educational propensity may have interfered with the success of agricultural movements among the Jews would be difficult to determine, but it is evidently a factor at the present time. Though commonly considered as a non agricultural people, the Jews have clung to their agricultural traditions with wonderful tenacity and have made innumerable attempts to place themselves on an agricultural basis. It would be important as well as interesting to determine what has held them back.

The difficulties of agricultural education are not peculiar to Palestine. The same limitations to human progress are being encountered even in countries that have elaborate provisions for agricultural education. More practical methods must be found, that is, more truly human methods if the full possibilities of any country or any people are to be realized. The issue seems more acute in Palestine, in the presence of a people who have fled from the urban civilization of Europe, as their ancestors escaped from Egyptian bondage. Urban educational ideas must be left behind if the permanent deliverance is to be attained. If a solution could be found, in spite of the extreme difficulty of the problem, no movement of our times would command a wider interest. The world would owe a new debt to the Jew, and Palestine would become more than ever the historical background of our civilization.

THE NATIONAL ZOOLOGICAL GARDEN

By Dr. R. W. SHUFELDT
WASHINGTON, D. C.

MY home at the present time is within ten minutes' walk of the National Zoological Park at Washington, and, as a matter of fact, when my study window is open, and outside conditions are favorable, the howling of the coyotes and wolves, the barking of the seals, and the calls of the big birds of prey are, each and all, heard with delightful distinctness.

Zoological gardens and parks have interested me most keenly as far back as I can remember, and in years gone by I have published, in one place or another, a number of articles about them, in which I have attempted to point out what extremely valuable institutions they are to any civilized community of people.

Within the past few weeks I have made quite a number of photographs in the National "Zoo," including some of the principal buildings, the animals and views. Some of these were taken for a definite purpose, to which they have already been applied. Others were taken to help illustrate a book I am writing on animals; while a few have a special interest for me on other accounts, and some of these I am using to illustrate the present article, as, for example, the superb specimen of the Kadiak bear shown in Fig. 1. This is the largest carnivore existing on this planet to-day, and is, as in the case of so many of our famous mammals, gradually, but very surely, being exterminated.

There are a number of different species of bears in the collection of the National Zoological Park, as for example the brown bear of Europe, the black bear, grizzly, polar bears and others. They are placed upon exhibition by being confined in a series of cages, here shown in Fig. 1, with "dens" built in solid masonry and stone-work at their farther ends. Although well and regularly fed, and the general surroundings very beautiful, these poor fellows are by no means happy or contented. Bears are extremely active in nature, and delight in climbing trees and in cutting up all sorts of antics in the forests. These cages are doubtless the best that the limited funds at the disposal of the management will purchase; but any one who knows anything of a bear's needs, knows full well that it is a cruelty to keep them in such quarters as those in which they are now confined. These cages should be five or six times their present size, and running water should pass through them. There should be areas enclosed of soft ground for the bears to scratch and roll upon; and, above all, a number of trees, as large as possible, should be enclosed, in that they could climb to their heart's content. It is a truly pitiable sight to see these poor creatures try to "kill time" in every way that their tortured ursine minds can devise in these big rat-traps.

No one appreciates these facts more keenly than Dr. Frank Baker, the present superintendent of the gardens, and Mr. Blackburne, the head keeper—a big-hearted man who *knows* animals, and feels for them as though they were his own captured and caged relatives. But the fault does not altogether lie in any such quarter; for, were the necessary

FIG. 1. THE KADIAK BEAR; the largest carniverous animal in the world.

amount appropriated by congress every year to make this park what it really should be, a credit to the American nation and an educational center of the greatest magnitude and importance, no such daily, hourly acts of cruelty would be perpetrated, and the kind of article I am now writing would never have been thought of, much less penned.

It is truly a marvel that so much has been accomplished at our "Zoo" with the meager means that the government allots for the purpose. This year $100,000 has been appropriated for the purchase of more land to be added to its present acreage, which is something,—a step in the right direction for the future; and were it backed up by half a million more, to be expended on what is now possessed and on its inhabitants, it surely would be a matter for national congratulation. But with salaries that would make a car conductor blush to receive; a third of the rare animals housed in hat-boxes; *no aquaria* or reptile house worthy of the name,—it's no wonder we are criticized. The idea of a park, a "zoo" like ours, with no photographic gallery, and no prosector or anatomical laboratory and work-rooms!

One of the grandest sights in our National Park at Washington is the great flying-cage for large-sized living birds. This immense wire structure is no less than 150 feet long, and 50 feet high and wide. I have photographed it both inside and out, and reproductions of these photographs are here shown in Figs. 2 and 3.

The picture shown in Fig. 3 gives a good idea of the interior of this elegant structure, which is situated in a very attractive spot, the surroundings being forest, stream and wooded hillside. Two black-bellied tree ducks (*Dendrocygna autumnalis*) are seen at the edge of one of the swimming pools in Fig. 3, and fine examples of pelicans, water turkeys, night herons, gulls, cranes, storks and their many allies live most happily in this enormous and attractive cage,—indeed, so attractive has it been made, and in such a secluded spot, that the wild herons come every year and build their nests on the top of it, in the vines there running over the wire. It is truly a grand sight and one of the redeeming features of the place.

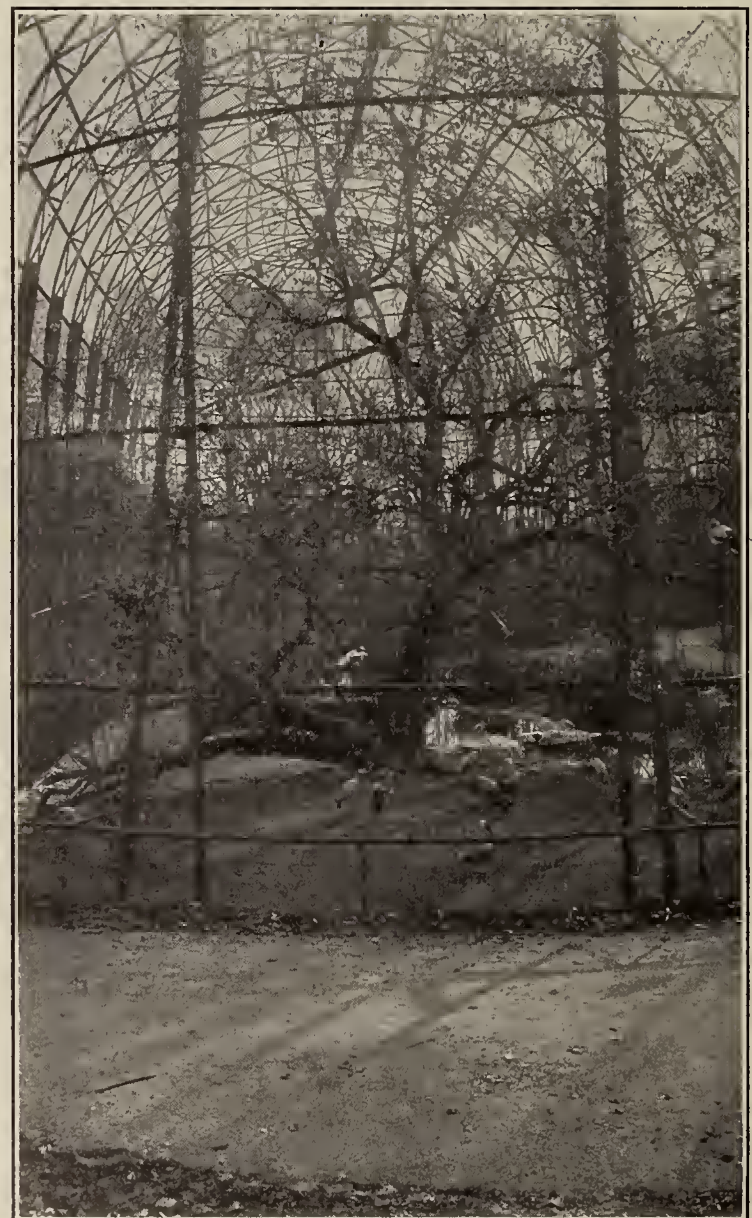

Fig. 2. The Flying-cage for Large Birds.

Fig. 3. Scene inside of Flying-cage.

Some of the paddocks for deer, moose, caribou and the like are as fine as can be found anywhere in the world, and the animals inhabiting them are probably as contented and certainly as comfortable as their relatives enjoying their freedom in their native wilds. One of my pictures (Fig. 4) gives a view of one of these paddocks in which deer are confined; it is just this side of the flying-cage, which may distinctly be seen through the trees in the background. There is a beautiful bunch of deer in sight, and it is easy to recognize the ideal conditions under which these elegant animals are kept. Even the skeleton wire-fence which surrounds their paddock fails to mar the general effect of the naturalness of the locality, which is greatly enhanced by the attitudes assumed by the deer, each being the very exemplification of alertness and curiosity as to the intentions of the photographer.

All the animals at the park, however, are by no means living under such ideal conditions; in fact, the lives led by some—altogether too many of them—are fit subjects for the action of the Society for the Prevention of Cruelty to Animals, and it is only a short time ago that the secretary of the Smithsonian Institution was compelled to print in his annual report that

It has been possible to make some needed improvements in the roadways of the park during the year, but many of the buildings are almost falling down. The need of means to put a permanent shelter over the animals can not be overstated. Mention has already been made in this relation of the aquarium building, which consists of a literal barn, and which was brought here until Congress could provide a special one; but although several years have elapsed, none has yet been provided. The elephant house, a small wooden shed, put up

Fig. 4. One of the Deer Parks in Winter.

as a temporary expedient ten years ago, requires extensive repairs to prevent it literally falling from rottenness.

As I say, the aquarium project has now been abandoned, and a nation of 90,000,000 of people must be satisfied with the dozen or more well kept, thoroughly inadequate and small aquaria at the building of the U. S. Fish Commission in Washington as the extent of the facilities for the study of living fishes in confinement; a few trout, turtles, bass, and *gold fish* which, as far as they go, in a measure instruct the people, and *certainly* amuse the scientists. But when we come to think what an immense problem in economics our fisheries presents, and how vitally important it is for us to study them in every possible way, both in nature and in aquaria, the negligence of congress in not amply appropriating money for the proper and extended prosecution of such enquiries by the scientific staff of the government is simply an indication of national inefficiency, and one of the trade marks of a backward, second class civilization.

At present, the one eagle cage that has been built is very good, as far as it goes; it has, however, been filled to its maximum capacity, and we find a superb specimen of the South American condor and a harpy eagle of great value cooped up in miserably small quarters, where, in the case of the latter bird, he can not enjoy the sunlight that his very nature craves.

Every intelligent naturalist and psychologist knows what wild animals of all kinds hourly suffer when confined for months—sometimes for several years—in small cages, pits and pens; their mental suffering is terrible, and only equaled by that endured by some highly educated person similarly confined. It is by no means an elevating sight to watch the pitiable efforts they make to relieve the terrors of what amounts to a great deal more than the mere loss of liberty; for it often means to them loss of companionship, sunlight, proper exercise, adequate amusement, and everything else that conduces to make even the life of a monkey or an elephant worth living. Still, if we close our eyes to all this and continue to hope that we may, some day, really have a congress that will appreciate these things, and do its duty by them, there is much to learn by a visit—or many visits—to our National Park.

Apart from my studies of the many animals there, it has, ever and anon, been a matter of delightful surprise and satisfaction to me when, at some unusual time and perhaps only two or three people—aside from keepers and others—could be found in the place, I have come upon some enthusiastic boy, vigorously at work with pencil, color or brush, in front of one of the cages, doing his best to faithfully portray its inmate. Ah, I've thought to myself then, may be a coming American animal painter; and, if it really turns out to be so in the future, not a few of the thousands of dollars congress has appropriated for this necessary project will have been more than well expended; for a world-wide known painter of animals is calculated to shed more real credit upon a nation than is an entire army of imported criminal good-for-nothings down in the east side of New York City or any other American city. All this likewise applies most forcibly to the nature classes we occasionally see at the Zoo,—the sculptor in search of correct poses of animals for his art; the scientific taxidermist; the artist and the biologist, and an hundred others of the classes that make up the great scientific, artistic and learned body of people of the country.

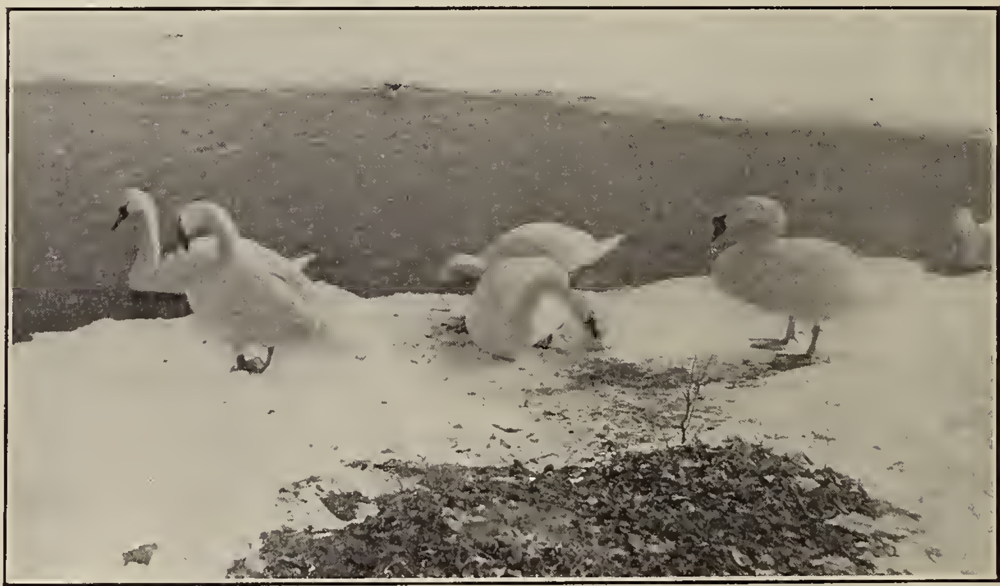

Fig. 5. Wild Swans in Winter. (Feeding Grounds.)

We must be patient, however, and all will come to pass in due time; even congress delights in making generous appropriations to national *successes*,—but to make the venture a veritable success, there's where the rub comes.

What we really need, in addition to what has already been put on foot at our National Park, is the establishment, on a broad basis, of a thoroughly equipped department of photography for the animals kept there, and what is even more important, a department of anatomy, with a recognized anatomist at its head. It should be his duty to make as complete a report as possible on the anatomy of every animal that dies at the park, and such reports should be fully illustrated and prepared for publication in any appropriate government avenue. There should also be a laboratory established for this purpose, and such material as came to the dissecting table worthy of preservation should, together with the skeleton of the animal, be sent to the National Museum for the department of comparative anatomy—a department that, at one time, was the envy of scientific Europe and the greatest possible credit to American science.

THE DISCOVERY OF CONTACT ELECTRIFICATION

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THE discovery that the mere contact of two dissimilar metals causes them to become oppositely electrified seems to be everywhere attributed to Volta, though Nicholson in the first volume of his "Journal," published in 1802, calls attention to the fact that both Bennett and Cavallo, in England, had made experiments upon contact electrification previous to its supposed discovery by Volta. The fundamental experiment from which Volta made this discovery is said by Auerbach in Winkelmann's "Handbuch der Physik" to have been announced by Volta in 1795, in Gren's *Neues Journal der Physik*, Vol. II., p. 144. The experiments which Volta, himself, seems to have regarded as fundamental in his theory of contact electrification were published in a postscript to a letter to Gren in Volume IV. of the *Neues Journal*. These experiments were not only the same in character, but were performed in the same manner and by means of the same apparatus as experiments which had been performed about ten years earlier by Bennett, and which had been published in a book to which Volta was a subscriber.

The actual discoverer of contact electrification seems to have been the Rev. Abraham Bennett, curate of Wirksworth, Derbyshire, who is known in the history of electricity as the inventor of the gold leaf electroscope, which still bears his name, and of a multiplier for increasing by induction the intensity of a given charge so as to render it measurable by an electroscope.

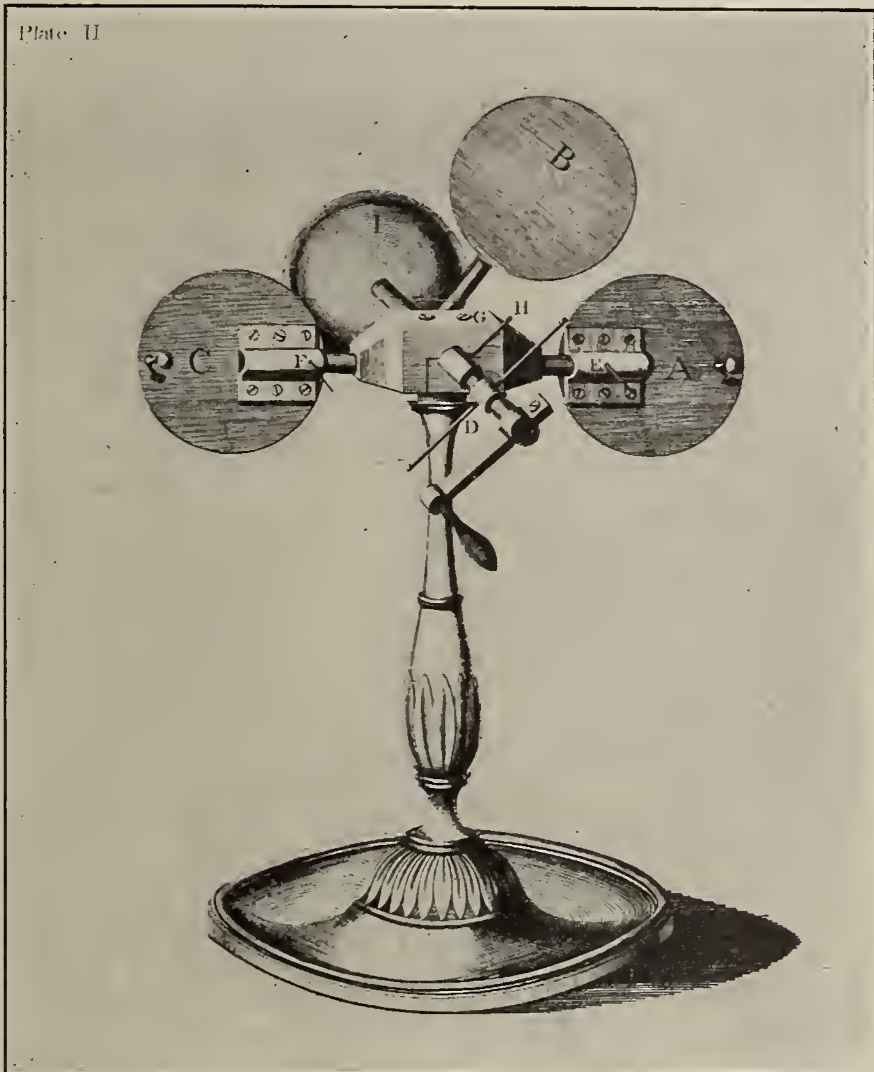
In 1789 Bennett published a small book entitled "New Experiments on Electricity," in which he gives an account of many of his discoveries and describes the construction of his electroscope and doubler, as well as the mechanical improvements made in the latter by Dr. Erasmus Darwin and William Nicholson. This book was published by subscription and contains a list of 394 subscribers, including many of the best known scientific men of the day, and among the rest, "Mr. Volta, Professor of Nat. and Exp. Philosophy." Volta had then been for ten years a professor in the University of Pavia, and had corresponded for some years with English physicists, notably Priestley and Cavendish, and only two years later was made a foreign member of the Royal Society.

Section VII. of Bennett's book is devoted to "Experiments on the Adhesive Electricity of Metals and Other Conducting Substances." In performing these experiments Bennett made use of Nicholson's improvement upon his own "Doubler," an invention which he had described in Vol. 77 of the *Philosophical Transactions.* Previous to this Volta had increased the sensitiveness of an electroscope by mounting condensing plates upon it, and Cavallo had still further increased its sensitiveness by using a double condenser. Bennett's first doubler consisted of three brass plates, one of which was mounted upon the standard which supported the gold leaves of his electroscope. The others were provided with insulating handles and were varnished on one side. When the electroscope had been given a small charge, one plate was laid with its varnished side upon the electroscope plate and touched with the finger. It thus received by induction a charge opposite to the charge of the electroscope. It was then raised from the electroscope by its insulating handle, and the other plate was laid with its varnished side upon it and touched with the finger. It accordingly received by induction a charge like the charge of the electroscope. It was then touched by its edge to the electroscope plate with which it divided its charge. Both unmounted plates were then discharged, and the process was repeated. By sufficient repetition the charge of the electroscope could be built up to any desired intensity.

Bennett's doubler was improved by Dr. Erasmus Darwin by mounting the plates upon horizontal arms which could be swung into and out of position readily, and later by mounting the plates vertically and moving them back and forth by a rack work in a direction always parallel to each other. In this form it was used by Darwin in the study of atmospheric electricity.

Bennett had noticed that his plates nearly always had a residual charge of electricity which made it possible to build up a charge on his electroscope without giving it a preliminary charge. To get rid of this he improved Darwin's form of the doubler by leaving the plates unvarnished and depending upon the air for insulation. He found that this made it possible for him to thoroughly discharge the apparatus, so that no charge could be built up until a preliminary charge had been given to the electroscope.

Soon after this Nicholson built a doubler in which two of the plates were fixed and the movable plate was mounted on an arm and turned about an axis by a crank, by which the proper contacts were also automatically made. This doubler Nicholson presented to Bennett, and it was used by him in his investigation of the "adhesive" effects of electricity. Bennett's original figure of this doubler is here reproduced. In this figure *A* is the fixed plate which remains permanently insulated and upon which it was desired to build up the charge. *B* is the movable plate which is carried on an arm from an axis which may be turned by a crank, and *C* is a fixed plate which may be either insulated, joined to *A* or joined to earth. *I* is a ball which serves to counterpoise the crank and the plate B so that B may be stopped in any position. When the crank is turned B passes alternately in front of and parallel to A and C. The contacts are so arranged that when B is parallel to A it is joined to earth and so charged oppositely to A. It is then revolved in front of C, at which instant C is joined to earth and is charged by induction oppo-



sitely to B and like A. As B again comes in front of A, A and C are joined and B is earthed. B now receives by induction a greater charge than before, since A has now received the greater part of C's charge. By successive revolutions of B the charge may thus be built up to any desired intensity upon A.

Bennett performed many experiments with this doubler, and after learning how to discharge it completely he tested the electrification induced upon metal plates by being placed in contact with various substances, both solid and liquid. He concludes that different substances "have a greater or less affinity with the electrical fluid," and he then undertakes his experiments on this adhesive affinity in the case of different metals.

At the beginning of Section VII., page 91, he says:

> Having fully proved by a frequent repetition of experiments, that the positive or negative spontaneous charge of the doubler depended upon the absorption or repulsion of the electrical fluid by the approximation of its parallel plates, and that by applying larger plates covered with minium or flour its electricity might be changed at pleasure, it easily occurred, that if the spontaneous electricity in the beginning of the process was sufficiently weak, the mere contact of metals or other substances having a different adhesive affinity with the electrical fluid might also change it, and a new and interesting employment for the doubler be discovered.
>
> This supposed effect of contact was confirmed by the following experiments, in which the doubler and electrometer were deprived of electricity, and used with the precautions and improvements mentioned in the last section.
>
> EXPERIMENT I
>
> The spontaneous charge of the doubler having been negative, and being deprived of this charge by the usual method, the plate *B* was placed parallel to the plate *A*, but so that *B* was not connected with the earth. The plate *A* was then touched with the blade of a knife, and the plate *B* at the same time touched with the point of a soften'd iron wire. With sixteen revolutions the gold leaf diverged about one third of an inch positively.
>
> EXPERIMENT II
>
> The doubler being deprived of electricity as before, and the plate *B* placed as in the last experiment, the knife was applied to *B* instead of *A*, and the soft iron wire to *A* instead of *B*, which opened the gold leaf negatively at 15 revolutions.
>
> These experiments were repeated very often, and the electricity changed each time, being always positive in the plate touched by the knife.
>
> To distinguish so minute a difference of adhesive electricity, as that which might be supposed between two metals so nearly alike as hardened steel and soft iron, wou'd appear incredible had not the frequent repetition of experiments confirmed it.
>
> Being now well convinced of this fact I tried many other substances with various success, sometimes the charge wou'd change regularly for a long time together, by applying the opposed substances to *A* and *B* alternately, as in the above experiments; and sometimes with other substances the charge wou'd be quite uncertain.

Bennett gives his experiments with six pairs of substances, each pair being tried about ten times. The charges given by contact to the plate *A* of the doubler were as follows: steel +, ironwire —; lead ore +, lead —; lead —, iron wire +; lead ore +, iron wire —; tinfoil —, iron wire +; zinc —, iron wire +.

He then tried charging the plate *A* of his doubler by a single substance while *B* was earthed. He found *A* to take a positive charge from lead ore, gold, silver, copper, brass, regulus of antimony, bismuth, tutenag, mercury, various kinds of wood and stone. Zinc and tin gave negative charges to his plate.

Here is apparently the beginning of that arrangement of substances which has since come to be known as Volta's Contact Series. It is well to bear in mind that these experiments were published in 1789, two years before Galvani made his celebrated observation on the twitching of frogs' legs which finally led up to the controversy through which Volta discovered the electric current.

The next experimenter to investigate the subject of contact electrification was apparently Tiberius Cavallo. Cavallo was an Italian by birth, but was a resident of London and a prominent member of the Royal Society. Cavallo published "A Complete Treatise on Electricity," which went through a number of editions. In the fourth edition, published in 1795, he adds a new volume containing the important discoveries in the subject since the publication of the third edition. Among these he gives first place to the investigations of Galvani and Volta on animal electricity, and mentions the fact that Volta suspected the phenomena might be caused by the contact of two dissimilar metals. He refers to Bennett's experiments, but says that others who have repeated them have obtained inconstant results. Finally he hit upon a different method of experimentation which enabled him to detect with certainty the electrification due to metallic contact. In his section devoted to experiments on metallic substances he says:

After many fruitless attempts, and after having sent to the press the preceding part of this volume, I at last hit upon a method of producing electricity by the action of metallic substances upon one another, and apparently without the interference of electric bodies. I say apparently so, because the air seems to be in a great measure concerned in those experiments, and perhaps the whole effect may be produced by that surrounding medium. But though the irregular, contradictory, and unaccountable effects observed in these experiments do not as yet furnish any satisfactory theory, and though much is to be attributed to the circumambient air, yet the metallic substances themselves seem to be endowed with properties peculiar to each of them, and it is principally in consequence of those properties that the produced electricity is sometimes positive, at other times negative, and various in its intensity.

The discovery of those properties of metallic bodies opens a new field of useful investigation, and renders more manifest the general or extensive influence of a fluid wonderful in its nature and action. But how far they will enable us to explain the phenomena of animal electricity, and of other operations of nature, are considerations which will be noticed after the recital of the experiments.—In this account I shall endeavor to select and methodise the experiments, in the best manner that the irregularity of their results seems to admit of.

Exp. I. A piece of zinc, which weighed little more than half an ounce, was dropped ten times successively upon an insulated tin plate. This plate was then brought in contact with the plate *A* of the multiplier: the lever was worked, and after ten additions of electricity, the plate C[1] communicated to the electrometer a sufficiently sensible quantity of positive electricity, which shows that the tin plate had been electrified negatively by the contact of the zinc. This experiment was repeated four times within the space of half an hour, and was constantly attended with the like effect; but on the following day the effect was found to be less conspicuous, for three times twenty additions just enabled the plate C to communicate a sensible degree of positive electricity to the electrometer. In short, the different states of the atmosphere seem to be much concerned in the result of this experiment, and yet the whole effect can not be attributed to it; but of this further on. Before, however, I proceed to the narration of other experiments, it will be necessary to dwell a little longer on the above-mentioned operation, not only to render it more intelligible, but likewise to avoid repetitions.

The tin plate used in the preceding as well as in many of the subsequent experiments, measures eight inches in diameter; and is fastened to a small piece of wood about three inches in length. Two glass sticks covered with sealing-wax are cemented into this piece of wood, and their other extremities are cemented into a larger piece of wood, which forms the stand or basis of the instrument. The operation is as follows: I hold this apparatus by the last mentioned piece of wood in my left hand, and keeping the plate in an horizontal situation, let the piece of zinc or other metallic body, fall upon it from my right hand, which I hold a few inches above the plate; then by inclining or shaking the plate, the piece of metal is caused to fall upon the table or upon a chair; from whence I take it up, and again let it fall upon the tin plate, and so on.

Cavallo repeated this experiment with a considerable number of metals, and with great precautions to guard against any other source of electrification. He found that repeated touching with an insulated body gave no greater effect than a single contact. He tried lifting his pieces of metal with iron tongs, or in a metal spoon, and found that in some cases this changed the sign of the electrification. He then performed a long series of experiments on the effect of heating the metals, and found a change in their electric properties due to temperature. In the case of bismuth, he was able to change the sign of the electrification produced on the tin plate by heating the bismuth very hot. His experiments upon the temperature change in contact electrification were almost the only ones made for a hundred years, and were probably the most important ones that have yet been published. At the end of his experiments he stated the following conclusions:

1. The contact of one metallic substance with another generally produces electricity.

2. The quantity and quality of the electricity so produced, is various according to many circumstances which seem to concur in the production of it, or in great measure to influence it.

3. Those circumstances are, the various nature of the metallic substances, their various degrees of heat, the state of the atmosphere, and the other body concerned in the experiment, viz. the hand of the operator, etc. Each of those causes has a share in the result of the experiment; for the variations of any one of them, when everything else remains unaltered, produce different effects. Thus in different states of the atmosphere, the very same metallic substances treated

[1] Cavallo used his own form of multiplier in which the plates were not named as in Bennett's figure.

in exactly the same manner, produce a greater or less quantity of electricity. Thus also, by only heating or cooling the metals, the electricity may be varied in quantity and even in quality.

I am inclined to suspect, that different bodies have different capacities for holding the electric fluid, as they have for holding the elementary heat; if however the experiments relative to this subject be carefully tried, under all the variety of circumstances which the combination of the above-mentioned causes is capable of producing, I do not doubt but that all the phenomena observed in the preceding pages may hereafter be reconciled to one, or to a few, simple laws, which will at the same time assist the farther investigation of the science of electricity.

These experiments of Cavallo's could not have been made later than the year of publication, viz., 1795. While Cavallo says in his discussion of animal electricity that Volta suspects that the phenomena of muscle contraction which Galvani and he were studying might be caused by the contact of the two dissimilar metals which were used in making the connection between the muscle and the nerve in many of their experiments, yet Volta seems not to have actually experimented with contact electrification until after the publication of Cavallo's treatise, and then to have begun with the repetition of Bennett's experiments made ten years before.

There seem to be many diverse statements as to how Volta arrived at his theory of contact electricity, but his own story of it is given in a so-called letter to Dr. Gren, which was published in volumes III. and IV. of Gren's *Neues Journal der Physik,* in the years 1796–98. These journals are not accessible to the present writer, so their exact date can not be given, though Vol. IV. was concluded in 1798. Volta's letters to Gren are translated in the *Philosophical Magazine* of 1799, from which the extracts here given are quoted.

In the first part of Volta's letter, which was published in Vol. III. of Gren's *Journal,* Volta says:

The contact of different conductors, particularly the metallic, including pyrites and other minerals as well as charcoal, which I call dry conductors, or of the *first class,* with moist conductors, or conductors of the *second class,* agitates or disturbs the electric fluid, or gives it a certain impulse. Do not ask in what manner: it is enough that it is a principle, and a great principle. This impulse, whether produced by attraction or any other force, is different or unlike, both in regard to the different metals and to the different moist conductors, so that the direction, or at least the power, with which the electric fluid is impelled or excited, is different when the conductor *A* is applied to the conductor *B,* and to another *C.* In a perfect circle of conductors, where either one of the second class is placed between two different from each other of the first class, or, contrariwise, one of the first class is placed between two of the second class different from each other, an electric stream is occasioned by the predominating force either to the right or to the left—a circulation of this fluid, which ceases only when the circle is broken, and which is renewed when the circle is again rendered complete.

Farther along he says:

We might consider this mutual contact of two different metals as the immediate cause which puts the electric fluid in motion, instead of ascribing that power to the contact of the two metals with the moist conductors. . . . In both suppositions the result, as may be easily seen, is the same. But though I have reasons for adopting the first as true rather than the second, yet the latter represents the proposition with more simplicity, and it may be convenient to adhere to it in the explanation, as it affords a readier view of it.

In a postscript to this letter published the next year (1797 or 98) Volta says:

Some new facts, lately discovered, seem to shew that the immediate cause which excites the electric fluid, and puts it in motion, whether it be an attraction or a repulsive power, is to be ascribed much rather to the mutual contact of two different metals, than to their contact with moist conductors. But though it can not be denied that in the latter case there exists an action, it is proved that it exerts itself in a far more considerable degree when two metals mutually touch each other. There arises by the mutual contact, for example, of silver and tin, an action or power by which the former communicates the electric fluid, and the latter receives it; or the silver suffers it to escape and the tin attracts it. This produces, when the circle is rendered complete by moist conductors, a stream, or continual circulation of the fluid. When the circle is complete, there is an accumulation in the tin at the expense of the silver; which indeed is very small, and far under the point necessary to enable it to announce itself by the most delicate electrometer. I have however been able, by the assistance of my condenser, constructed on a new plan, and still better by Nicholson's doubler, to render it very perceptible: I shall here communicate the result obtained by my experiments, which I made some time ago with great satisfaction.

Exper. I. The three plates of the doubler are of brass. I took two strong wires, one of silver and the other of tin, and brought the former into contact with the movable plate, and the other with one of the fixed plates; while they both rested on the table, or, what is better, on moist pasteboard, or any other moist conductor, so as to be in communication by the intervention of one or more conductors of the second class. I suffered the apparatus to remain some hours in this state, then removed the two wires and put the machine in motion. After 20, 30 or 40 revolutions (or more when the atmosphere was not dry, or the insulation imperfect) I brought one of my straw electrometers into contact with the movable plate, and observed indications of positive electricity ($+E$) which arose to 4, 6, 10 degrees, and more. If I suffered it to touch the fixed plates, I had the corresponding indications of the opposite kind of electricity ($-E$).

The silver, therefore, poured the elastic fluid into the brass plate when it had been some time in contact with it; and the tin attracted it from the other plate, which was also of brass, while in contact with it. This was confirmed by the following experiment, which is a real *experimentum crucis.*

II. I reversed the experiment, so that the silver was in contact with one of the fixed plates, and the tin with the moveable one. The electricity which I obtained from the latter, after the apparatus had remained a sufficient time in that position, was negative ($-E$); while that of the fixed plate was positive ($+E$).

III. This is the reverse of the former. The piece of tin was applied to one of the fixed plates, and the moveable one was insulated from all metallic contact. The result was now reversed; that is, the fixed plates were electrified negatively, and the moveable one had positive electricity.

Volta then varied the experiments, just as Bennett had done, by applying the tin wire only to the movable plate and testing its charge, and then to the fixed plate, and repeating the process. He then replaced the movable brass plate of the doubler by a tin plate, and using brass and tin wires for touching the plates, he found that he got a charge by touching his brass plate with a tin wire and his tin plate with a brass wire, but got no effect when he touched the plates with wires of their own metal. He then says:

> We must therefore conclude that the contact of two metals of a different kind with moist conductors, without the mutual contact of these metals themselves (which is wanting in the sixth experiment, where brass is in contact with brass, and tin with tin), produces nothing or almost nothing; and that, on the contrary, the mutual contact of the two metals of a different kind, which takes place in the fifth experiment, produces the whole, or almost the whole, effect.

The above considerations seem to make it certain that though Volta was apparently the first to recognize the existence of a current in a circuit composed of two metals and an electrolytic conductor, he has no claim to be regarded as the first discoverer of contact electrification. This honor should undoubtedly be accorded to the Rev. Abraham Bennett, while the discovery of the variation of the phenomenon with temperature is due to Tiberius Cavallo.

THE APPLICATION OF THE PHYSIOLOGY OF COLOR VISION IN MODERN ART

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Introduction

LEONARDO in his treatise on painting says:

> Those who become enamored of the practise of the art without having previously applied themselves to the diligent study of the scientific part of it, may be compared to mariners, who put to sea in a ship without rudder or compass and, therefore, can not be certain of arriving at the wished-for port. Practise must always be founded on good theory.

Instead of serving as an incentive to more extensive study of the use of colors in art, these words seem to have marked the advent of an epoch extending over several centuries, during which colors came to be less and less successfully employed. The ideals of art came to be dictated by the academic painter and they were much more mythological and allegorical than founded on the beauty of color patterns. Much of art became black painting, little attempt being made to use pure colors even in landscape painting, and no consideration being given to the effects which could be produced by the influence of juxtaposed colors on one another. With the exception of some masters the ideal of artists was merely to reproduce as closely as possible the color tones and values as seen in nature—to produce a colored photograph without adding to it that mysterious something for which is responsible the peculiar charm and strength of the paintings of the early Italian masters and of the Chinese and Japanese, and which includes some subtle influence of the picture itself quite apart from what it represents; something that endows it with a charm that is all its own, and which no colored photograph can ever contain.

It is true that from time to time in the history of modern art masters have arisen who have, intuitively as it were, produced pictures the color schemes of which have contained this "something." But it is the individual rather than the system that has been responsible, and no attempts have been made until comparatively recently to evolve new principles for the use of colors which would serve as a guide to all; nor indeed was such an evolution possible until some progress had been made in the scientific interpretation of color. This progress is itself only of comparatively recent date.

At the present day there is an unrest in the world of art, an unrest which has resulted in the creation of innumerable schools, each endeavoring by some peculiar method of its own to inculcate new principles and to establish new ideals. Within a short period of time realism has given place to impressionism, impressionism to post-impressionism, and this again has become parent for so many other "-isms," that, to follow them, has become almost impossible. However unpictorial from our ordinary viewpoint the creations of some present-day artists may appear to be, there is nevertheless in many of them some newly discovered truth; they are the steps in an evolution, and we may hope that some day the evolution will be consummated and that from out of the apparent chaos, which at present exists, a really compelling picture will be created.

It is most of all in landscape painting that the evolution of modern art can be seen. The old landscapes of Claude Lorrain and Constable are no doubt full of charm, but they entirely lack the atmosphere and force of the so-called impressionist paintings of Monet, Sisley, Pissaro, etc. In the older landscapes an attempt was made to copy everything that could be seen by prolonged study, and the canvas was covered with detail to its very edges; in impressionism, it is merely the flash, the fleeting effect of the landscape which it is attempted to reproduce. There may indeed be considerable detail in certain portions of the picture, but the greater part is merely a color pattern. But after all such an impressionistic picture can occupy our attention for a moment only. We do indeed receive an impression more or less like that which the artist received on viewing his object, but closer study of the picture does not carry us farther; there is something absent from it with which nature abounds, something that compels us, as when viewing a landscape, to keep shifting our gaze from point to point, a restlessness, a constant source of interest and fascination. In post-impressionism the attempt is being made to supply this want, to compel us namely to regard more than the fleeting impression. The closer we study such a picture, if it be successful, the more comes out of it, colors by their influence on one another become changed in hue and saturation, a curiosity develops and, subconsciously, we are compelled to continue our study with the result that we get ever other and other effects. It is kinetic, not static, art; it is a pattern of nature designed to create visuo-psychic impressions expressing an idea rather than an object, subjective rather than objective.

There is a physiological reason for this visual restlessness and before we go into the science of colors it may be well to explain what this reason is. The innermost layer of the eye, on to which images of exterior objects are focused, is specialized to react to sensation of light, thus setting up nerve impulses which are transmitted to the brain where they are interpreted. This layer of the eye is called the retina and it is very much more sensitive at a small spot in the center than it is over the much larger outer (peripheral) portions, so that, of the image which is focused on it, it is only that part falling on the central portion which is distinctly seen. When we regard a stretch of country, for example, it is only in one part of it that the objects are seen in any detail—namely that part which is focused on the central portion of the retina—the remainder, since it falls on the outer portion, causing only a vague, indefinite impression. We may say indeed that the function of the greater part of the retina is merely to give us a general impression of the environment of the object which is being looked at; an impression, that is to say, which will enable us to judge of its relationship to other things. It tells what else there is to look at, and subconsciously we shift our gaze so that, piece by piece, the whole landscape comes to be focused on the central portion. We regard with the central portion what we know exists to be regarded on account of the duller image thrown on the rest of the retina.

Coming now to the question of color, any attempt to apply the scientific principles of color vision in making a picture must surely fail if it be not granted at the outset that it is only to a limited degree that those principles can apply. Color appreciation is as much a psychical as a physiological process, and indeed it is psychical not only with regard to the objective impression itself, but also with regard to the subjective, the associational mental process. Previous knowledge and training, experience, tradition, the association of color impressions with impressions previously received through other senses and stored away as memories, all play a part in determining the effect which a color or a pattern of opposed colors, has upon us. But even granting all this, there are many of the physiological laws of color vision which must be adhered to before we can expect to produce these effects.

In attempting to show how these laws may be employed in art it will be necessary for us to explain briefly some of the physical and physiological observations upon which they depend. The first of these is a physical one: it is the dissociation of white light into the spectral colors by means of a prism, or better, by means of a diffraction grating.[1] The spectral colors are red, orange, yellow, green, blue (indigo) and violet, the various shades of purple being entirely absent. When we look at such a spectrum we are at once struck with the fact that the colors differ from one another not only in their hue but in their brightness or luminosity, the yellow and the immediately adjacent portions being much brighter than the others. At once then we recognize two

[1] In the light decomposed by a prism some hues, such as those of red and yellow, occupy much less space than others, such as blue, although they do not correspondingly differ in wave-length. When light is decomposed by a diffraction grating (a glass plate ruled with very fine equidistant lines) the spaces occupied by the various hues are proportional to their differences in wave-lengths.

physiological properties for each spectral color, *hue and brightness.* There is, however, another property of colors as seen in nature which is absent in the spectrum, namely saturation. This refers to the degree of white light with which the color is mixed. It is more or less related to the artist's "value" which expresses the translation of the colors into gray.

The most characteristic of these properties of colors is their hue, and for the present we shall confine our attention to this. To understand what the hue is due to we must remember that rays of light exist in space as vibrations of the surrounding ether and that these vibrations occur at right angles to the line of propagation of the light rays. The rate of the vibration varies according to the hue. In other words, the light rays are made up of waves which are small and close together when the vibration is rapid, as at the violet end of the spectrum, and are large and wide apart when the vibration is slow, as at the red end. When these waves strike the retina they create impressions which differ from one another according to the wave-lengths. These differences we interpret as differences in hue. When the rays of the various spectral colors are reunited before striking the retina, the sensation which is created is that of white. This recombination of the spectral colors, which is called synthesis of colors, may in general be brought about in two ways: (1) by causing them to fuse together by means of some suitable optical device (such as a second prism, or reflecting mirrors) before they enter the eye, (2) by causing them to become superimposed upon one another on the retina in rapid succession, in which case the impression created by each color lasts for a sufficient length of time so that it becomes fused with those which succeed it. This result depends on the phenomenon of positive after-images; which can be demonstrated by momentarily regarding some brightly illuminated object and then closing the eyes, when the image continues to be seen for some time. Rapidly succeeding images therefore become fused into one composite impression. This retinal synthesis, as we may call it, is well illustrated in the impression produced by observing the spokes of a rapidly revolving wheel.

For experimental purposes it is brought about by using Maxwell's machine, which consists of circular cards painted in sectors with the various colors and which are caused to revolve around their centers by means of a motor. A spinning top may also be used for this purpose. By revolving a card painted with the seven spectral colors a sensation approaching that of white is produced,[2] by choosing various proportions of the spectral colors this white becomes tinted with all possible intermediate hues.

From these facts we might imagine that the retina contains a special

[2] It would be pure white were it possible to obtain artificial pigments that reflected none other than their own characteristic hues.

kind of sensory component for each of the seven spectral hues, that equal stimulation of all produces the sensation of white and that varying degrees of stimulation of certain of them, that of the hues which are intermediate between those of the spectrum.

Such a hypothesis could not however be of much practical value in explaining the color phenomena with which we have to deal in daily life. It had to be simplified. This was done by Thomas Young and Helmholtz, who discovered that three of the spectral hues, such as red, green and violet, or certain other triads, are sufficient, when mixed on the retina, to produce the same sensations as those which are produced by the seven spectral hues. These are known as *primary* colors; when equal quantities of each are used a sensation of white (or gray) results; when only red and green, the sensation is yellow; when green and violet, it is blue; and when violet and red, it is purple. Not only this, but the various intermediate hues can readily be obtained by altering the proportions of the primaries; thus, to produce orange a disc containing a larger proportion of red and a smaller proportion of green is used, and so on.

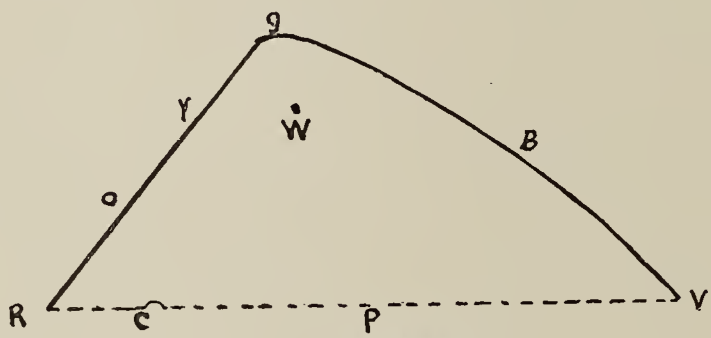

FIG. 1. COLOR TRIANGLE.

To represent these fundamental facts and hold them in mind the so-called color triangle has been constructed. At the angles of this triangle are placed the primary hues, the other spectral hues being distributed along its two sides at distances which are proportional to their wave-lengths and the purples along its base, which, since these hues are absent from the spectrum, is represented by a broken line.

But white light can be produced in still another way, namely by retinal synthesis of certain pairs of hues which on this account are called *complementary*. Thus red and greenish-blue, yellow and blue, orange and blue-violet are complementary. We may express this all-important fact by stating that for every spectral hue there is another which when mixed with it on the retina in approximately equal quantities produces the sensation of white. When other than equal proportions of complementary hues are chosen, colors are produced which are of hues intermediate between those of the complementaries and which are mixed with varying degrees of white. They are incompletely saturated colors. These facts may be satisfactorily represented by finding a point, called

W, inside the color triangle, so that any straight line passing through it will on striking the sides of the triangle join two hues which produce white. This method of finding the complementaries necessarily implies that they must be separated from one another by a considerable distance on the spectrum. For representing these facts a circle instead of a triangle may be employed, and for practical purposes, in the use of colors in painting, such a circle has been found more useful than the triangle. Before we proceed to explain its use, however, it may be well to indicate some of the applications which can be made in art of the facts we have already learned.

It is in pointilism that this application is most evident. In this method the pigments are laid down in minute areas or spots or lines so that, when the picture is viewed from a certain distance, the different hues act on the same nerve endings of the retina and therefore produce the same effect as if they had been superimposed, as by the use of Maxwell's discs. Thus, if a white surface be dotted over with red, green and violet, or any other primary colors, or with red and greenish-blue, or any other complementary colors, the surface at a certain distance will appear grayish white. If, in any of the combinations, one hue be in preponderance of the others the gray will become correspondingly tinted, so that a complete picture may be built up of areas which on close inspection are a mosaic of pure colors but appear at a distance as tinted grays.

The impressionists, Monet, Segantini, etc., appear to have laid as the basis of their picture a gray at the brightness (or value) which they desired each portion of it to assume. On these surfaces they then applied color more or less pointilistically. The neo-impressionists, such as Seurat and Segniac, on the other hand, went a step further in that the saturation was made to depend entirely on the synthetic principle. They laid on their pigments strictly in dots on a surface which was as nearly pure white as possible. Some of these neo-impressionists had, however, already begun to apply certain of the principles of color apposition in masses which we shall study later. To build up a picture pointilistically must obviously greatly increase the technical difficulties of the artist, especially with regard to outline and form; his freedom of expression is also seriously curtailed. It becomes necessary therefore that very great advantages should be the outcome of such labor. Among the advantages are the sense of atmosphere, the vibrating, scintillating quality of the color areas and the very satisfactory transitions at the edges between them, all of which are qualities that can be rendered in no way so satisfactory as by pointilism.

There can be little doubt that a great part of the peculiar impression produced by pointilism depends upon the slight movements which the eyeballs are constantly undergoing, even during our most intent fixation. This of course produces a certain amount of overlapping of the colors on the retina just as when they are superimposed by means of Maxwell's machine. In the same way vibrations of the eyelids by moving the eyelashes across the palpebral cleft assist the synthesis, this being made evident by half closing the eyes, a method often used in studying pictures.

The success with which the desired impression can be created in a pointilistic picture often depends upon the purity of the colored dots, its vibrating quality being at the same time much enhanced by leaving a narrow margin of white around each dot. When this is successfully done there comes into play another physiological process known as *flicker,* which can be experimentally produced by rotating discs with black and white sectors at a speed which is just insufficient to cause a uniform gray. The resulting flicker possesses a glittering quality which makes it appear of distinctly greater brightness than the gray which results from complete synthesis. The same thing may be seen by observing the spokes of a wheel revolving at different velocities. Instead of black and white the sectors may be composed of different hues.

In the flicker experiments the gray remains of the same degree of saturation at whatever rate the disc is revolving, provided it is revolving more quickly than is necessary to produce complete fusion, and so in pointilistic painting, when the picture is viewed beyond the distance at which fusion occurs the impression is practically that of the older painting. It must be viewed at a distance just short of that which is necessary to produce complete synthesis. The post-impressionists such as Cezanne, Matisse, etc., realizing this limitation in pointilism, have been searching after a method by which the color scheme maintains its effect on us at whatever distance the picture is viewed. The physiological principle upon which this depends is that known as *contrast,* and this we will now proceed to study. Being a property exhibited most strikingly in the case of complementary hues, it becomes necessary for us to have, besides the color triangle, some simple experimental methods by which the complementary hues may be determined. Such methods include the experiments of simultaneous and successive contrast, in connection with which many facts of fundamental importance in the use of pigments are brought to light.

Simultaneous contrast is illustrated by regarding a strip of gray against a colored field when the gray becomes tinted with the complementary hue. There are two simple methods for performing this experiment, one is to spin a colored disc, midway between the center and circumference of which is a circle, composed partly of black and partly of white; this synthesizes to a gray which becomes tinted with the complementary hue of the colored field. The other way is to lay a narrow strip of gray paper (cut as a zigzag) on a colored sheet and then to cover the whole with thin tissue paper; the gray will assume the complementary hue. No experiments in color vision are more striking than these, nor are there any that have more direct application in the use of colors in picture painting; thus, a gray wall viewed against a sun-lit background of green is no gray, but like the piece of paper in our experiment it becomes tinted of a purplish hue. Similarly, a shadow cast on yellow sand is blue and one thrown on the skin when this is otherwise in strong light often acquires a striking quality of green.

The phenomenon of *successive contrast* is elicited by steadily regarding a patch of a certain color for some time and then either closing the eyes, or better still, directing the gaze to a neutral surface, such as a gray untinted wall. A vivid color impression of the same shape as that of the colored patch previously looked at will be seen in both cases, but exhibiting a hue which is complementary to that of the patch.

In the experiments above described the complementary color is demonstrated by the use of a gray surface. It is evident, however, that, if we cause it to be projected against a background which itself possesses a certain hue, the two hues (the complementary and that of the regarded surface) will become blended and will have the same effect as if they had been spun on a Maxwell's disc. For example, suppose we regard for some time a blue surface and then direct the gaze to one of red, the impression will be that of orange, because the complementary of blue, being yellow, fuses with red and produces orange.

Having determined the complementaries by means of these contrast methods we may confirm our results by color synthesis; thus supposing we have determined by the contrast methods that the complementary for a certain yellow is a certain blue, we may proceed to ascertain whether this is strictly the case by preparing discs composed of these two hues and rotating them on Maxwell's machine. If the hues are complementary the greatest possible degree of whiteness will be produced.

Successive contrast finds only a limited application in art, although it is of course conceivable that the intensive fixation of one colored area in a painting, or a design, might, by successive contrast, greatly modify the colored impression created by shifting the eyes to another part. It is improbable, however, that any artist, either intentionally or unintentionally, has laid on his pigments with this object in view. Nevertheless, successive contrast may assist us greatly in the actual determination of the complementary hue. Thus, to take again our example of the gray wall against the green background, we may exaggerate the effect of the green on the gray by regarding the green for some time and then shifting the gaze to the wall, when its purplish hue will be found to be much intensified. On the other hand, simultaneous contrast is of paramount importance in art; indeed it is as important in the final impression produced by a painting or a design as any other quality which this may possess. This importance depends on the fact that when two colored surfaces are placed in apposition each becomes changed as if it were mixed to a certain extent with the complementary hue of the other; or if a gray or a tint of low saturation (see p. 460) is apposed against a saturated color field it will assume a complementary hue of greater or less saturation according to the relative area of brightness of the apposing areas. By applying these principles in picture painting unsaturated hues may be caused to assume much greater degrees of saturation while, if the apposition be false, hues in themselves of almost complete saturation may become dull and subdued.

To the artist it comes to be of the highest importance that he possess some easily remembered scheme by which he can predict these contrast effects. The color triangle may be thus employed, but a simpler, though perhaps less scientific device, for the same purpose is the chromatic circle of Rood. To construct such a circle we must know the wave-lengths of the various colors which we desire to contrast.[3] The differences in wave-lengths are then calculated so as to correspond to angular differences, these angles being formed by the radii of the circle. As in the color triangle, opposite radii will join complementary colors and the center will represent white light, *i. e.*, the nearer the center the less will be the saturation of the color.

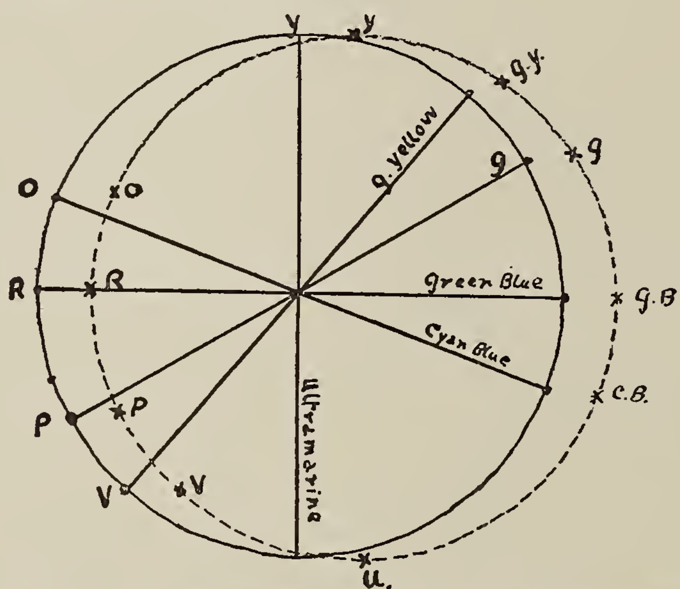

Fig. 2. Rood's Chromatic Circles as used to show the Influence of one Color on the others.

If one such circle, drawn on transparent paper, be superimposed on another, the effect which is produced by contrasting two colors can be readily ascertained. Thus, suppose we desire to determine the influence which red has when contrasted with the other colors. Having accurately superimposed the two circles we move the transparent one so that the point on it which corresponds to red is displaced along the line joining red and its complementary, blue-green. The colors on the upper circle will now stand in positions on the lower corresponding to the

[3] This can be done by comparing the colors with those of a highly magnified spectrum of white light alongside of which is a scale of wave-lengths.

changes in hue and saturation which they would have suffered by contrast with red. Thus orange will stand nearer the center and somewhat nearer yellow, whereas green-blue will merely be removed farther from the center, which means that orange will become less saturated and yellower, whereas green-blue will increase in saturation but be unaltered in hue.

In general we may say that the effect produced by contrasting two colors is to move them farther apart on the chromatic circle, thus causing mainly a change in hue in the case of colors that stand near one another, but making a change in saturation in those which are far apart.

In order that the contrast effects may be taken full advantage of, certain conditions must be fulfilled. The most important of these are as follows: (1) The complementary tint which gray assumes is most vivid when it is somewhat darker (*i. e.*, of less brightness, see p. 460) than the hue against which it is apposed, in the case of the warm colors (the reds, oranges and yellows), and when it is lighter in the case of the cold colors (the greens and blues). The dividing line between the warm and cold colors may be taken as that joining the complementaries, yellow-green and violet. (2) When a color of low saturation (*i. e.*, nearly a gray) is apposed to one of high saturation and of complementary hue, the former will become more saturated, and conversely, if two colors which are identical in hue but of unequal saturation be apposed, the paler one may appear gray. When they are not complementary, the hue which undergoes the greater change is that which is the paler. (3) The greatest effects are produced when the color field, whose hue it is desired to alter, is much smaller in extent than that of its complementary and when it is completely surrounded by the latter. By placing a thick black line between the areas the complementary effects may be suppressed. Thus, the complementary hue which a piece of gray paper placed on a colored field assumes when it is viewed through tissue paper becomes much less evident if a thick black line be drawn on the tissue paper at the edge of the gray. When the color areas are large it is at the edge only that the complementary influence is noticeable. On the other hand when a colored area is very small it undergoes no complementary change, but merely blends with the neighboring color. (4) To obtain full advantage of color apposition the colored patterns should be very simple and of similar texture and their surfaces should be broken up by detail to the least possible degree. (5) The most marked complementary effects are obtained when the opposing hues are of equal brightness.

When we attempt to employ the chromatic circle for another purpose, namely for determining what will be pleasing and what displeasing color combinations, we find that its use is somewhat limited. This is because a psychological influence enters into our judgment in such cases.

In general however it may be taken as a working hypothesis that good combinations are always more than 80°–90° apart on the circle, that is, they should be separated from one another by about one quarter of the circumference. Even complementaries may form displeasing combinations (*i. e.*, certain reds and greens), in which case, as Rood has pointed out, the hues are usually far removed from the line which separates those that are cold and warm. When we are compelled to appose hues having a hurtful influence on one another, the unpleasing impression which they create may be lessened by certain tricks, such as by assigning one of the hues to a much smaller field, or by decreasing the saturation of one of them, or by adding a third hue whose position on the chromatic circle is as far as possible removed from the others: thus the disagreeable effect of a yellowish-green and yellow is much improved by the addition of some violet, etc.

So far, for simplicity sake, we have regarded but one quality of a color, its hue, although in doing this it has been impossible entirely to neglect the closely related qualities of *brightness and saturation.* These we shall now proceed to consider.

Brightness is most marked, under ordinary conditions of illumination, around the yellow portions of the spectrum. It is a property which is exhibited in marked degree by different grays. Indeed it is measured by finding a gray which appears of equal brightness to that of a given color. Such measurements may be made with considerable accuracy by finding a gray background against which the color becomes indistinguishable when viewed by the very outermost portions of the retina which are color blind, that is, which see no hue in a color but only a grayness, the degree of which is proportional to the brightness of the color.[4] To make such comparisons, the person must regard a dot in the center of a plain black surface and must then gradually move a small piece of colored or of gray paper, mounted on a suitable handle, from the periphery towards the center of the surface. At a certain position the colored paper will be seen as gray because the rays of light from it are striking the color-blind areas of the retina. Various grays are used until one is found which matches exactly with that created by the colored paper. A still simpler method consists in rotating the color on a Maxwell disc along with a synthetic gray. In this case judgment of equality may however be somewhat confused, on account of the gray assuming the complementary hue.

Brightness plays a most important part in the phenomenon of con-

[4] The power to judge hue depends on the presence in the retina of peculiar nerve endings called cones. These are absent from the peripheral portions and only gradually make their appearance towards the center. There is, therefore, a region between the periphery and the center of the retina which is partly color blind, blue and yellow being perceptible, but red and green still appearing as gray.

trast, for not only is the simultaneous contrast of hues obtained most strikingly when these are of equal brightness, but we constantly experience brightness contrast itself. Thus pieces of the same gray paper placed on gray backgrounds of varying degrees of brightness do not look at all alike. It is particularly at the border between the two grays that contrast brightness is most evident. This subserves the function of creating a sharp border between the grays, and it can be demonstrated by causing strips of different gray papers to overlap one another like the tiles of a roof or, still more strikingly, by rotating a disc on which when spun appear three circles of different grays, each synthesized from black and white. In both experiments the grays, though really perfectly uniform, will appear as if shaded from their edges.

Since we measure brightness in terms of grayness, and since it is most marked at the yellow portion of the spectrum, it follows that if we desire, for successful contrast effects in picture painting, to appose yellows with blues or deep reds, we must employ some artificial means either to increase the brightness of the blues or reds or to decrease that of the yellows. This can be done by mixing the pigments with white (or black), that is to say, we may alter what the artist speaks of as the value of the color but which in so far as white is used for producing the alteration is more correctly called the saturation.

It may indeed be said that the object sought in mixing pigments with white (*i. e.*, changing their saturation) is to give the impression that their properties of brightness have been altered.[5] When it is desired to raise the brightness of a given color, we can succeed only to a limited degree by using more pigment; to obtain it further, we must, as already explained, employ the property of simultaneous contrast. These methods used by the artist to alter the brightness of his colors are however liable to have a dulling effect on the whole composition unless they are used with great care and judgment. When he is compelled to lower the saturation of one color he must be careful to apply those neighboring on it in such a manner as to give the impression that the whole of that portion of the picture is of the same brightness. This he may do, either by making his pigments of similar saturation or by assorting the size of the colored areas, so that they appear by contrast to be of similar saturation.

It is a well-known fact that our judgment of the relative brightness of colors, and to a certain extent of their hues, becomes altered when the conditions of illumination are changed. A picture viewed in broad daylight may create a very different impression from that which it produces in dull illumination. For example, its hues may be dull and muddy under the conditions of illumination that are ordinarily present in a dwelling, or even in a gallery, whereas when viewed in broad day-

[5] Brightness must be distinguished from color intensity which is purely a physical property and depends upon the amplitude of the wave-lengths.

light it may sparkle with brilliancy; or there may be very little change in the actual hues, but the portions of the picture which appeared to be of greatest brightness in broad daylight may in dull light actually shift to some other part. These changes are due to what is known as *adaptation of the retina.* The most striking illustration of this is furnished by observing the colors of a flower-border after sundown. Let us suppose that the border contains geraniums (scarlet), lobelia (blue), and coreopsis (orange). As darkness approaches it will be noticed that the red geraniums become duller and duller until at last they turn black; that the orange coreopsis also becomes more neutral, but that the blue lobelia maintains the same color qualities as it possessed in daylight. The most remarkable change of all occurs, however, not in the hues but in the relative brightness of the colors, for it will be noticed that the sensation of greatest brightness has gradually shifted from the reds and yellows to the blues and greens, so that the foliage and the lobelia may actually come to appear brighter than the coreopsis and the geraniums. It is needless to point out how important an appreciation of these adaptations must be to the artist, how careful he must be to paint his picture in the degree of illumination in which he expects it to be viewed. The physiological explanation of this adaptation is that the outer portions of the retina assume a much greater degree of sensitiveness in dull light, indeed they come to be more sensitive than the central portion itself. This curious change explains why without directly looking at it we may be conscious of the presence of a small light in the darkness—a star for example—which however disappears when we direct our gaze to it. The ability of the thus sensitized outer portions of the retina to judge colors differs from that of the central portion.

When we come to apply many of the principles of chromatics in art, we are met with difficulties which at first sight may appear to be insurmountable. In most instances, however, this is by no means the case, and we shall now endeavor to show how certain of these difficulties can be explained. First of all, with regard to the mixing of pigments as compared with the mixing of colored lights, of course the two processes yield very different results: for example, mixing yellow and blue lights, as we have seen, produces almost pure white, whereas mixing these colors as pigments, as every artist knows, produces green. The entire want of similarity in the results which follow the mixing of colors by the two methods has had the effect of making some artists conclude that the laws of chromatics are useless as guides in the practical use of pigments. But this is wrong, the apparent difference being really due to a very simple cause, namely to the fact that by mixing pigment we subtract color rays from entering the eye, whereas we add such rays when we mix colored lights. To make this clear let us return to our example of blue and yellow. When we use these as pigments, we must remember that the pigment particles have a certain degree of transparency so that light partly penetrates them, certain rays being then reflected and certain absorbed according to the hue. A blue pigment, for example, absorbs all constituent rays of white light except the blue and the hues which border on blue in the spectrum, it being impossible to procure pigments which are so pure that they do not let some other hues besides their own characteristic one pass through them. Similarly with yellow, it absorbs all the spectral rays save the yellow, the orange, and the green. Adding these two pigments together, we get every spectral ray absorbed except green, a certain amount of which both pigments have allowed to pass. In a similar way we can explain why blue and red give purple and why a mixture of all the spectral colors as pigments produces a dark gray of uncertain hue.

The above applies to a matt surface; when there is any trace of glaze there comes into play another factor which we must now consider, namely, surface reflection of some white light which has not penetrated the pigment particles at all and which therefore causes the color to be more or less unsaturated. It is by diminishing surface reflection of white light that the colors of a picture may be raised in saturation by subjecting it to alcohol vapor, which softens the medium and removes surface cracks. Reflection of white light also takes place at the surface of the pigment particles themselves and is greatly diminished when these are extremely small, hence the importance in the manufacture of pigments of thorough grinding. It is further minimized by suspending the pigments in oil, because this causes the light before it strikes the surface of the pigment particles to pass through a medium which is of approximately the same density as that of the particles themselves. This reduces the reflection, because the greater the difference of density between two media the greater the reflection of light at the interface between them.

The quickly vibrating (blue) rays of the spectrum tend to be reflected more readily than the slowly vibrating (red) rays, hence we often find that a substance is bluish by reflected light, whereas it is reddish when the light passes through it. It is indeed for this reason that during the day the sky looks blue, the light being reflected from the fine particles of dust and moisture which are constantly suspended in it, whereas after the sun has set it is red because the slanting rays come to be transmitted *through* these particles.

Artificial illumination alters the hues of pictures mainly because of mixture of colored lights, that is to say, of the hue of the light reflected from the surface of the picture and of the hue due to the particular pigments employed. Thus, if we regard a picture in yellow light (gas, carbon filament, etc.) the pale blues may appear white (mixing of complementary colors), the deeper blues assume a greenish hue, and the reds turn to orange.

In the colors which we see in nature influences of a similar kind are constantly at play, for every object, besides being illuminated by the prevailing light, has thrown on to it colors which are reflected from near by objects. In analyzing these influences there are, as Rood has pointed out, at least three factors that must be borne in mind. These are: (1) the natural or "local color" of the object, the cause for which we have already explained; (2) the colored light which is reflected unaltered from its surface, just as we have seen white light to be; (3) the portion of this colored light which is not entirely reflected but which penetrates the surface and is then reflected. Let us suppose that we are regarding a red wall of glazed brick at the edge of a grass lawn: the local brick-red of the wall will be materially altered by surface reflection not only of the white light but also of blue-green which, being approximately its complementary, tends to lower its saturation and pull it towards neutrality; at the same time, the green rays which have penetrated will on reflection assume a yellowish orange hue. The total effect is therefore that the red is somewhat removed towards neutrality and at the same time made to assume an orange hue. But it is by no means always possible to analyze these color effects, so that we must depend rather on the accuracy of the impression which we receive, at the same time bearing in mind that even objects with which we usually associate the most positive of hues may under certain conditions become entirely altered in this regard. In their use of colors, the post-impressionists are most careful to allow for these influences, although they may employ hues to produce them which at first sight appear to be entirely out of place.

Finally, we must say a few words about the relative refractability of different colors, that is to say, the ease with which the different spectral hues are brought to a focus on the retina. The rays of slow vibration, as at the red end of the spectrum, are less readily focused than those which vibrate quickly, as at the violet end. Consequently, when red rays are in focus, violet rays are overfocused and *vice versa*. The application of these principles in art depends on the fact that our judgment of distance is partly associated with the amount of effort which we must make in order to accommodate our vision. At rest the optical apparatus of the eye is accommodated for distant objects so that when these come nearer than a certain point an effort is required to make the focusing stronger. From the amount of this effort we judge in part of the distance of the object. Now it takes more effort to focus red than green or blue rays so that we always tend to locate a red object as being nearer than one that is blue or green. These facts can be very beautifully demonstrated by looking at red and green lamps placed side by side; the green light appears to be behind the red. And in picture painting the same principles can be applied, and seem to be so in many of the post-impressionists' paintings; objects are brought forward by being colored in the reds and they are pushed back by the use of blues and violets.

These facts bring us to a discussion of the influence of the blue-violet line which so many post-impressionists are using to outline objects to which they desire, without shading, to give the impression of rotundity, or more correctly, of projection. The effect of such a line is perhaps best demonstrated in still life studies where its existence at the edges of, say, a vase, will, when the picture is viewed at such a distance that the line just disappears, cause the vase not only to stand forward from its background but also make it appear rotund, as if shaded towards the edges. The line is sometimes used in landscape pictures with the object of holding the pattern together. These effects are most marked when the object is painted in hues that are considerably removed from blue on the chromatic circle, or are of much less saturation (more removed towards neutrality). Similar effects can sometimes be obtained by the use of a black line, but none of the flaring hues can be successfully employed for making it. It is difficult to explain the action of these outlines, indeed it is almost certain that several factors play a rôle in producing the illusion which they produce. When the line is a blue one and the prevailing hue of the color field which it borders tends towards yellow a synthetic gray will result at a certain distance, thus creating the impression that some space exists between the object and its surroundings. When a black line separates two colored areas there occurs a certain amount of irradiation on to it of the neighboring hues, which therefore undergo a more or less sudden lowering of intensity at its edges, which becomes more and more pronounced towards the middle of the line until the hues finally meet and partly overlap, thus producing a certain amount of synthetic gray. This phenomenon of irradiation is well illustrated by comparing two squares of equal size, one being black on a white field and the other white on a black field; the white square looks distinctly larger than the black one. The reason is that the stimulus produced by white, mainly because of imperfect focusing, spreads on the retina somewhat beyond the margin of its image.

In this account we have not essayed to explain all of the peculiar effects which are produced by some of the most modern creations of the so-called post-impressionists. We have merely indicated some of the physiological truths of color vision upon which certain of their color illusions depend. To go further would require consideration of many optical illusions for which at present there exists no satisfactory explanation. These are not illusions of color but illusions of line, indeed many of the latest post-impressionistic pictures are produced almost entirely in black and white and the peculiar emotions which they arouse depend on metaphysical processes whose explanation we can not undertake to expound. Their aim is "to create an illusion of the fact" rather than the fact itself; to write "a visual music which shall in itself arouse the emotions."

THE PETRIFIED FOREST OF MISSISSIPPI

By Professor CALVIN S. BROWN
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THE petrified forests of Arizona are well known to geologists and others interested in such things, but I am not aware that anything has yet been published on the petrified forest at Flora, Mississippi.

There are various forms of petrified woods in the state of Mississippi, but the great majority of them are silicified woods. Many of them are white or at least light-colored, and because of the color often go popularly under the name of hickory wood or hickory logs. Petrifactions which are formed in the lignite beds are often stained to a dark brown or even black shade; one and the same trunk is sometimes found partly petrified and partly lignitized. In the northeastern corner of the state there are also found samples of wood in which iron-ore is the material replacing the original woody structure. The beautiful wood jaspers, carnelians, opals and agates of Colorado, Arizona and other western states, are not ordinarily to be found in this state; though the Mississippi trees sometimes show excellent quartz crystals of small size.

Much of the Mississippi wood shows the vegetable structure almost perfectly and tends to split with the grain of the wood. Though a large

Fig. 1. Showing line of demarcation between Quaternary and Tertiary. Above this line a log is seen in its original position. Flora, Miss., June, 1912.

FIG. 2. A PETRIFIED LOG ABOUT SIX FEET IN DIAMETER AND TWENTY FEET LONG, SPLIT THROUGHOUT ITS LENGTH. Behind it is seen the erosion wall. Beneath the log evidences of erosion may also be seen. Flora, Miss., June, 1912.

FIG. 3. PETRIFIED WOOD. Flora, Miss., June, 1912.

FIG. 4. PETRIFIED WOOD. University of Mississippi.

part of it is exogenous, good specimens of palm-wood are found in south Mississippi.

Most of the petrified wood in the state is found in the Lafayette formation but some is found lower down in the Wilcox and other Tertiary formations. Dr. Hilgard surmised that a great part, if not all, of the silicified wood found in the upper formation was derived ultimately from the several lignitic stages of the Tertiary.

The petrified forest, or speaking more accurately, the group of silicified logs, which I wish particularly to mention in this brief article, is found near Flora, seventeen or eighteen miles northwest of Jackson, the state capital. Here is a large field where erosion is actively taking place at the present time. Throughout the area are scattered logs and fragments in varying stages of disintegration.

An amphitheater some twenty or twenty-five feet deep and about one hundred and fifty feet in diameter, where the Columbia loam and the Lafayette sand have washed away down to the Tertiary formation, offers the best single exhibit of the logs. At the mouth of the valley the erosion has extended several feet into the Tertiary. There are at least ten logs exposed in this amphitheater which vary considerably in color and composition. Some of them are almost pure white and apparently contain nearly pure silica; others are stained with more or less of foreign matter.

These logs vary in size and preservation and none of them presents the full length of the original tree. The largest observed is about six feet in diameter by twenty feet in length and is of a brown color.

FIG. 5. PETRIFIED LOG FROM PITTSBORO, MISS., now on the lawn of Dr. Calvin S. Brown at the University of Mississippi.

Another is four feet at base by about seventeen feet in length. A dark-colored log near by is five feet at base and eleven feet long. Another in a ravine to the east is four feet by twenty feet; and there are still other logs and fragments of logs scattered at various points.

Most of these logs now rest upon the Tertiary formation and therefore are slightly displaced; that is to say, the sand of the Lafayette formation has washed from beneath them and left them lying upon the Tertiary. In several places however in the vertical erosion walls logs are seen projecting from the Lafayette sand some distance above the Tertiary.

In the accompanying illustration, number four, the line of union between the Quaternary and the Tertiary is distinctly seen running horizontally through the middle of the picture. Some distance above this line is seen projecting from the Lafayette a log in its original position. No stumps *in situ* were anywhere observed by the present writer, nor were any small branches or roots found. There are many excellently preserved knots, a beautiful example of which is seen in the picture just mentioned. So far as observed by myself, there are no other fossils in this field; but further investigation is desirable.

It is evident that disintegration is going on very rapidly in this silicified wood. The difference in the appearance of several logs was clearly noticeable after an interval of fourteen months which elapsed between two visits to the Flora forest. The principal agent in disintegration seems to be freezing; rainwater penetrates the logs and by freezing splits them. A tree which has been exposed in the writer's yard but a short while (Fig. 5) shows signs of splitting, while another in the university museum is as well preserved as when Dr. Hilgard put it there over sixty years ago.

While the Mississippi forest can not be said to rival in extent or in the coloring of its petrifactions the celebrated forests of Arizona, it is nevertheless a fine illustration of an interesting phenomenon of nature.

ECONOMIC FACTORS IN EUGENICS

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ALTHOUGH eugenics is perhaps the newest of all the sciences, it has already become one of the topics of the day. And this is well, for no science was ever founded which promises to do so much for the improvement of mankind. Sir Francis Galton defined eugenics as "the study of agencies under social control, that may improve or impair the racial qualities of future generations, either physically or mentally." Such a broad definition evidently makes eugenics include a large part of sociology.

The object of the present essay is not to review or multiply the sad facts concerning the diminishing birth rate among the better members of all civilized communities and the unrestricted propagation of the inferior and unfit. All intelligent people are familiar with these lamentable facts. In America, indeed, popular education concerning the latter evil has so far progressed that two states, viz., Indiana and California, have already passed laws which provide, under proper control, for the sterilization of confirmed rapists, criminals, idiots and imbeciles in the state institutions. The same states and also New Jersey have acts, which provide that no marriage license shall be issued when either party is imbecile, epileptic or insane. A similar act on the statute books of Michigan provides that "no person, who has been afflicted with syphilis or gonorrhea, and has not been cured of the same, shall be capable of contracting a marriage." Ex-president Roosevelt and others have also aroused Americans somewhat to the need of positive work against race suicide, and several societies have been formed to encourage marriage, and to promote all influences which tend to raise the birth rate. One western state in a fit of enthusiasm actually passed a law which put a tax on all bachelors who should not marry within a certain period of grace!

The present writer will not concern himself with these laudable endeavors in the cause of eugenics, but will rather aim to present the social conditions in a new light; namely, to show that their basic causes are chiefly economic, and hence that remedial measures, if they are to succeed, must also be chiefly economic. In order to do this I shall take up some of the leading problems of eugenics, and point out their economic factors. In making this analysis I wish to warn the reader against misunderstanding. When I mention only the economic factors in a problem, I do not mean thereby that these factors are the only ones, not always indeed that they are the most important ones. I shall often take it for granted that the reader is familiar with the other factors of a biological or ethical nature.

I shall begin my presentation with a discussion of birth rates. The falling birth rate in all civilized countries is one of the chief anxieties of social students and statesmen. In France it has sunk so low that, in spite of the low death rate of 22, the births from 1893 to 1902 exceeded the deaths by only 1.2 per thousand annually. Even in 1850–60 France had the low birth rate of 26, and it has fallen steadily ever since, until it has now reached the figure 21, and in some departments there are three deaths for every two births. Whereas a century ago the population of France formed one quarter of that of the world's civilized powers, and she lorded it over the Germanic nations, now her population has fallen to seven per cent., and she has almost lost her place among the great powers of Europe. Between the two ten-year periods mentioned above the birth rate has also fallen in England from 33 to 30, in Italy from 38 to 35, while in Austria it has risen from 37 to 38. The birth rate has also fallen greatly in the United States in recent decades, especially in New England among the native population. Whereas at the beginning of the nineteenth century the population of the United States was doubling every 22 to 23 years, in the last 20 years it has increased only a trifle over 40 per cent., and the increase of 21 per cent. for the last decade was the smallest on record. Most striking is the stationary population of the great agricultural states of the middle west; here the increase for the whole decade was only 6 to 7 per cent., and Iowa showed an actual decrease. The three rural New England states showed a gain of but 5 per cent. Only in the sparsely settled far-western states was the increase over 50 per cent., undoubtedly due chiefly to immigration. California, for instance, increased her population in the last decade by 60 per cent., but the birth rate for recent years has hardly exceeded the low death rate of 15 by a larger margin than that in France herself. In the New England states also the death rate for 1900 among the native whites actually exceeded the birth rate by 1.5 per thousand. Here race suicide was even worse than in France. The birth rate of the foreign-born whites in New England, however, was nearly 45. This means nothing less than that the native American stock is dying out in New England, and is being replaced by foreign races from southern Europe.

Now is it merely a coincidence that the high birth rate among the native New Englanders began to fall rapidly after the years 1820–30, at the same time that large numbers of immigrants came from Europe? The late Francis A. Walker, superintendent of the census in 1870 and 1880, maintained that the great immigration during the last seventy years had undoubtedly been a direct cause of the fall in birth rate among the native population, by means of the disastrous competition introduced. Indeed the arrival during the years from 1830 to 1840, of large numbers of Irish and German peasants who had a much lower standard of living, and so lowered the general level of wages, was nothing less than an economic disaster for our old American stock. They shrank from the inferior competition, and were naturally loth to bear children, who must compete in the labor market with these unwelcome invaders. There is overwhelming evidence that the birth rate in all countries has always been much affected by economic changes. Professor Richmond Mayo Smith, for example, says in his "Statistics and Sociology" that a sudden fall in the birth rate is the result of war or of commercial distress or of economic disaster. We have seen that the rapid immigration of European peasants about 1830 was truly an economic disaster for the native New Englanders; and there is no reason to doubt that these unfavorable economic conditions were responsible for the great fall in their birth rate. Benjamin Kidd has said in this connection: "The unwillingness of men to marry and bring up families in a state of life lower than that into which they themselves were born is one of the most powerful of known influences working to restrict the birth rate." The causal connection between this immigration into New England and the decline in the native birth rate is deduced especially from the fact that this decline appeared first and most markedly in those very states and counties into which the immigrants chiefly went.

This check in the increase of the native population was so effective that in 1850, in spite of the immigration of nearly two million persons during the preceding decade, our total population was only 0.03 per cent. more than it would have been from natural increase alone *at the former birth rate*. This check on the native increase has persisted, indeed strengthened, with the passing decades and the ever-increasing immigration of poorer and poorer stock from Europe and Asia; so that in the Report of the Industrial Commission in 1901 Mr. Walker maintained that "if there had been no immigration into this country during the past ninety years, the native element would long have filled the place the foreigners have usurped."

I shall consider the method of action of economic conditions on the birth rate during the latter half of the last century, togther with their action at the present time. But I must explain at the outset that there is this important distinction between the two periods with regard to the operation of economic forces: namely, during the former period, when modern methods of limiting families were generally unknown, economic pressure produced an involuntary reduction of the number of children by postponing the age of marriage and by preventing many marriages altogether; while during recent years, as Neo-malthusianism becomes more and more widespread, the economic factor produces not only this unintentional diminution of births, but also *a much larger intentional* prevention of children. Mr. Charles F. Emerick has indeed sought to prove, in THE POPULAR SCIENCE MONTHLY for January, 1911, that our modern small families and low birth rates are due almost wholly to the practise of Neo-malthusianism among married couples. But it is a biological fact that women marrying at thirty or older are less fertile than those who marry younger; and the reduced number of children usually resulting from such marriages is doubtless involuntary in many cases, and partly unintentional, at least, in the rest. The reader is accordingly requested to keep in mind in the following discussion that the economic factors mentioned may reduce the birth rate in either of these two ways or in both at once. The tremendous significance of the modern knowledge and use of "preventives," in making the birth rate much more dependent upon economic conditions than formerly, is evident.

Let us now analyze these economic factors somewhat. We might place them under five heads, as follows: (1) The increased uncertainty of a livelihood among the working people; (2) the great rise in the cost of living without a corresponding rise in wages and salaries; (3) the general ambition among Americans to give their children better food, better clothing, and especially better education than they had themselves, and so to enable them to rise in the social scale; (4) the general entrance of women into all occupations and professions; (5) the demand for luxuries, especially superfluities for children.

The first factor, uncertainty of livelihood, has increased *pari passu* with the concentration of ownership of land and other means of subsistence in fewer and fewer hands and the creation of a rapidly growing proletariat. Whereas up to the year 1820 only 5 per cent. or less of our population lived in cities of 8,000 or over, and the great majority were independent farmers, in 1910 no less than 33 per cent. lived in such cities, and probably three fourths of them are dependent upon their employer for their living. Even the farmers have lost the ownership of their land, largely by mortgaging it. They are then really working for the holder of the mortgage, and only obtain for themselves in the form of net profit, after paying their interest, a wage often smaller than that of the city worker in a store or a factory. It is not necessary to quote statistics as to the great number of men unemployed, and so without a living, in the United States even in good times and without strikes. The labor-market, at least for unskilled labor, is always congested, and during commercial crises, such as that of 1907, and great strikes, hundreds of thousands of working men and women are deprived of their livelihood for considerable periods. This sad state of things makes it extremely difficult or quite impossible for our working-men to marry young and support large families decently. They know what it means for a man with a family to lose his job and see his family starve and be evicted from their tenement; and a great many naturally refuse to subject the woman they love to the danger of such a fate, or to hang such a heavy burden about their own necks in the economic struggle. They postpone marriage until they have saved up a little capital to protect them against loss of employment; or, as often happens, they postpone marriage until it is too late, and never marry at all.

Next comes the great rise in the cost of living, which is a perennial source of complaint and perplexity to both rich and poor. This is a rather hackneyed subject, and I will not burden the reader with statistics of prices of the various food-stuffs and other necessaries; but merely make two general comparisons. The United States Bureau of Labor computes each year an "index number" from the average prices of the most important commodities, which shows most accurately the general trend of prices. Now this "index number" rose from 90.4 in 1896 to 122.4 in 1906, a rise of 35.8 per cent. Supposing the same rate of advance since 1906, and it has probably rather accelerated, average prices as shown by the index number would be 54 per cent. higher in 1912 than they were sixteen years ago in 1896, just before the Spanish war. This means that on the average $1.54 will now go no farther than a dollar did in 1896; and consequently, unless a family which received about $500 a year in 1896 now gets at least $770, it has actually become poorer, for it can really buy less commodities.

The second way of gauging the increased cost of living is by comparing reliable estimates made at different times in the same places of the yearly income absolutely necessary to support a family of two adults and three children, the "standard" or "average family." In 1902–3, for instance, a prominent official of one of the largest charities in New York City stated that about $624 a year is necessary for a family of five in that city. The New York Bureau of Labor declared in 1902 that "$520 a year is inadequate for city workmen." Robert Hunter, the well-known authority on social conditions in New York, states in "Poverty" that "while $624 a year is probably not too high for New York City in view of the excessive rents, etc.," he considers only $460 "essential to defray the expenses of an average family in the New England states, New York, Pennsylvania, Indiana, Ohio and Illinois." He wrote this in 1904. And now in 1911 the Sage Foundation of New York states: "Families having from $900 to $1,000 a year are able in general to get food enough to keep body and soul together, and clothing and shelter enough to meet the most urgent demands of decency." This was the result of an investigation among 391 families living in the New York tenements. This agrees very well with the estimate of Professor R. C. Chapin, quoted by Professor Scott Nearing in his new book, "Wages in the United States," that "a New York family, consisting of man, wife and three children under fourteen, could maintain a normal standard at least so far as the physical man is concerned on an annual income of $900." According to these estimates, then, the cost of living rose for New York City from $624 in 1902–3 to about $900 in 1911, a rise of no less than 44 per cent. The reader will notice that this figure is still higher than the increase of 36 per cent. arrived at above by comparing the index numbers for 1896 and 1906, although the latter period is longer.

But some people deny the great social and eugenic effect of this undeniable rise in prices, because they think that it has been accompanied by a corresponding rise in wages. This is a much discussed question, and wages vary so in different parts of America, and have risen at such varying rates in different trades, that it is impossible to obtain such accurate figures here as I have given for prices and the cost of living. Inasmuch as the majority of our wage-earners are still classed as unskilled, I will take a large class of them for comparison. In 1900 the Industrial Commission reported that the 150,000 trackmen working on the railroads received wages ranging on the average from 47.5 cents a day in the south to $1.25 a day in the north. Not allowing for unemployment, these men had a yearly income of less than $150 in the south and less than $375 in the north. Nine years later the Interstate Commerce Commission reported that the 320,000 trackmen then employed on the American railroads received an average of $1.38 a day, or $414 a year. This is an increase above the average for the north of only 10 per cent. for the nine years, as compared with the rise of 44 per cent. above quoted in the cost of living in New York City from 1902 to 1911. In some few trades, to be sure, wages have risen much more, though hardly in any as much as has the cost of living; but space does not permit of detailed comparisons; a general estimate for unskilled workers at the beginning and the end of the last decade must here suffice. Robert Hunter, for example, wrote in 1904: "It is hardly to be doubted that the mass of unskilled workers in the north receive less than $460 a year," and this must include more than half of all wage-earners. And Dr. Scott Nearing in the book already mentioned estimates that half the adult males of the United States are receiving less than $500, and three quarters of them less than $600 yearly. This lower-paid half of the total male workers must correspond fairly well with Mr. Hunter's "mass of unskilled workers," except that his estimate was confined to the north, where wages are higher than in the south. To compare the two estimates, then, quite fairly, we should probably increase the later one of Dr. Nearing's, which refers to the whole country, by about 10 per cent. to express the slightly higher wage-level in the north. We then have $460 for the wage index in 1904 and $550 for the same in 1911; and find that this means a rise in average wages of 19 per cent. in the seven years. This rate would make an increase of 24.4 per cent. for the nine years, 1902–1911, in contrast to the increase of 44 per cent. for the cost of living in New York and 36 per cent. for the rise in average prices during the decade 1896 to 1906. I see no escape from the conclusion that *the cost of living has increased since 1896 at least 50 per cent. more than wages have risen.*

This great uncompensated rise in the cost of living means nothing less than progressive impoverishment of the mass of the American people; and is of the greatest possible injury to the welfare of the nation as well as to the racial qualities of its future citizens. Here we are only concerned with its effect upon the birth rate, which it tends strongly to reduce among the superior, foresighted part of the population, who feel the responsibility of bringing children into the world, and have the knowledge and self-restraint required for limiting offspring. The paupers, however, unless prevented by the state, will continue to breed as rapidly as ever; and the generally inferior, less industrious, ambitious, and provident part of the population will also restrict their births but little. The result is, for it is actually taking place now, that the percentage of the inferior and unfit steadily increases, while that of the superior and fit *pari passu* diminishes; and, *if this process of degeneration is not checked, the nation as a whole will become unfit and will succumb,* as most nations have done in history.

Dr. A. F. Tredgold in the *Eugenics Review* for April, 1911, gave the following fact in corroboration of the differential decline in the birth rate. He found the average number of children among 43 incompetent, parasitic working families was 7.4, while that among 91 thrifty, competent working-class families was 3.7 or just one half. Mr. Sidney Webb also found that among the members of the Hearts of Oak Benefit, which is composed of healthy, thrifty artisans of a superior type in England, the birth rate had declined by 52 per cent. from 1880 to 1904, which was nearly three times the decline for all England and Wales during this period. The same writer declares that both pauperism and degeneracy have undoubtedly increased in England since 1901. We have just reviewed the incontrovertible evidence that poverty has rapidly increased in America since 1896. Have we any reason for believing that degeneracy has not likewise increased for the same reasons as in England?

In regard to the ways in which this second economic factor works to reduce the birth rate it is only necessary to say that they are nearly the same that have been mentioned above for the first factor; namely, uncertainty of a livelihood. But the second is chiefly responsible for late marriages, sterile marriages resulting from venereal disease, failure to marry at all, and intentional prevention of children. It is the shame of the twentieth century in the richest nation of the world, that for the great majority of Americans the big, happy, old-fashioned family of six to twelve children has become a luxury, which is absolutely beyond their means.

Our third factor in reducing the birth rate was the common ambition among our working and middle class people to give their children better advantages of all sorts, to enable them to rise in the social scale. This is surely the leading motive with a great many ambitious parents for intentionally limiting themselves to two or three children. They could afford to feed, clothe and shelter four to six children and send them to the public schools, but they could not give the boys a college education and a start in business or a profession, and send the girls to college or a finishing school, and also enable them to come out properly. Hence they have only two children, and try to give them all these social advantages. This motive for limiting births is probably the chief reason why immigrant families in the United States usually show a markedly lower birth rate in the second and third generations. In the old country escape from the working class was never dreamed of; but in democratic America they soon learned that thousands of other working people, foreign-born or of foreign-born parents, had raised themselves by industry, self denial, and prudence (usually combined with luck and shrewdness) to wealth and social position. What wonder that they aspire to do likewise, and that they find prudence absolutely demands a small family?

The same desire to give their children every possible advantage to enable them to keep their social position is perhaps much more operative among the middle class as a reason for limitation of children. The fear among middle-class parents of seeing their children sink into the proletariat is probably a stronger motive than the desire of the working-class parents to see their children rise out of it. Witness the fact that the birth rate among the professional class is only one half that of the industrial class.

We come now to the fourth economic factor in the birth rate: the entrance of women into all sorts of trades and professions, in short the whole modern woman's movement. This is extremely interesting in its relation to eugenics. Let us first consider the effect of the higher education of women. I can find no statistics to prove it, but most authorities, including Dr. J. W. Ballantyne, seem to agree that college women not only marry later, as a rule, but have smaller chances of marrying at all than their less educated sisters. Dr. Ballantyne has also pointed out that the higher education of women in America has had a distinct influence in diminishing the birth rate, and that the college-trained girl has certainly not been the mother of many children. As I have already stated, late marriages are always less fertile on the average than early ones. But these college women, who marry late, not only have fewer children, but they also fail to bear the best children of which they were capable. For English students of eugenics have proved by extensive investigations that, when a woman bears her first child at about 25, and continues to bear at intervals of two years, the quality of the children usually improves up to the fifth or sixth, which is accordingly the best that she is capable of. But, if she bears her first-born at the age of 30 or more, all the children are usually inferior to what they might have been. It would actually seem as though nature, like a human artist, needed practise, before producing her best creations; and that women, who bear only two or three children, never give nature a chance to do her very best, but are content with her first attempts. It is evident that *all who have the cause of eugenics at heart must do all in their power to favor early as well as fruitful marriages among the better part of the population.* Sir Francis Galton laid emphasis upon this.

It should be mentioned in this connection that too close application to intellectual pursuits often causes neurasthenia and menstrual troubles in young women, which may contribute to sterility later or prevent marriage on account of poor health. Excessive indulgence in sports also frequently injures the nervous and reproductive systems.

Let us now consider the larger question of the effect upon number and quality of offspring produced by woman-labor. Here a few statistics will be necessary. In 1900, out of 23½ million women over sixteen years of age in the United States nearly five million, or about 21 per cent., were employed. Of these five million 44.5 per cent. were under twenty-five. The number of women at work had more than doubled since 1880. Women were represented in all but nine of the 303 occupations listed. In 1910, Dr. Nearing informs us, 60 per cent. of all the women-workers in the United States received less than $325 a year. Now most of these women are employed solely or chiefly because they were able and willing to work for lower wages than men; so it is fair to say that they have underbid the men, and either displaced them or forced them to accept the same wretched pay. As a result, there are "textile towns" in New England, where the vast majority of the operatives are women and children, and the men stay at home and take care of the babies! Moreover, in the public schools throughout the land women-teachers have an overwhelming preponderance over men. It is difficult to determine what is the principal effect upon the birth rate of woman's employment outside the home. On the one hand, the reduction of the man's wages by woman's unfair competition postpones and prevents his marrying; and, on the other hand, the young woman by means of her occupation may be able to save up something to marry on, and young couples, relying on their both continuing to earn money, may marry earlier than they otherwise could, and perhaps have more children. In England, at any rate, the birth rate is highest in those counties where we find the largest proportion of women employed in factories; namely, in the urban, industrial counties of Nottingham, Staffordshire and Durham. Here we also find large numbers of married women, who are under age—in Durham over 23 per cent.—and the highest infant mortality. The infants born to these working girls have the highest mortality from premature birth, deficient vitality and all congenital defects; and all these working mothers have such a high death rate from all causes among their neglected children, that the increase of births, which results from this employment of young women, is wholly undesirable and results in deterioration of the population.

The last factor in my list was the increased demand for luxuries. A great many young men of marriageable age in the business and professional classes postpone marriage year after year, and perhaps renounce it altogether, because of the false idea that they must provide a wife with a six-room house, two servants, cut glass, fine furniture, fine clothes, and all the other luxuries which she or her richer friends enjoy. In short he "must have at least five thousand a year." The same selfish refusal to give up any unnecessary creature comforts after marriage makes many women stifle their maternal instinct and spend their substance on automobiles instead of on children. Mr. Roosevelt's well-known sermons against race suicide as a selfish, unpatriotic shirking by modern women of their highest duty to the state indeed applies with fairness only to wealthy women, who deliberately barter their unborn children for luxury and freedom from maternal suffering and cares; but these rich women and their husbands, who are equally to blame, well deserve our ex-president's stern reproofs. In this modern growth of luxury the most dangerous feature from the eugenic point of view is the superfluity of things demanded for children by middle-class parents "in order to keep up with the procession," as the phrase is. This "keeping up with the procession" has an interesting sociological basis, which deserves mention here.

The phrase really means the attempt to equal one's neighbors and business acquaintances in all the externals of life, particularly in dress, in order to maintain or better one's social position. And the economic basis of this well-nigh universal endeavor to dress better than one can afford is the class struggle. The upper classes always feel that they must show their superiority by dressing more expensively or in some new style; while the lower classes as continually attempt to obliterate this class distinction by imitating their dress and manners.

The following quotation from a recent article in the Los Angeles *Times* shows what the modern standard of expenditure for boys and girls is in the middle class.

Girls cost three times as much as boys. The girl of twenty years ago was content with one party dress and a ''good'' hat. Calico dresses made on the family sewing-machine were good enough for ordinary wear. The first cause of the girl's higher cost is naturally clothes. *She must dress as the others dress.* The second cause is entertainment. The college girls try to outdo one another in costly luncheons. Only families in good circumstances can afford to send their children to college for the full four-year course. The cost of sending the girl to college can be figured thus: first year, $1,250; second and third years, $900 each; fourth year, $1,000 and $200 extra for traveling during vacations; total, $4,250. The boy's expenses, on the other hand, will be $700 per year with $100 for vacations, a total of $2,900. What is the cause of this phase of the high cost of living? The setting of costly standards by the rich, which the poor, the well-to-do and the near-rich try to imitate.

It is evident that if a family demands these luxurious standards for their children, they can hardly obtain them for more than two children even with five thousand a year. It would seem that "the simple life," which Pastor Wagner came from France to teach us a decade ago, has not yet been entered upon by any of us who have the means to live otherwise. Even the poor avoid simplicity as much as possible, witness the elaborate shirt-waists and "picture-hats" often worn by working-girls and the great sums spent on liquor and cigars by working men.

So much for the economic factors in the birth rate. Let us now consider the closely related subject of infant mortality. It is now generally agreed that the best single antidote to this national evil is breast-feeding for nine full months, or as long as possible, and that in this respect the poor infant fares better on the average than the well-to-do. In spite of this advantage, however, the infant death rate is much higher among the poor than among the wealthy. Dr. Fischer, of New York, for example, found that of 500 very poor women in that city 90 per cent. nursed their children over nine months, while of 500 prosperous mothers only 17 per cent. nursed for the same period. When we learn, however, that 154 of these rich infants were supplied with wet-nurses, we see that, after all, 48 per cent. of them were breast-fed.

German investigations do not show such a striking difference between the percentages nursed by poor and by rich mothers; and the figures quoted by Dr. Fischer are undoubtedly too low for the American middle-class and probably also too high for the average working-class. A doctor, who has delivered 300 women in a country town in California, informs me that only six of them failed to nurse. We must turn to Germany for reliable statistics on nursing in different economic classes. In the city of Barmen (population 150,000) in 1905 the following percentages of infants were being nursed in the four different classes, into which the parents were divided according to income:

I	II	III	IV
Income under $375	$375 to $750	$750 to $1,500	Income over $1,500
Nursed: 80.9 per cent.	68.7 per cent.	45.2 per cent.	47.3 per cent.

It is noteworthy that the percentage nursed is slightly higher for the richest class than for class III., which corresponds to our middle class. Indeed poverty prevents a great many women from nursing successfully. It does this in two ways: (1) By depriving them of sufficient and suitable food, rest and general care, which causes their milk to fail in both quality and amount; (2) by forcing them to go out to work and give over their infants to foster mothers and cease entirely to nurse them. No doubt, however, many mothers are directly induced by poverty to nurse, because it seems to be the cheapest way. Indeed authors vary greatly in the importance they attribute to these two factors in preventing women from nursing. Dr. Spaether, for example, found that among the poor women visiting his clinic in Munich the necessity to earn money was the cause of not nursing in 20 per cent. of the married women and 52 per cent of the unmarried, while in 15 per cent. and 60 per cent., respectively, it was the cause of premature weaning. Dr. Keller found that, among 1,300 poor mothers in Vienna in 1908, two hundred and seventy-eight had not nursed at all; and, of these, 94 declared it was because they had to go out to work. Investigation revealed the fact, however, that sixty of them had received maternity insurance for four weeks, and hence were not really prevented by poverty from nursing during this period, at least. Their excuse was that it did not seem worth while to them to nurse an infant for such a short time, after which they must wean it, and have much distress in doing so.

What is the statistical effect of the employment of women in factories upon infant mortality? Dr. G. Newman in his excellent book on "Infant Mortality" shows that the death rate in England is higher in the manufacturing towns than elsewhere, and is highest in those places where the highest percentage of women of child-bearing age are employed in factories. Thus the average infant mortality for 1896 to 1905 among eight "textile towns," where on the average 43 per cent. of married women below the age of 35 were employed, was 182 per thousand; whereas the average rate among eight "non-textile" towns, where only 3.1 per cent. of this class of women were employed, was 150, that is, over one sixth less. The average infant death rate for all England then was 152. It hardly needs to be pointed out that the employment of mothers in factories in nearly all cases robs the infants of their mothers' milk and mothers' care, which results in their being improperly fed and often badly neglected, so that they either die or survive as the degenerate population, of which these mill-towns largely consist. This deplorable state of things, this persistent crime against humanity, is a necessary result of our heartless economic system, which gives these infants' fathers such a small proportion of the wealth they produce, that their mothers are forced to tear themselves away from their babesin-arms and let themselves also be exploited in the factory, so as to keep the wolf from the door. Does any society that is callous to such waste of human life deserve to be called civilized? Is this heartless and protracted starvation of infants by depriving them of their natural food much more worthy of a civilized and so-called Christian nation than was the deliberate exposure of infants to a more merciful death by the ancients? The United States is, alas! no less guilty of such undesigned "slaughter of the innocents" than Europe, possibly even more so, for we do not even provide our women factory workers with a month's maternity insurance, as is done by Austria, Germany and Spain.

I have no space in the present paper to consider the economic factors of other racial problems; much less to point out in detail what economic changes I think would aid most in "improving the racial qualities of future generations." I can not conclude, however, without stating my conviction that the most thorough-going economic measures are urgently demanded, and at the earliest possible moment, before the rapid degeneration of our people shall have brought us to the danger point.

Sir Francis Galton must have foreseen the need of economic reform when he said: "The economic burden of raising a family is such as to discourage many, whose qualities should be continued to other generations, *and there can be no doubt that it would pay society to furnish ample means for the industry of child raising to those who are especially fitted to engage in it.*" The philanthropy of even our American millionaires would be hopelessly inadequate to furnish "ample means" to a quarter of the American families, "who are especially fitted to engage in child raising." Only the state, that is the nation, could foster practical eugenics on such a grand scale. There is no doubt whatever that state support of mothers and children would solve the race-suicide problem, and I see no reason to hope that anything else will. As an editorial in The Popular Science Monthly recently said, "Children are no longer a financial asset to their parents, but they are this to the state and to the world; the state must ultimately pay for their birth and rearing." It is absurd to fear over population in America for centuries to come, since, as Professor Herbert Miller has ably shown in the same journal for December, 1911, the law of diminishing returns is obsolete and "the resources of production show no more signs of exhaustion than the heat of the sun." Finally, as soon as public opinion has been educated sufficiently to appreciate the justice as well as the desirability of such legislation, there seems to be no reason why an intelligent cooperative commonwealth could not or would not prevent the conspicuously unfit from marrying or reproducing at all, discourage the relatively unfit, and encourage the fit, in every way consistent with humanity.

HOW THE PROBLEMS OF THE RURAL SCHOOLS ARE BEING MET

By MARY A. GRUPE

WASHINGTON STATE NORMAL SCHOOL, ELLENSBURG.

THE little red schoolhouse is all well enough as a matter of tradition and history. It has served its purpose and no amount of sentiment for its past achievements can make it a thing acceptable to the present generation. Time was when the one-room school house was quite as well built and furnished as the dwellings from which the children came, but that is past and there is no gainsaying that the one-room district school is generally unsightly, illy ventilated and meagerly equipped. Moreover, the few children, many classes, formal bookish instruction, and inadequately trained teachers make it altogether unsatisfactory. However, a habit dies hard even though through evolution the use for that habit has disappeared. No doubt the one-room district school was and still is a necessity in some isolated and inaccessible localities, but because it got fixed as a system it still maintains where conditions no longer warrant, and where it positively saps vitality without bringing adequate returns. This ancestral school, once performing an important function in New England, still persists there, although, because of migrations to centers of population, it has practically lost its use. The district system, thus originating in New England, was naturally, but unfortunately carried west and all over the United States became the prevailing type.

Heartless as it may seem to say so, the outlook for any radical improvement of the one-room school, especially under the district system, appears hopeless. Poor as it is, the cost per pupil is greater than that for the best city schools. The Michigan report for 1902 shows that for schools averaging fewer than six, the cost per pupil was $99.50 each year, schools of fewer than fifteen paid $41.60, while the city average was $19.50. This condition is wide spread. The district system is to a large degree responsible for the weaknesses of the rural schools. To secure the building and equipment necessary for efficient work would make the tax upon the people of such a small area as a district too burdensome. The isolation and hampering conditions make it almost impossible to secure well-trained teachers. Kansas tried to attract better teachers by raising the salaries, but failed, for the discomfort and inconvenience they must undergo of living in unheated rooms, of being forced to sit with the families to study in the evening, and of having no congenial companions, were not recompensed thereby. Moreover, the large number of classes and subjects imposed upon one teacher will always forestall any attempts to make the work equal to that of the city schools, or to introduce a course of study especially adapted to the needs of the country. Expert supervision can not be supplied because the many schools, long distances apart, make the attendant expense prohibitive.

In refutation of the above hopeless outlook for any improvement of the one-room district school the optimist points proudly to one here and there, modern in every respect, as an example of what may be accomplished anywhere. However, he forgets that these few schools were made excellent through incidental or local enthusiasm and support. He forgets, or he does not know, that there are thousands of one-teacher schools which can not be so reached. For example, in 1907 Texas had 2,668 one-teacher schools, in 1909 Kansas had 7,756, and Nebraska over 4,000. Mississippi reports 75 per cent of her schools to be of this type at the present time.

Unconsciously a solution of the difficulty began early in Massachusetts along the lines that are being consciously pushed to-day. Parents began sending their children from their own districts to larger and better schools. This led to the abandonment of some and the joining of other districts in order to have good schools nearer home. But natural evolution proved too slow a process, so we find as early as 1869 that the legislature enacted a law empowering a town to raise money by taxation for the transportation of children to larger schools. Thus consolidation for the betterment of rural schools began. Later the state passed a law extending the minimum length of the school year to thirty-two weeks, a measure which materially helped to close small schools and to promote the growth of larger ones. At the present time consolidated schools are found in nearly every county of the state. By 1897 all the New England states had adopted laws similar to those of Massachusetts.

Since that time some form of consolidation has been tried in about thirty-four states. A 1910 bulletin, by G. W. Knorr, special field agent for the Bureau of Statistics, states that 95 per cent of the school patrons trying consolidation are enthusiastic in its praises and not one abandonment of a completely consolidated school was found among those investigated. It is as successful in Idaho, Vermont or Florida as in the prairie states of Indiana and Illinois. Superintendents of states where consolidation has not been tried express themselves as believing that it ought to be adopted. The large number of official bulletins on rural schools attest to betterment along the following lines: building and equipment, grading and course of study, length of term, attendance, interest on the part of pupils and patrons, teachers, salaries, supervision and administration. The growth of the local high school and larger high school attendance is marked. The advantage which ought to make its appeal to the practical man is that there is a far more adequate return for the money invested.

The greatest drawbacks to the furtherance of consolidation are the reluctance of communities to give up their district schools and to substitute a new order of things, and the lack of legislation to permit and encourage it. The few real difficulties, such as bad roads, great distances to be traveled, long hours away from home, and cold lunches, which have been urged against consolidation, are also met with by those who attend district schools, and are on the contrary partially solved by transportation. In Indiana improvement of roads is following fast in the wake of the consolidation movement. The installation of domestic science enables the schools to furnish warm lunches. Those who make the complaint that expenditure is increased overlook the fact that the man who sends his children out of the district to a better school pays twice for their education, taxes in his own district and tuition in another, and the man who patronizes his own one-room school sometimes spends four times as much as the city man while receiving a poorer return for his money. The cost per pupil in a consolidated school is often the same or more than in one of the larger one-teacher districts; however, it is not cheapness that should be sought. The cost certainly should not be exorbitant, but it should be adequate to secure the best educational advantages. A recent study by Professor J. F. Bobbitt mentions the following objections which are being made to consolidated schools: attendance is not radically bettered, scholarship is not improved, and cheapness is not secured. Professor Bobbitt replies that while his statistical study shows there is not a great difference in attendance during the first five years, the attendance is much better in the upper grades. He also says that those who argue that scholarship is not strengthened base their opinion upon the results of formal examinations, utterly ignoring the fact that children in the consolidated schools have a broader curriculum, more individual attention from teachers and better social and sanitary conditions, all of which can not be measured by the traditional word examination.

On the whole it seems that consolidation has been tried long enough and in a sufficient number of geographically different localities to raise it above the experimental stage and to prove it a solution for some of the ills from which the country schools are suffering.

The student of the rural problem is next confronted by the question of means that have been found effective in furthering consolidation and in making consolidated schools more efficient. Those states possessing laws of a prohibitive, persuasive or constructive type have a basis of procedure the lack of which has prevented progress in other states.

From nearly every state superintendent to whom Professor D. D. Hugh sent a questionnaire asking for information regarding legislative or other means that have been found most effective in promoting consolidation, came the reply that a larger administrative unit is desirable; and the majority favor the county unit with one board of education in charge of all the schools of the county. Under such a system local district feeling is abolished. The county is districted according to topography, roads and population. In Maryland the county is made the tax unit for the collection and distribution of school money. This system is found in the south and is gaining adherents in the west. Oregon has lately made provision for the establishment of a county educational board in counties having sixty or more districts, and for a supervisor for every fifty districts in such a county. In Utah several districts may place themselves under the management of one board of education for the purpose of securing better administration and supervision. Last year New York put a law in operation which combines towns into larger administrative districts and which ought to make supervision of country schools more efficient. The township plan prevails throughout New England and the Middle West, but a number of superintendents in these states express themselves as believing that the county unit would bring even better results.

Legislation designed to promote the efficiency of schools rather than consolidation sometimes forces the latter. Probably the greatest incentive for consolidation in Indiana is the stringent law abolishing all schools where the attendance has been twelve pupils or fewer for the period of a year. Legislation fixing the minimum length of the school year is aiding consolidation in Massachusetts and in other states, as small schools can not afford to keep open for so long a period.

The earliest and most wide-spread encouragement given to consolidation through legislation was that by which transportation of pupils was paid for out of the tax fund. In Chippewa County, Wisconsin, it is estimated that transportation is 50 per cent cheaper than the cost of maintaining two separate schools. Where public conveyance is provided, the increase in enrollment and average attendance is very marked.

One of the latest forms of legislation for encouraging consolidation and improving the work of the schools is that of providing grants of money to be given to schools attaining certain standards of efficiency. Minnesota offers $1,500 yearly to rural schools of four departments maintaining teachers of certain qualifications, a library, and agricultural and industrial work. Smaller sums are given to schools of three and two departments. Aid for building is also granted to the amount of 25 per cent of the cost, provided that no building shall receive more than $1,500. In Washington a bonus of $150 is received by each consolidated school composed of two district schools. A special grant is made of $300 per year by Wisconsin to graded schools of three departments and of $200 to those of two. To schools providing for instruction in the work of agriculture, domestic science or manual training special aid is also given. A very few other states, among them Oklahoma, New Jersey and South Carolina, make some small appropriations to further consolidation. Mr. Hugh,[1] in commenting upon the above methods of encouraging better schools says:

> Many of the advance movements in education have needed to be fostered at first in some special way and why should this not be true of our rural schools? There is no good reason from the standpoint of educational efficiency why our system of prorating all the state education funds among the children is necessarily the best. A judicious use of a part of this amount to encourage laudable educational undertakings might secure much more valuable results.

In this connection the "object lesson" consolidated schools built and maintained in four provinces of Canada by Sir William McDonald merit attention. Each school was equipped for manual training, household sciences, nature study and school gardening, and efficient teachers were provided. For a period of three years all expenses above the cost of maintaining the small schools which these larger ones supplanted were paid by Sir William. The results are encouraging. The average daily attendance was estimated to be 55 per cent higher than that of the former schools of the localities. The high school attendance increased wonderfully. After the three years were up the people took over the support of the schools. Moreover other schools were consolidated; Nova Scotia, for example, made twenty-two effective schools out of fifty-five poor ones.

Another means of bettering schools which is probably more effective than the offering of grants for attainment of certain fixed standards, is that of giving outright from the state or county fund larger amounts to the weaker districts instead of making an apportionment on a pro rata basis. Opposition is still raised to such procedures on the ground that some districts get more than they pay for, but we are fast coming to a realization that there should be equality in educational opportunity and that to strengthen the weak is of advantage to the strong as well. One of the best discussions of the rural school problems and of the appalling condition of a large number of Ohio's rural schools has recently been held by the School Improvement Federation of that state. This body in advocating equality of educational oportunity for all and is planning a campaign to secure legislation which will make the county the unit for taxation and which will create a state fund to be apportioned, not according to school attendance, but according to the needs of districts.

One of the great hindrances to progress in our rural schools is the inefficient instruction prevailing there. Statistics show that only young, untrained teachers or those who can not obtain positions elsewhere are in the main the teachers of the one-room district schools. Consolidated

[1] D. D. Hugh, "The Consolidation of Rural Schools," *Bulletin State Teachers College*, Greeley, Colo.

schools are able to attract and to hold a better teaching force, not only because of higher salaries, but because of better living and social opportunities.

However, while it is possible to secure for consolidated schools trained teachers who are able to carry out a course of study such as is found in our city schools, at the present time there is a dearth of teachers who know anything about the country schools or who have been trained for the special purpose of teaching in these schools. Normal schools fulfill but half their mission if they neglect the rural schools. They are fast waking up and endeavoring to supply the need, as is evidenced by the fact that nearly all the 1912 circulars contain offers of work in agriculture and instruction for rural teachers. Terre Haute, Macomb, Kirksville, Hays and a few other western normals have established model rural training schools. Certainly normal schools and agricultural colleges should keep in touch with country schools through systematic visitation, and this is being done in some states. When Minnesota offered grants for efficient rural school work she wisely offered bonuses to higher institutions for the establishment of departments of manual training and agriculture. Not only normal, but high schools and some fifty others come under this provision. A Minnesota educator writes that some of this work is being wretchedly done and the money wasted, but it must be borne in mind that the pedagogy of the rural school is still in its infancy and blunders are bound to be made. Wisconsin has a system of county training classes, and other states have established such classes in connection with high schools, but what should be the character of the rural school curriculum is still very problematic. At the present time there is a very strong feeling that nature study, school gardening, elementary agriculture, domestic science and manual training should be a vital part of the country school curriculum. In Europe the school garden originated with the rural school, and as early as 1814 it was to be found in Germany. Practically all northern European countries with the exception of England require school gardening or elementary agriculture to be taught in the country schools. Certainly a policy that has been pursued for so many years in industrial Europe merits attention here. In this country, on the contrary, the school garden movement developed in the city. At the present time about ten states require elementary agriculture to be taught in the rural schools, and teachers to pass examinations in the subject. These states are mostly in the south.

It would seem that the establishment of rural school libraries would have been one of the earliest and easiest steps to have been taken for the betterment of these schools, but practically little has been accomplished. New York boasts of a library for every school. Ohio has a large traveling one. Minnesota encourages the establishment of libraries by the offer of state grants. Missouri, Maryland, North and South Carolina have either compulsory or conditional legislation on the subject.

That the consolidation movement has been responsible for an increase in the number of rural high schools is certain, but exact information is not available. In the bulletins on consolidation frequent mention is made of consolidated schools adding one or more high school years to their curriculum. It is estimated that where local high schools are maintained the attendance of pupils of high-school age is increased from 60 per cent to 70 per cent. The presence of the high school has been reactive and in many instances has stimulated the work of the grades and caused a greater number to complete the elementary course. Besides developing out of the grade schools the consolidated high school has had independent growth in many states; districts have joined for the purpose. In New England and the middle west the township is the prevailing unit; in other sections of the country the county high school is favored. Each of these plans has drawbacks and advantages so that several states have provided for the use of any one or all of them. Again we note that if the county were the administration unit the location of high schools could be put upon a more rational and economical basis. Nineteen states encourage the establishment of the support of rural high schools by direct subsidy, by free tuition, by reimbursement for free transportation, or by a combination of these methods. It is exceedingly gratifying that the country is beginning to feel that it is quite as much the right of every child to have the benefit of a high school education as to possess that of the elementary school. The course of study adopted in most of these schools does not differ from that of the city, and while there is a great deal said about the necessity of a course of study especially adapted to the country, no one has come forward with anything very practical. The Minnesota law encourages the teaching of manual training, domestic science and elementary agriculture by offering grants to schools so doing.

It is high time for an awakening in regard to the status of rural education. The gravity of the situation is emphasized if the estimate made by Mr. Foght[2] that one half the school population belongs to the rural schools and that 95 per cent never get beyond their respective districts is correct. That the rural school situation is the great problem in the educational world to-day, and that it is to receive the attention of educators at least, is evidenced in the interest manifested last year by the National Educational Association resulting in the appointment of a committee to thoroughly investigate and to recommend means of improvement, and of awakening the public to a realization of the rural school needs. What will be accomplished by this committte remains to be seen.

[2] Foght, "The American Rural School."

THE INCREASE OF AMERICAN LAND VALUES

By Dr. SCOTT NEARING

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So much has been said and written regarding the theoretical importance attaching to the rise of land values that the student of economics looks eagerly for some collection of facts which shall in a measure substantiate the numerous theories advanced. To his consternation he discovers, after a careful examination of economic literature, that little of importance has appeared on the subject. The fundamental significance of land value increases is conceded in every land, yet, with the exception of farm land values, there has apparently been no systematic attempt to discover the extent of the land value increases. Although an examination of the available facts has convinced the writer that the time is not yet ripe for an authoritative statement, the data at hand do indicate rather clearly the trend in land valuation.

Land values, in so far as they relate to the present discussion, may be conveniently grouped as follows:

1. The value of lands containing minerals and fuels.
2. The value of water rights.
3. Timber land values.
4. Farm values.
5. Urban land values.

Mineral land values and the value of water rights may be dismissed with a word. Repeated inquiries directed to state officials, to the federal authorities, to trade journals and to prominent engineers, failed to elicit any response worthy of consideration. Indeed, one of the most prominent mining engineers in the country goes so far as to write:

> I have no reliable information to give you as to the extent to which mineral land values have increased during recent years. Mineral lands become valuable only with favorable developments, and do not rise in value in conformity with laws determining values of other kinds of property.

The editor of *The Engineering and Mining Journal* (Mr. Walter R. Ingalls) writes (January 9, 1913):

> We have not compiled any data regarding the increase in the value of mineral lands, and do not, in fact, see how any such data that would be worth anything could be compiled.

The State Mining Board of Illinois, in a somewhat more optimistic mood regarding the statistical possibilities, writes (December 19, 1912):

The coal lands in certain parts of the state have increased a hundred per cent. in value for a period of ten years, while in other portions of the state the increase in value has been very slight. The values as a whole are increasing from year to year.

The Wisconsin Tax Commissioner, after a most exhaustive report, makes the following statement:[1]

Under present statutes minerals enter into the valuation of the land in which they are deposited. This law is absolutely impossible of just enforcement. The assessor can have no reliable information as to the amount of the mineral in the ground, even in operated mines, much less its value, which must depend upon the quantity and quality of the deposit, cost of mining, and other matters requiring the highest expert knowledge. In practise the consequence is that no effect is as a rule made to tax the mineral.

The net result of this rather extensive inquiry into the increase in the value of mineral lands was therefore practically *nil*.

Even less success attended the attempt to secure any reliable information regarding the value of water sites. The development of water power on a commercial basis is so recent, and the variation in the facilities afforded by different sites is so extreme, that it seems impossible to make any just estimate of the extent to which these sites are increasing in value. It seems fair, however, to state that with the exhaustion of the coal supply, on the one hand, and the improvements in electrical appliances on the other, the near future should witness a rapid advance in the commercial value of water-power facilities.

Aside from the discouragement involved in this attempt to draw statistical blood from an economic stone, the results yielded by the study of land values, though in no sense conclusive, are in every way suggestive. The federal government has recently completed an extensive investigation of the lumber industry. The Census Department and the Department of Agriculture both attempt to secure farm values, and a number of cities have instituted systems of separate assessments for land and improvements, which makes a determination of land values in those cities comparatively easy. Therefore, for timber lands, for farm lands and for city land the sources of information merit attention.

Unlike mineral and fuel deposits, timber tracts are susceptible of definite measurement and valuation. Private dealers as well as state and federal authorities were most generous in the cooperation. The information from private sources and from state officials is intended only to corroborate and supplement the excellent body of information compiled by the Bureau of Corporations.

Timber is an anti-social scapegrace. For a generation it has been the leader in the merry race of upward-moving prices. Since 1890, the prices of timber products have risen faster than the prices of any other group of commodities. The latest wholesale price-list issued by

[1] Report of the Wisconsin Tax Commission, 1910, Madison, Wis., 1911, p. 16.

the Bureau of Labor (Bulletin No. 99, March, 1912) reports for lumber products a rise in price which is little short of phenomenal. Taking as a basis the price between 1890 and 1899, the price of hemlock lumber rose (1890–1912) from 105.2 to 172.9; of hard maple, from 100 to 129.5; of white oak, from 98.6 to 154.5; of white pine, from 96.4 to 214.2; of yellow pine, from 112.4 to 177.3; of poplar, from 97.2 to 196.4; of spruce, from 113.5 to 169.2; of shingles, from 110.7 to 130.1; of tar, from 122.4 to 176.4; of turpentine, from 122.0 to 203.1; and rosin claps the climax with an increase from 96.1 to 466.5. This series of twenty-two years, therefore, shows a remarkable rise in the wholesale price of timber and timber products. One turns from this extraordinary increase in the price of timber products to inquire into the increase in the value of the lands from which timber comes. Has the rise in the value of the land from which the raw material is derived corresponded with the rise in the value of the raw material?

The inability of officials and of private persons to supply data on the increase in the value of mineral lands was more than offset by their generosity in furnishing information regarding the rise in timber values. The editor of *The Lumberman's Review,* Frederick J. Caulkins, comments (March 19, 1913):

> The sharp upward movement began about 1899, since which time I should say that timber had increased at about the same rate as lumber, namely, about one hundred per cent.

A number of private firms wrote interesting letters regarding the movement of prices in their own section. A lumberman from Au Sable, Mich., states (March 5, 1913):

> Hard-wood lands from which the pine had been cut were sold (1895) by pine operators, from one to two dollars per acre. Gradually, but steadily, these lands have advanced in value, until at this time they would bring from twenty to sixty dollars, and more, an acre.

A prominent lumber manufacturer from Bay City, Mich., writes (April 3, 1913):

> In Minnesota white pine has been sold at from eight to twenty dollars per thousand feet. In Michigan, hard woods, including hemlock, have advanced from five and ten dollars per acre to, in some instances, as high as ninety dollars per acre for especially good tracts of timber.

Another lumberman gives an excellent illustration of a small increase in values (March 24, 1913):

> Six years ago I bought a tract of hard-wood timber land in the upper peninsula of Michigan. The average cost was about nine dollars, and the interest, taxes and fire protection brought the investment up to about sixteen dollars an acre. The land could not be sold for over twenty dollars an acre to-day.

Similar letters from other sections of the country show a comparatively wide variation in the extent of the increase in forest lands, but a very obvious increase none the less.

Public officials were also liberal with information. The secretary of the Forest Park Reservation Committee of New Jersey gives it as his opinion that

It is no overstatement to say that forest property in any part of New Jersey is worth at least double what it was worth ten years ago.

The acting state forester of Minnesota believes (January 3, 1913)

that the value of wild lands in the northern part of this state has advanced rapidly in the last ten or fifteen years. I believe that it is safe to say that this increase has been as much as from one hundred to one hundred and fifty per cent.

The Conservation Committee of the State of New York writes that

In 1890 a law was passed providing for the purchase of land for forest preservation purposes, not to exceed one dollar and a half per acre. The lumbermen that operated these lands and removed the spruce down to about twelve inches stump diameter, seemed to be anxious to sell their land at that time for this price. It has often been stated that property which the state acquired at that time for this price is worth from twenty-five to thirty dollars per acre at the present time.

Austin F. Hawes, the state forester of Vermont, believes that

It is safe to say that land covered with good timber has doubled in value within the last fifteen years.

The state forester of Kentucky writes that

Judging from the experience of Berea College, which owns about five thousand acres of timber land, on the average timber has more than doubled in value in the last ten years.

The State Board of Forestry of Wisconsin fully confirms the estimates made by private lumbermen from that section of the country. The state forester writes (March 4, 1913):

I believe that the following prices are approximately accurate for the state as a whole:

	Stumpage 20 Years Ago	Stumpage To-day
White pine	$3.00	$10.00
Norway pine	1.00	8.00
Hemlock	.50	3.00
Birch	2.00	6.00
Basswood	3.00	8.00
Elm	2.00	6.00
Tamarack	.50	3.00
Cedar	1.00	3.00
Spruce	2.00	6.00

On specific tracts of pine I know of several instances where the stumpage has increased from $2.00 to $5.00 twenty years ago, up to from $15.00 to $20.00 to-day. Another specific tract of mixed timber was appraised and offered for sale by the state for $425, in 1902, but there was no bidder at this price. This winter we have sold the timber on this tract for $1,860.

The federal government in Part I. in the Report on the Lumber Industry takes up the problem in very great detail. While recognizing the difficulty of making a definite statement regarding the extent to which the timber land has increased in value, the writers of the report are nevertheless struck by the extent of the increase.[2]

> The value of timber varies so extremely, according to location, species, quality and stand, that it is impossible to measure accurately the average amount of the advance. For the purpose of this report it is not necessary so to measure it. The comparative figures hereafter given are not intended to represent the average values of any kind of timber or to establish in any sense a timber price.
>
> That the increase has been nothing less than enormous is recognized by the men most familiar with the business. In speaking of the rise of prices in the last twenty years they refer to changes from 12½ cents to $4.00 per thousand; from 10 cents to $3.00 a thousand; from $5.00 to $20.00 an acre; 300 per cent. in ten years; from $1.50 to $20.00 an acre; from 50 cents to $3.00 per thousand. These figures are for southern pine. In cypress: from 15 cents to $5.00 a thousand. In the Lake states men in the business similarly speak of increases from "no market value" (hemlock and hardwoods) to $4.00 to $10.00 a thousand; from $2.00 to $6.00 a thousand (hardwoods). In the Pacific-Northwest similar general statements are made of rises in value, such as 15 cents to $2.50 a thousand; 10 cents to $2.50 a thousand; "no market value" to $2.50 a thousand; 75 cents to $2.50 a thousand.
>
> While these statements give no accurate measure of the general rise of stumpage values, they do show that, according to this report of lumbermen, such rise during the last twenty or thirty years has been enormous.[3]

There are obvious difficulties in the way of setting any definite limitation on the increase in the value of timber lands.

> The rise in stumpage values is likely to be greatest when a new region or a new species is just beginning to attract attention. When timber is selling by the acre at rates equivalent to ten cents a thousand, it may rise almost at once to fifty cents a thousand. The increase on each thousand feet in such a case is unimportant; yet it is an advance of four hundred per cent.[4]

Roughly, during the decade ending with 1907 or 1908 (the period immediately before the industrial depression) the federal investigation indicates that "the value of a given piece of southern pine taken at random is likely to have increased in any ratio from threefold to tenfold."[5] The investigators found instances of even greater increases. For example, tracts which sold by the acre at ten or fifteen cents a thousand feet had advanced twenty, or even thirty fold, in ten years; but in general these figures seem to hold fairly true. In the Lake region "the general ratio of advance of timber values during the last ten or twenty years has probably been less than in the south. Perhaps

[2] "The Lumber Industry, Part I., Standing Timber," Washington, Government Printing Office, 1913.

[3] *Ibid.*, p. 25.

[4] *Ibid.*, p. 214.

[5] *Ibid.*, p. 214.

the advance of any given tract, taken at random, in ten years from 1898 was most likely to be between twofold and fivefold." In the Pacific northwest, where the development in lumbering has been comparatively recent, "a tract taken at random is likely to have increased in any ratio from threefold to tenfold in the ten years ending in 1907 or 1908."[6] Here the proportion of extraordinary advances "is probably greater than in the south."

The rise in timber lands would therefore seem to have more than justified the increases in the wholesale price of lumber. Even in the older section, where the timber has been largely cut away, the increases have been rapid. In the newer section, which have recently developed as lumbering regions, the rate of increase in timber land values has been little short of stupendous.

No student can turn away from these records of the increase of timber land values since 1890 without a feeling of profound wonder. Twofold, fivefold, tenfold increases in two decades are immense, even in a developing country. That the price of timber products should have advanced rapidly in view of this tremendous increase in the value of timber land goes without saying.

Timber is in a peculiar position, economically. A hundred years ago it was an obstacle to American progress; to-day it is one of its rapidly vanishing resources. The approaching exhaustion of the timber supply undoubtedly plays a large part in causing the upward trend of prices. Not until the growing of timber is placed on a business basis and the demands of timber users are made commensurate with that business in this country, can a normal adjustment of prices be expected.

Farm land values present no such unusual difficulties as these encountered in the analysis of timber land values. Farming is an established business. The best farm land of the United States is largely under cultivation. If properly pursued, farming does not exhaust the resources of the land—rather it increases them. Hence, the increases in farm land values present an illustration of very normal land value increase.

The material dealing with the increase in farm values is by far the most accessible of all the data on land values in the United States, since the Bureau of the Census makes elaborate returns on the subject. Although these returns are open to some very obvious and often-repeated criticisms, they probably represent, on the whole, a fairly accurate statement of the increase in the value of farm lands in the districts which they cover.

The censuses of 1900 and 1910 give a separate statement of the value of land and buildings. Prior to that time land and buildings were grouped together. The last two censuses therefore furnish as

[6] *Ibid.*, p. 215.

accurate a measure as may be of the extent to which farm land, irrespective of improvements, is increasing in value.

During the decade between 1900 and 1910, the value of all farm lands in the United States increased from $13,058,000,000 to $28,476,000,000—equivalent of 118.1 per cent.[7] Not one of the nine geographical divisions covered by the census shows any decrease in farm land values. The increases, however, vary extremely. The least increase (19.1 per cent.) is shown in the Middle Atlantic States; the greatest increase (313 per cent.) is in the Mountain States. The largest total increase (slightly more than six billions of dollars) occurred in the Middle Western States, which gave a percentage increase of one hundred and fifty-eight.

A further inspection of the figures by states shows that the farm land increases are sectionally rather uniform. For example, in New England three of the states (New Hampshire, Vermont and Massachusetts) have increased between twenty and thirty per cent.; for Connecticut the increase was 37 per cent.; for Rhode Island it was 12 per cent.; and for Maine, 75 per cent. In the Middle Atlantic States, New York shows an increase of 28 per cent.; New Jersey, of 33 per cent.; and Pennsylvania, of 9 per cent. The increase for Pennsylvania is the smallest increase in agricultural land values shown by any state in the country between 1900 and 1910. The increases among the East North Central States vary from 45 per cent. (Michigan) to 104 per cent. (Illinois). In the West North Central States, however, the variation is considerably greater—from 82 per cent. (Minnesota) to 377 per cent. (South Dakota). Of the South Atlantic States, four (Delaware, Maryland, Virginia and West Virginia) show increases of less than one hundred per cent. In this same class fall Kentucky and Tennessee from the East South Central Group, and Louisiana from the West South Central Group. All of the other Southern States have increases of over one hundred per cent., and Florida (204 per cent.) and Oklahoma (334 per cent.) lead all of the others in their ratios of increase. Among the Mountain and Pacific States, only three show increases in land values of less than two hundred per cent. They were Utah (147 per cent.), Nevada (165 per cent.) and California (108 per cent.). The increase in Montana was 130 per cent.; in Idaho, 319 per cent.; in Colorado, 301 per cent.; in New Mexico, 470 per cent.; and in Washington, 421 per cent.

The total increase in the value of farm land from 1900 to 1910 for the whole United States was fifteen and a half billions of dollars, more than thirteen billions of which is credited to the territory lying west of Pennsylvania, north of the Mason and Dixon Line and west of the

[7] All of the figures in this section are taken from the abstract of the 1910 census.

Mississippi. In short, the great farm land value increases occurred in that section of the country from which most of the necessary farm products are derived. An examination of the figures in the preceding paragraph shows that of the 22 states outside of this area, none reports increases of more than two hundred per cent., while only eight show increases of more than one hundred per cent. Within the area (west of Pennsylvania, north of the Mason and Dixon Line and west of the Mississippi), of the 27 states, seven report increases of more than two hundred per cent., while 19 of the 27 report gains of more than 100 per cent.

There is, to be sure, a partial explanation of these immense western increases in the increase in acreage. The number of acres devoted to farming purposes is greater in 1910 than in 1900. This increase is not, however, considerable. Although the population west of the Mississippi increased 30 per cent. between 1900 and 1910, the total number of farms increased only 18 per cent., the total acreage in farms increased only 9 per cent., and the total amount of improved land in farms increased only 29 per cent. If the reader will bear in mind the fact that the northeastern section of the United States is increasingly dependent upon the West for its food supply, the increase in the amount of farm land west of the Mississippi is less than might have been expected.

An appeal to the census table showing the value of farm land per acre bears out the suggestion that the increase in western farm land values can not be attributed to increased acreage. The percentage of increase in the value per acre of all farm land between 1900 and 1910 was 108 per cent. In the New England, Middle Atlantic, East North Central and East South Central States, this increase in value per acre was less than one hundred per cent. For the other groups of states, namely, for those lying west of the Mississippi, the increases ranged from 146 per cent. for the Pacific States to 222 per cent. for the Mountain States. An examination of the figures for individual states shows that among the 14 New England, Middle Atlantic and East North Central States (lying east of the Mississippi and north of the Mason and Dixon Line), only one state (Illinois, 105 per cent.) shows an increase of over one hundred per cent. Among the 22 West North Central, West South Central, Mountain, and Pacific States, only two states, Minnesota (73 per cent.) and Louisiana (85 per cent.), show increases of less than one hundred per cent. in farm values per acre; while nine states show increases in the value per acre of between two hundred and three hundred per cent., and one state (Arizona) shows an increase of 476 per cent. Among the eastern states the increases in farm land value per acre are therefore comparatively small—less than one hundred per cent. in all but two instances. Among the states west of the Mississippi, on the other hand, the increase in value per acre has been immense—more than one hundred per cent. in twenty out of twenty-two cases, more than one hundred and fifty per cent. in fifteen out of twenty-two cases, and more than two hundred per cent., in ten out of twenty-two cases.

The total figures showed that the bulk of the increase in the farm land values in the United States between 1900 and 1910 occurred west of the Mississippi. The figures for increases per acre lead inevitably to the same conclusion, namely, that the farm land in the states lying west of the Mississippi has increased, during the past decade, between one hundred and three hundred per cent. in value.

The same movement for the increase in farm land values has apparently been going on steadily for sixty years. Although the census figures prior to 1900 gave the value of land and buildings together, the value of farm land predominates to such an extent that the figures for land and buildings are indicative, though not conclusive, for the increase in the value of the land.[8]

The acreage increases between 1850 and 1910 were so extensive in the states west of the Mississippi that it would scarcely be fair to cite increases in total farm land values. It is interesting, however, to note that during these six decades the total number of farms in the entire United States increased from one and a half to six millions; that the total land in farms increased from 294 millions of acres to 879 millions of acres; and that the total improved land in farms increased from 113 millions of acres to 478 millions of acres. Thus the total number of farms increased fourfold, the total acreage in farms threefold and the total improved land in farms fourfold, while the total population increased slightly less than fourfold. Meantime, the total value of all farm property rose from 3,967 million dollars to 40,991 million dollars (an increase of tenfold); and the value of farm land and buildings rose from 3,272 million to 34,801 million dollars (an increase of elevenfold).

The increase in the value of farm land and buildings between 1850 and 1910 is distributed very irregularly over the different sections of the country. For the entire United States the increase in the value per acre was from $11 to $40; in New England the increase was from $20 to $36; in the Middle Atlantic States, from $29 to $57; in the East North Central States, from $13 to $75; in the South Atlantic States, from $6 to $23; and in the East South Central States, from $6 to $21. West of the Mississippi the increases in value per acre were, for the West North Central States, from $6 to $50; for the West South Central States, from $6 to $19; for the Mountain States, from $6 to $21; and for the Pacific States, from $1.55 to $48. A comparison over so long a

[8] In 1910 the total value of the farm land alone was 28 billion dollars; of the farm buildings the value was 6 billions, or about a sixth of the total value of farms and buildings combined. The proportion was approximately the same in 1900—land value, 13 billions; buildings, 3½ billions.

period is really unfair, because up to 1890 the agricultural land of the Far West was a negligible quantity in so far as its value was concerned. These figures do show, however, the immense increase which has occurred.

The really important material on the increase in farm values is available only between 1900 and 1910. The other data are, however, of considerable significance. The whole body of information indicates that in those sections of the United States from which the food products of the country are chiefly derived, the land values during the last few decades have increased at a very rapid pace, culminating in the decade between 1900 and 1910 with an increase for ten years of double, treble or quadruple their 1900 values.

For manifest reasons, the increases in the values of lumber lands were prodigious, yet in many instances they are insignificant when compared with the increases in agricultural land values, which should yield an essentially stable value over so short a period as ten years. Instead agricultural land has fairly leaped into the field of rising values.

While farm values constitute the chief concern of the territory west of the Mississippi, the northeastern section of the United States is interested primarily in city land values. Did the census officials devote even a tithe of the effort to the determination of city land values that were lavished upon farm values, there would be collected a body of data valuable in the extreme. No such procedure has been adopted, however, hence the unfortunate seeker after the truth of changes in city land values is compelled to rely on the little information that may be culled from private sources.

Most American cities have no record at all of the increase in the value of land separate from improvements. Indeed, a prominent land-valuation expert goes so far as to write:

> I do not believe that any authentic information concerning the increase of city land value exists. Until assessments are made by the same method everywhere, there will be little in the way of statistics that will exhibit the information you desire.[9]

In one sense this statement is perfectly correct. The data which have been collected on land values are neither authentic nor scientific. They are, however, indicative of a certain tendency which Mr. Richard M. Hurd, president of the Lawyers' Mortgage Company, characterizes by saying,

> In general land values have increased enormously in the best part of the leading American cities; the land is now selling, in many sections, from two to three times the figures given in my book.[10] (Published in 1903.)

[9] A personal letter, December 23, 1912, from E. W. Doty.
[10] A personal letter, December 24, 1912.

Innumerable instances might be cited to support the contention that city land values have risen. For example, the New York City Commission on Congestion of Population cites the increase in the cost of lands purchased for school purposes. On the Island of Manhattan, the land in connection with School No. 14, at No. 33 Greenwich Avenue, cost, in 1849, 79 cents per square foot; in 1851, 84 cents per square foot; in 1890, $8.40 per square foot.; in 1897, $9.56 per square foot; and in 1905, $12.37 per square foot. In the Bronx, School No. 18, on Cortland Avenue between College Avenue and 148th Street, secured land in 1848 for 3 cents per square foot; in 1885 for $1.07 per square foot; and in 1896, for $2.18 per square foot. School No. 34, in Brooklyn, at Norman, Eckford and Oakland Streets, purchased land in 1867 for 23 cents per square foot; in 1904, for $3.16 per square foot; and in 1906, for $7.16 per square foot.[11]

A very effective study was made by the New York City Club (Homer Folks, chairman of the transit committee) regarding the increase in land values resulting from the construction of the rapid transit lines. Along the route of the new subway, assessment values, as given by the Department of Taxes and Assessments, were taken for the year 1900 on vacant lots. These were compared with the assessment values of 1907, the figures in each case representing one hundred per cent. valuation.

> To ascertain the proportion of the increase in land value attributable to the building of the subway, it was necessary to deduct from the total rise what might be termed a normal rise, or the increase that would have taken place through the natural growth of the city, without added stimulus of a new transit line.

This normal rise was determined by taking the increase from 1893 to 1900 on the same territory. The study shows that up to 110th Street the increase in land values between 1900 and 1907 was about forty-five per cent. This equaled the normal rise previously determined. The Subway apparently made no difference in this land, because excellent elevated connections already existed. Between 110th Street and 129th Street the increase "was much more noticeable, averaging about seventy per cent." The location of Columbia University at this point rendered the calculations of little value. From 135th street northward the problem appears stripped of complications. "The aggregated rise in this land from 135th Street to Spuyten Duyvil was about $69,300,000." The estimated normal rise of $20,100,000 was therefore exceeded by $49,200,000 "apparently due to the building of the subway." This increase is one hundred and four per cent. increase on the value of 1900. A similar rise in the land values of the Bronx was shown. Between the

[11] Report of the New York City Commission on Congestion of Population, February 28, 1911. New York, Lecouver Press Company, pp. 56–57.

Harlem River and Bronx Park the increase in land values due to the building of the subway was $31,300,000.

The report goes on to state that, while the increase in land values above 135th Street, due to the building of the subway, was $39,200,000, the cost of building the subway from this point to 230th Street was $7,375,000, or but 15 per cent of the actual rise caused by the new line. Similarly, the increase in the Bronx land values of more than thirty million dollars was caused by subway construction costing $5,700,000.[12]

These instances are typical of the land value increases which are so apparent in New York City. Other great centers of population, however, show similar conditions. Mr. C. B. Fillebrown, in his "The A-B-C of Taxation," cites some interesting illustrations of increases in the land value of Boston. For example, the land values irrespective of improvements,

> on both sides of Winter Street, including the estates on the Tremont and Washington Street corners were in 1898, $61.57 per square foot; in 1907, $97.50 per square foot.[13] . . . The land in Winter Street, which was assessed at less than four dollars per square foot, in 1850, was assessed in 1907 at one hundred and thirty dollars per square foot. During the fifty-seven years intervening, the income, above taxes, from the land, in rent and appreciation has amounted to an average of one hundred and fifty per cent. annually on the investment of 1850.[14]

Similar illustrations might be cited in endless detail, showing the rise of land values in American cities. Even the casual observer must admit the very obvious facts of land value increase. The one thing needful is some accurate measure of their extent.

There are a few American cities in which a careful assessment of land independent of improvements has been made. In New York City, for example, the land and improvements have been separately assessed since 1906. The Report of the Commissioners of Taxes and Assessments for 1912 (pages 20–23) gives the land value assessments in considerable detail. The value of the land alone for Greater New York was, in 1906, 3,367 million dollars, and in 1912, 4,563 million dollars. This represents an increase in the per capita value of land from $811 in 1906 to $898 in 1912. Incidentally, the total value of all improvements in 1912 was only two billion, seven hundred and sixteen millions, or about three fifths of the total land value.

The boroughs separately show a considerable divergence in the ratio of increase. In the Borough of Manhattan, for example, the increase in

[12] "Building of Rapid Transit Lines in New York City." A memorandum addressed to the Board of Estimate and Appropriation by the City Club of New York, October 2, 1908.

[13] C. B. Fillebrown, "The A-B-C of Taxation," New York, Doubleday, Page and Company, 1912, p. 56.

[14] *Ibid.*

the value of the land between 1906 and 1912 was from $1,196 per capita to $1,296 per capita. This represents a total increase in land value of more than five hundred million dollars. In the Borough of Bronx the per capita land value fell from $771 to $657. This decrease was due primarily to the fact that during these six years the population of Bronx was almost doubled. For this borough, the total land value increased sixty per cent. For the Borough of Brooklyn, the per capita valuation rose from $325 to $450. The population increased less than twenty per cent. and the land value rose from 456 millions to 786 millions. The Borough of Queens, which is the least developed in Greater New York, shows an increase in per capita land value from $388 to $862, an increased 60 per cent. in population and an increase in the total land value from 81 millions to 278 millions. The problem in the Borough of Richmond is very similar to that in Brooklyn.

Although the land valuations in New York extend over only six years, they show that during that time the total increase in the value of the city's land was about 40 per cent., while in the newer sections of the city, notably in the Bronx and in Queens Borough, the increase was about 60 per cent. Neither in their totals nor in their proportions do these increases compare with the increases in timber land values or in farm land values. If the increase in New York land values is compared with the increase in the farm land values of the richest agricultural states, or of the best timber lands, they are comparatively small.

The land of Boston has been assessed separately for the improvements, at "the full and fair cash valuation" since 1887. There has been no material addition to the area of the city of Boston during this time; in fact, the number of square feet of land taxed decreased from eight hundred and ninety-six million in 1876 to eight hundred and fifteen million in 1912. This decrease was due to the taking of land for streets and other public purposes. It is interesting to note in this connection that between 1896 and 1911 two of the twenty-five wards in Boston show a decrease in land value; one shows an increase of one hundred dollars; one shows an increase of twelve thousand dollars; while twenty show increases varying from one million to twenty millions of dollars.[15]

The value of all land in Boston between 1887 and 1911 has increased steadily.[16] There is no year during the period that shows a decrease. In 1887, the land valuation was 322 millions. For the next two decades it was:

1890	$365,548,000	1905	$618,642,000
1895	443,695,000	1910	672,100,000
1900	532,934,000	1911	685,484,000

[15] Annual Report of the Assessing Department for the Year 1911, City of Boston Printing Department, 1912, p. 46.

[16] *Supra*, p. 16.

Twenty-four years show a total increase of slightly more than 100 per cent.

The land values of Boston are therefore increasing at less than half the rate of those of New York. During the years for which comparison may be made (1906–1911) the land values of New York rose 38 per cent., while those of Boston rose less than 8 per cent.

Two other cities in the East make separate assessments of land and improvements. The increase for these cities is:

Trenton, N. J.[17]

1906	$21,866,000
1907	21,707,000
1908	21,735,000
1909	21,866,000
1910	22,140,000
1911	23,530,000
1912	23,561,000

Newark, N. J.[18]

1907	$122,904,000
1908	121,465,000
1909	125,515,000
1910	129,469,000
1911	134,764,000
1912	141,059,000

Although the period covered in both cases is short, the rate of increase is very similar to that of Boston for a similar period. The seven years in Trenton show an increase of slightly less than one tenth and in Newark of one seventh.

The records of some western cities furnish a striking contrast in this ratio of land value increase. Milwaukee in the Middle West assessed land in 1890 at $52,386,000. For succeeding years the assessment was:[19]

1895	$74,229,000
1900	75,816,000
1905	$85,961,000
1910	99,502,000

For 1911 and 1912, the basis of assessment was increased from 60 per cent. to 100 per cent. The 1912 valuation was $193,799,000. The rate of increase for Milwaukee is somewhat greater than for Boston, though not so great as for New York. (Between 1891 and 1912, the area of Milwaukee was increased from 21 to 24 square miles.)

The three far western cities for which separate land assessments were secured[20] (Dallas and Houston, Texas, and Seattle) report far more rapid rates of increase.

[17] Letter from Commissioners of Assessment of Taxes, December 18, 1912.

[18] Letter from the Board of Assessment and Revision of Taxes, December 27, 1912.

[19] Letter from the Deputy Tax Commissioner, December 31, 1912.

[20] The facts for San Francisco are likewise available, but are rendered very inconclusive because of the fire. The land assessments then were:

1905–06	$304,135,000
1906–07	237,038,000
1908–09	258,652,000
1910–11	$288,095,000
1912–13	301,196,000

(Annual Financial Statement of San Francisco, 1911–12, p. 156.)

City of Dallas[21]		*City of Houston*[22]		*Seattle*[23]	
1907	$16,477,000	1904	$19,787,000	1905	$ 70,038,000
1908	21,300,000	1905	20,588,000	1906	125,735,000
1909	21,356,000	1906	23,682,000	1907	155,751,000
1910	38,530,000	1907	30,353,000	1908	178,427,000
1911	44,468,000	1908	30,486,000	1909	184,737,000
1912	44,605,000	1909	36,533,000	1910	205,309,000
		1910	36,627,000	1911	212,014,000
		1911	46,916,000	1912	212,929,000
		1912	61,389,000		

There has been no considerable increase in the acreage of Dallas or Houston during the period under consideration. The acreage of Seattle, however, has increased from 29 to 60 thousand acres, between 1905 and 1912. The table is therefore worthless for comparison.

Many Canadian cities make separate assessments of land and improvements. Though they are outside the strictest limits of the discussion, they are probably typical of the rapidly growing towns in the western states. It is at least worth noting that the land values in Vancouver more than trebled between 1895 and 1909, that the increase in Victoria is approximately the same, while in the newer cities like Winnipeg the increase in valuation is even more rapid.

City land values are increasing—slowly in the east, more rapidly in the west. Each decade sees from twenty per cent. to one or two hundred per cent. added to the value. Still the rate of increase does not compare with that for forest or agricultural lands.

The increase in the land values throughout the entire United States has been immense during recent years. Particularly since 1896, timber and farm land values have advanced rapidly in price. City land values, though less rapidly, have risen none the less surely. What the future may hold in store for a nation whose timber lands treble, and whose farm lands double, in value during a single decade, the student of statistics may not venture to prophesy. The matter is at least worthy of serious consideration.

[21] Letter from the Commissioner of Finance and Revenue, April 8, 1913.

[22] Letter from the chairman of the Board of Appraisement, December 20, 1912.

[23] Letter from the County Treasurer, April 1, 1913.

THE SCIENTIFIC STUDY OF CHILD DEVELOPMENT

By JAMES BURT MINER, Ph.D.

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THE public recognition that questions of development are different from questions of health has caused a constantly increasing demand for another type of expert than the physician. We may call him an expert in child development. When a parent stops to consider the matter he knows that neither the short boy nor the short-minded boy is primarily a sick boy. Moreover, if a child is persistently poor in mathematics, it is not because of ill health. Mathematics makes him sick, but in a different sense. He may lack the native interest necessary for a mental flight into the fourth dimension. When a mother discovers that her daughter can not play the piano, she does not take her to a doctor. She recognizes that it is a question of the absence of a capacity for music or of improper training. Which fault it is, she often can not tell.

The expert in judging development must understand, not only how the child is influenced by disease, but also how it is influenced in other and more fundamental ways by hereditary tendencies, environment and education. The attempt to specifically prepare such experts began some fifteen years ago with the establishment of the first psychological clinic. This work has now been taken up by half a dozen of the leading universities. Graduates, trained by their psychologists, are giving special service of this character in connection with the public schools, juvenile courts, bureaus for vocational guidance, special schools for exceptional children, schools for feebleminded, correctional and penal institutions. Besides improving the methods for diagnosing the individual child, scientific study is now rapidly increasing the data for deciding how large groups of children should be handled in school and out. This study of groups has been called to general attention most prominently by various investigations of laggards in the public schools. The most extensive of these is an elaborate report by Professor George D. Strayer, published by the U. S. Bureau of Education, which covers hundreds of cities scattered throughout the country. To understand what the scientific study of development stands for, it is necessary to consider both the researches which are directed at the study of groups of children and those which emphasize the prolonged study of particular children.

Practical people and school authorities everywhere are forcibly aroused when they learn, through the statistical studies, that our public educational system is based upon a theory of the pupil's progress in school which perhaps miscalculates by two years the success of the ordinary child in passing through the grades. According to the estimate of retardation made by Ayres, the average child in the country at large would not complete the eight grades in less than ten years. This means unmistakably that a decided change must be made either in the curriculum or the teaching if our schools are to become adapted to the abilities and needs of the average child.

Group studies are being made of many other sides of child life. A recreation survey of the city of Milwaukee, made by Mr. Rowland Haynes, a field secretary of the American Playground and Recreation Association, brings out, as do similar surveys elsewhere, many facts which bear upon the most dangerous part of the child's day, the play hours. With about 350,000 tickets sold weekly on the average to shows in Milwaukee, 60 per cent. are to moving picture shows and 21 per cent. to vaudeville houses. The public has not begun to realize the tremendous possibilities of the moving picture show for good and bad. Again, this report shows that, after allowing 300 children to play on every usable acre of public and private play space within three districts tested, half of the thousand children enumerated would have to play in streets or alleys or not play at all out of doors in those districts. Perhaps even more significant of a condition of child development is that for 1,400 children observed in these districts outside of school hours, half of them were neither working nor playing, but doing nothing. Idleness, mischief and bad development probably correlate closely in the child's make-up.

For those who can stand statistics or, perhaps I should say, understand them, the frequent enumerations of child welfare conditions have served to demonstrate the needs and dangers of childhood. We have learned of the tremendous unnecessary waste of life through infant mortality, which is the most important health problem of the day, because proper care will here save the most lives. Statistics have also shown the need for medical and dental treatment for school children. Lying back of these problems are still more fundamental biological problems of eugenics and euthenics. A whole school of statistical experts traces its origin and inspiration to the personality and work of the late Francis Galton, who established just before his death the Galton Laboratory of Eugenics in London. The work of these eugenic experts and the biometrists is making it clearer every day that the problem of the mental defective is mainly a problem of heredity.

There is a childish query which aptly puts the question of inheritance and environment. A little lad was gazing raptly at the stove when he suddenly burst forth with one of those inspirations of infants: "Oh, papa, suppose our cat had kittens in the oven, would they be kittens or biscuits?" Many biometrists would agree with papa that the oven is not so important as the old cat. The more this group of scientists studies mental defectives and bad boys the more evidence they disclose that to get good biscuits you must have good dough, that the dough out of which boys are made is more important than the "dough" spent in bringing them up.

Statistical inquiries will lay bare the great underlying causes at work in modifying human development. They are essential to estimating the relative importance of public questions which the community must settle, and they enable society to attack intelligently its most vital problems. On the other hand, when we come face to face with the question what shall we do with a particular child, statistics are often woefully dumb. We may know that a town is seriously affected by its unrestrained temptations to strong drink, and yet the particular boy we are interested in may not be at all influenced by this temptation. We may know that a hundred women successively admitted to the reformatory at Elmira, N. Y., were all feebleminded, as was recently discovered, and yet this does not settle the question whether or not the girl we have before us is weakminded. The statistical cross-section studies of groups must be supplemented by prolonged studies of the same individuals before we shall be able to scientifically apply our knowledge to particular cases.

It is because the now well-known method of measurement devised by Professors Binet and Simon, of Paris, is of importance in diagnosing the mental development of a particular child that it has given so much impetus to the study of childhood. When one reads the literature on the subject it is easy to get the impression that the diagnosis of mental age begins and ends with the Binet tests. This is one of those popular mistakes which is very disquieting to the scientists. Ever since the first psychological laboratory was established in Leipzig in 1879, a large part of the work in this science has borne directly or indirectly upon the problem of mental measurement. The attempt of an inexperienced person to measure intelligence or to use the Binet scale without some knowledge of this twenty years of investigation along similar lines is likely to be more or less of a farce. Even the studies that have been made the past five years of the Binet tests alone would fill a good-sized volume. There are at least half a dozen materially different English translations and adaptations of these tests. In this situation a parent had better trust the opinion of the school teacher as to his child's mental development, than to depend upon a diagnosis by the Binet scale which is made by a person inexperienced in psychology and in the use of laboratory tests. A properly trained expert, however, can diagnose a child's mental age within a year, and thus provide an important check upon the opinion of his school teacher.

Perhaps I can illustrate the reliability and value of these mental examinations of children by telling a joke on myself. In a paper read at the State Conference of Charities and Correction, I cited an example of the examination by a student of mine of twenty boys at the Minneapolis Juvenile Detention Home. I stated that among these twenty there was only one boy who was normal mentally and in the proper grade at school for his mental development. Later, in going over these examinations again, I noted a fact, which had escaped me before, that among these twenty boys reported was the son of the superintendent of the home. What was my surprise to find that it was he who was normal and in his proper school grade. The examinations had indirectly singled out the only boy on the farm who was not a juvenile delinquent, as well as brought out the irregular mental and scholastic development of delinquents.

The most important part of a diagnosis of development is, of course, not the question what stage has this child reached now; but what accounts for his retardation, if he is retarded, and what improvement may we expect in the future if his physical or environmental handicaps are corrected and he is given proper training from this time forth. So far as this prognosis is concerned its value to-day depends largely upon the experience and judgment of the person making the prediction. We are only beginning to gather and record these data for prognosis and it will be years before we can make predictions with the scientific precision that is to be desired. A beginning, however, has been made. We know that if a child stands still in his mental development for a year after receiving the best medical treatment and under expert training then we may be reasonably sure that all except the simplest school training is virtually wasted. We should have a case of arrested development resembling the case of Abbie described by Dr. Goddard. Abbie came to the New Jersey Training School when she was eleven years old with a mental development that was about that of a seven-year-old child, as nearly as can now be judged. After receiving expert training and treatment for ten years she was examined and found still to have a seven-year-old mind. The ten years thrown away in trying to teach Abbie to read and cipher might have been much better spent in improving her work in those employments suitable for a seven-year-old child, and then allowing her to occupy herself with them under proper guidance. If the seriously deficient child is to be permanently isolated from society, as has been suggested by experts in eugenics, the public would undoubtedly be better satisfied to have the final disposition of these cases postponed until after a year or more of special training following the diagnosis. This suggestion has been made by Dr. H. D.

Newkirk, director of the juvenile-court clinic in Minneapolis, and it merits careful consideration by those formulating our laws.

In rare cases, on the other hand, we find that the mentality is in advance of the child's school attainment. I have in mind one boy whom we examined in our clinic who was brought to us by one of the probation officers from the juvenile court. He had attended one school after another, jumping about from parochial to public school and back again with no assistance at his home and general neglect on the part of his incapable parents. We found him to be nine years old intellectually and yet he was not succeeding in first grade work. He was thus retarded at least two years in school attainment. In thirty hours of expert training, after he had been properly fitted with glasses, he was taught to read in the Second Reader, although he could not read in the First Reader when the training began. A decided deficiency in mathematics or reading has thus been overcome occasionally by special training.

In one system of schools in the east, examined by Dr. H. H. Goddard, about one out of five pupils who were retarded in school attainment were shown by mental examinations to be at least a grade behind the grades most frequently reached by pupils of their mental development. Some of these were undoubtedly kept back because they had started school after they were seven years of age or had been long absent. We should hardly expect a fifth of the scholastic retardation to be corrected by brief expert training, and yet how much might thus be alleviated we do not know. It is one of the most important questions that has been raised by these tests for ability.

The measurement of the intellect, such as is accomplished by the Binet scale, should not be overemphasized. It is only one of the ways in which the study of individuals has of late been undertaken. The Vocational Bureau at Boston and vocational tests in Cincinnati have opened a large field. The child welfare work makes another demand. In mentioning the recent impulses to child study, which seem to be thrilling the social body, we should not slight what promises to give the greatest inspiration to this movement, I mean the work of Maria Montessori. Dr. Montessori has rediscovered the golden rule of scientific education, observe how the child develops. Instead of inviting a healthy young fledgling to ride in his teacher's air-ship, she would let him try his own wings under guidance of a mother bird.

The moral development of the child has been most recently brought under scientific observation in connection with the clinics established at several of the juvenile courts. Dr. William Healy organized the first of these about four years ago in Chicago. Several such clinics are now accumulating most interesting data. We have found in Minneapolis, through a survey of about 300 boys and 100 girls consecutively found delinquent in our juvenile court, that the most prominent measurable difference between these delinquents and the ordinary school children is apparently their retardation in school and in mental development. Seven out of ten of the offenders among the boys and nine out of ten among the girls were lagging a year or more behind the average position attained by those of their ages in school. This frequency of retardation in the delinquent groups is three and four times as great as among Minneapolis school children generally. When the average amount of retardation in school is considered it is found to be nine times as great among the delinquent boys and twenty times as great among the girls as among school boys and girls generally in the city. In intellectual development the indication is that over half of the repeaters and those sent to the detention home or state training schools are a year or more backward, while about twenty per cent. are three years or more retarded mentally.

Another serious condition which our study has disclosed is that nearly half of the girls who get into the juvenile court and half of the boys at the detention home are living with one parent or with neither. In other words, half of these more serious offenders and half of the delinquent girls come from homes which have been broken up by death, desertion or divorce.

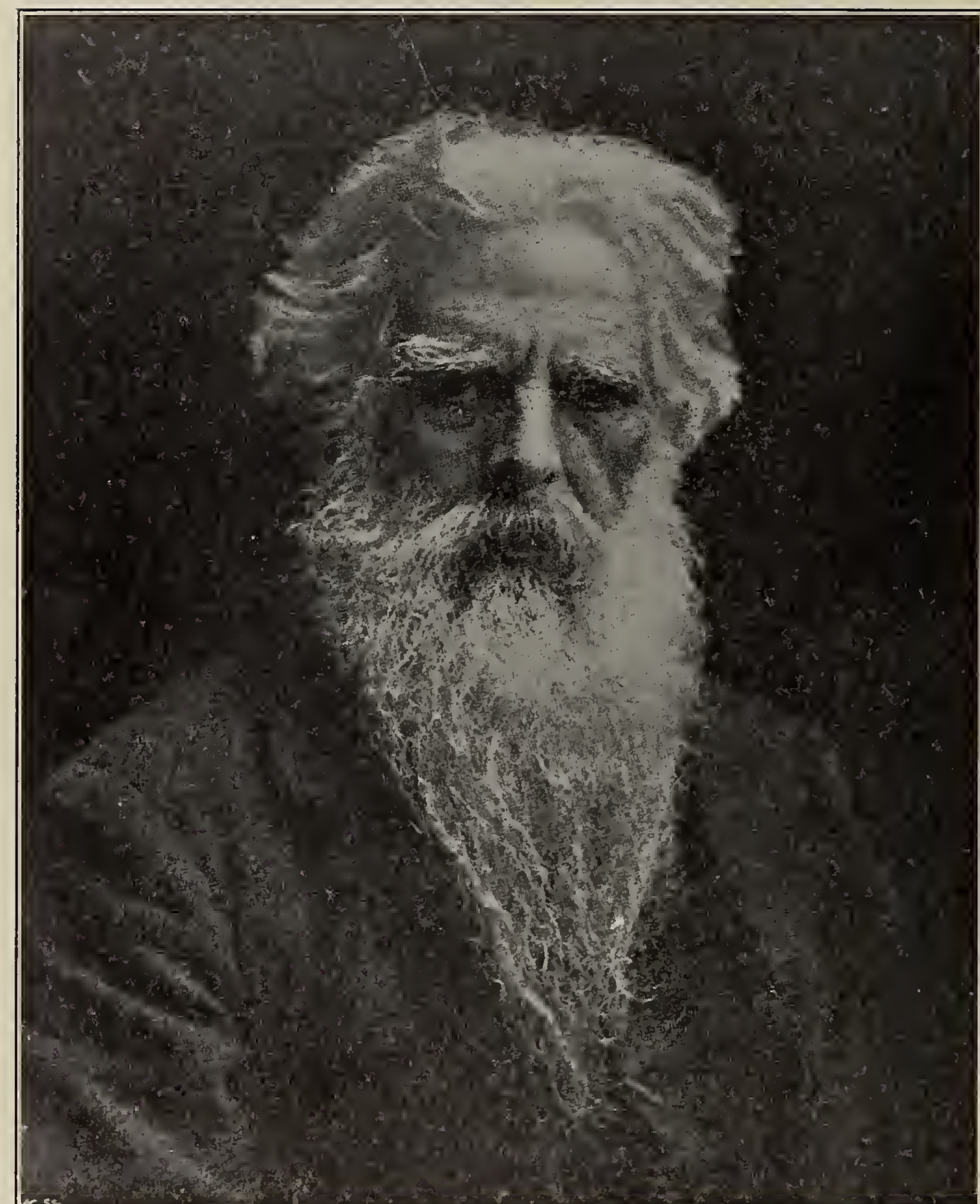
Any child will be handicapped by disease, physical defects, bad training, or unsympathetic and improper environment at home, in school or at play. The removal of these handicaps, however, does not at once convert a youthful offender into an intelligent and upright citizen, when he has been subject for years to these baneful influences. This is a lesson which the difficulty of reforming character always drives home. To make a good boy or girl requires more than restoring his health and giving him some money to spend. He must be taught how to use his strength and his resources. This is a vastly more difficult problem than curing a disease. How difficult this training problem is may be indicated by telling you the story of one of the boys we have studied in our juvenile court work.

There is to-day nothing very bad about this boy, Harold, either as to his health or his mental ability, and yet his history shows a collection of physical handicaps which he carried from infancy. One of these disabilities of health made it impossible to send him to school until he was nine years of age. A year after that he had adenoids removed which had also been troubling him for years. Another ailment, with which he had suffered nobody knows how long and which would have kept him in a highly nervous state so long as it lasted, was discovered and corrected since the first of the year. Last December, when he was examined, he had the mentality of a child about two years younger than himself, although he had then been improving noticeably.

Since the removal of his last physical handicap I have examined him again and he is to-day about normal in his mental ability, having apparently advanced almost two years in type of intellectual activity in less than a year, largely because relieved of these physical drains on his vitality. The physical defects, we may say, are to-day practically corrected and he is quite a healthy boy. But the result of all these past handicaps has been serious for Harold and he has carried over to his present age of twelve years the childish propensities and childish lack of control which he acquired during those long years of childish mental existence, while he was associating with boys much younger than himself and amusing himself almost like a child in the kindergarten. One of these childish impulses, while it was little more than mischievous, has become so firmly established that society must be protected from the boy until he can learn to correct it and control himself. His particular passion is for horses. When the whim strikes him to take a ride, all of the restraints which his parents, his teachers, the probation officers, the court and a term at the detention home are able to pile up for him have apparently so little effect that he will not think twice before driving off the nearest and most convenient horse in his vicinity. Longer training at the detention home, which all desired, he has made impossible by running away almost as quickly as he is taken there, another manifestation of his childish lack of control. Five times he has come to his home in Minneapolis, 15 miles away, in spite of the warning that boys were sent to the State Training School for this. On the last of these visits at home he went to a neighbor's barn, harnessed up the horse and drove off with another boy for an evening's ride. After this lark they returned the animal unharmed to the stable. Having repeatedly tried and finally exhausted the entire list of milder forms of restraint, it was necessary for the good of the boy and the protection of delivery wagons to see what the more severe discipline of some months of life at the State Training School would do to break up this childish habit which has been carried over into youth, to teach the boy the self-control that must belong to young men and which he would probably have normally attained had he not been handicapped by the ill health which kept him for years in the stage of early childhood.

Harold was trained under favorable conditions at home and in school. There is an excellent prospect for him to turn out well; but how much more difficult is the problem when the home is a nest of filth and corruption, as it sometimes is. The probation officers have discovered homes of delinquents where literally the pigs are brought up in the parlor; others where children do not know what it is to sit down to a table for their meals, but walk about helping themselves to the family bowl of mush or loaf of bread. Worse than this are the examples of theft and vileness set by others in the house or neighborhood. Fortunately, very bad conditions are rare; but they are frequent enough to make the need for assistance vastly greater than the supply.

With many of us who were born in the west the joy of pioneering still continues. In this work of training retarded children and youthful offenders we are again on the frontier, hewing down forests of bad habits and founding homes for the future generations. As our resources increase and our knowledge accumulates we may look forward to the time when we shall be able, at these border lands of society, to select the good seeds, mother them in a fruitful soil, weed out the tares, and raise a bumper crop of boys and girls that will do credit to the nation.



Eadweard Muybridge.

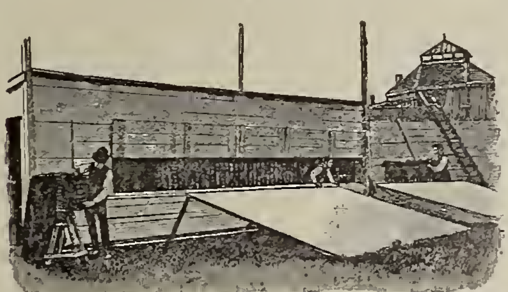
THE PROGRESS OF SCIENCE

THE SCIENTIFIC ORIGIN OF MOVING PICTURES

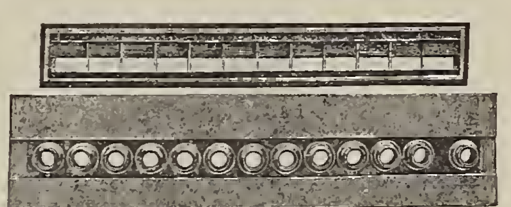
Eadweard Muybridge began his experiments in instantaneous photography in California in 1872 and subsequently carried them forward at the University of Pennsylvania, which provided him with grants amounting to more than $40,000. We thus have an instance in which scientific investigation supported by a university has been the origin of an enterprise of immense practical and commercial importance. The annual receipts from moving-picture shows in the United States are about $150,000,000; a royalty of ten per cent. on these receipts would defray the entire cost of all the real university and research work in this country.

The experiments of Muybridge at the University of Pennsylvania were originally undertaken to study animal locomotion, and in this direction were of much importance, both for science and for art. Painters and sculptors should represent men and animals as they appear to the eye, not as they appear in instantaneous photographs; but the knowledge of the position of the body in movement, first learned through such pictures, is of value to the artist comparable with a knowledge of anatomy. Several of the original pictures taken by Muybridge are here reproduced from original plates in the possession of the University of Pennsylvania, by the courtesy of Mr. George Nitzsche, recorder of the university, who has contributed to *Old Penn* an article describing the methods used.

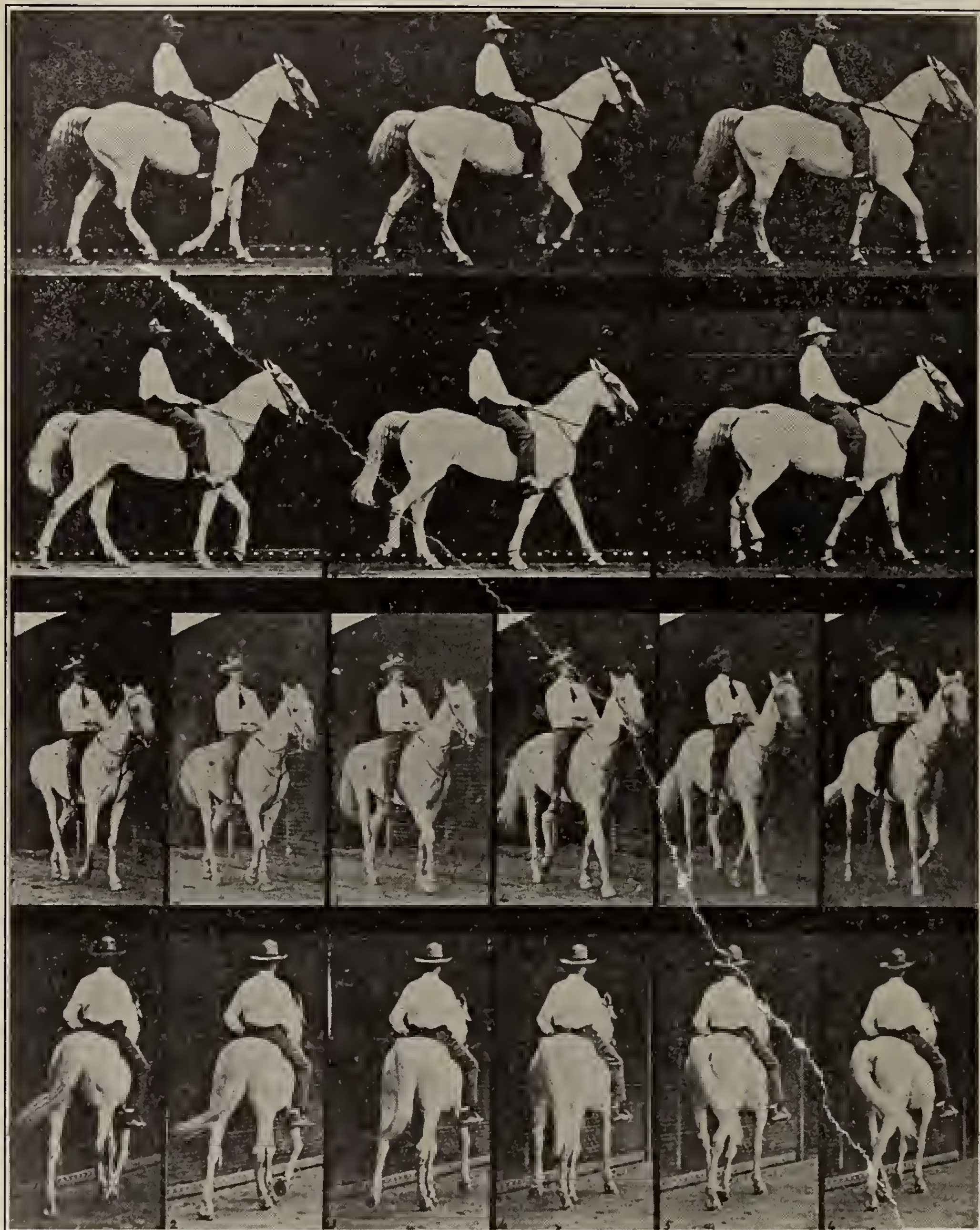
On the grounds of the University of Pennsylvania a shed was built, about 120 feet in length, painted black with a net-work of white threads. Opposite the shed was the camera-house, shown in the illustration, in which were 24 cameras, each having a lens 3-inches in diameter. The cameras were operated electrically by a motor clock, so that twelve successive exposures could be made in one fifth of a second. In some cases three batteries of cameras were arranged so that simultaneous views from different positions were obtained. Thus in one of the pictures here reproduced the stride of a walking horse is shown in 36 different photographs, twelve successive positions being reproduced from three points of view. There is similarly shown the front and side views of movements in making a high jump. Instantaneous pictures of animal locomotion were subsequently made by M. Marey in Paris, who used a sensitized film, so that a succession of pictures could be taken with a single lens. Mr. Edison later applied the film to the kinetoscope and to projecting moving pictures on a screen with a lantern.



Building Showing Battery of Twenty-four Cameras.



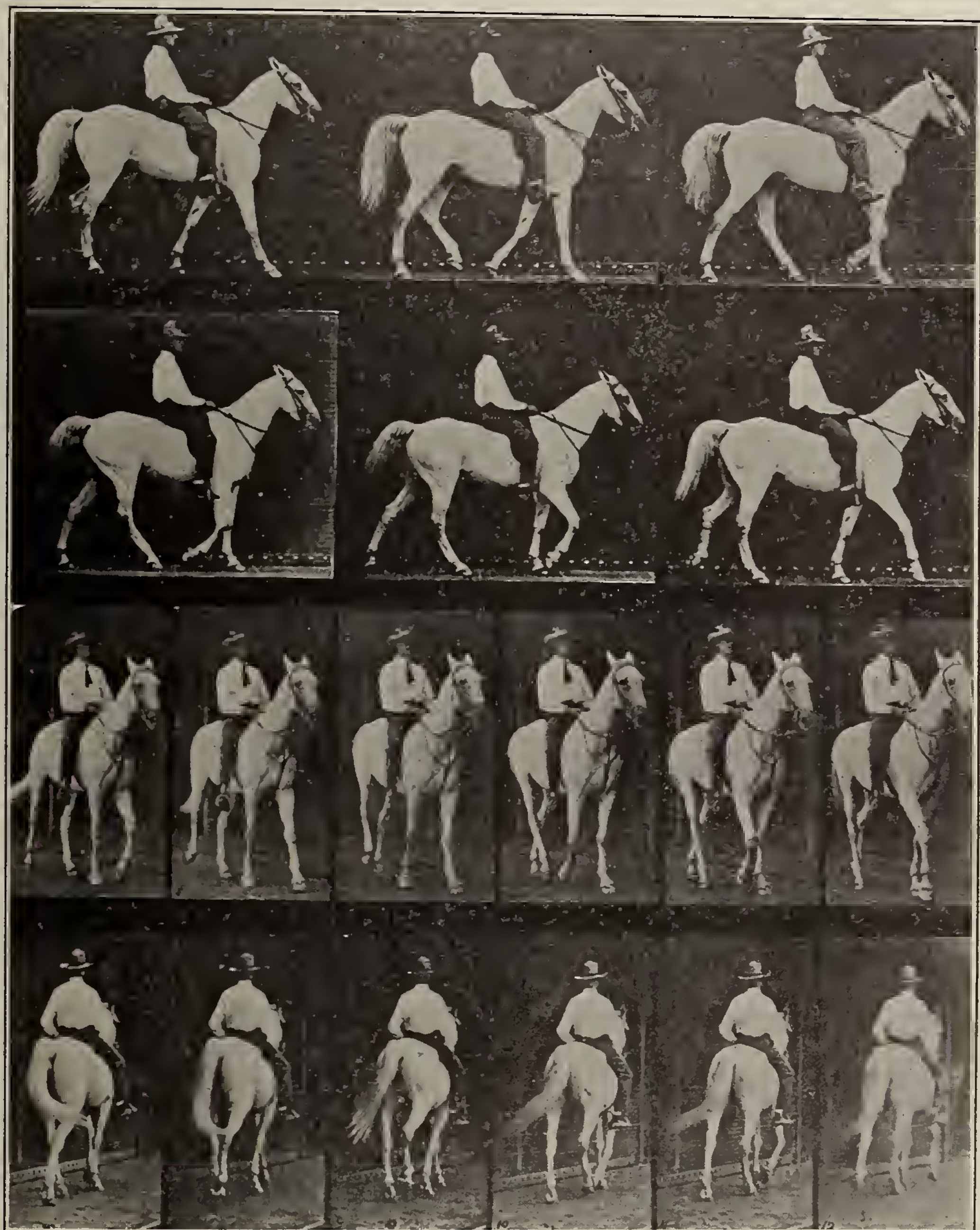
Photographic Camera Divided into Compartments, each having a lens of the same construction, and arranged to correspond with the compartments in the Electro Photographic Exposors.



Walking Horse. Side, Front and

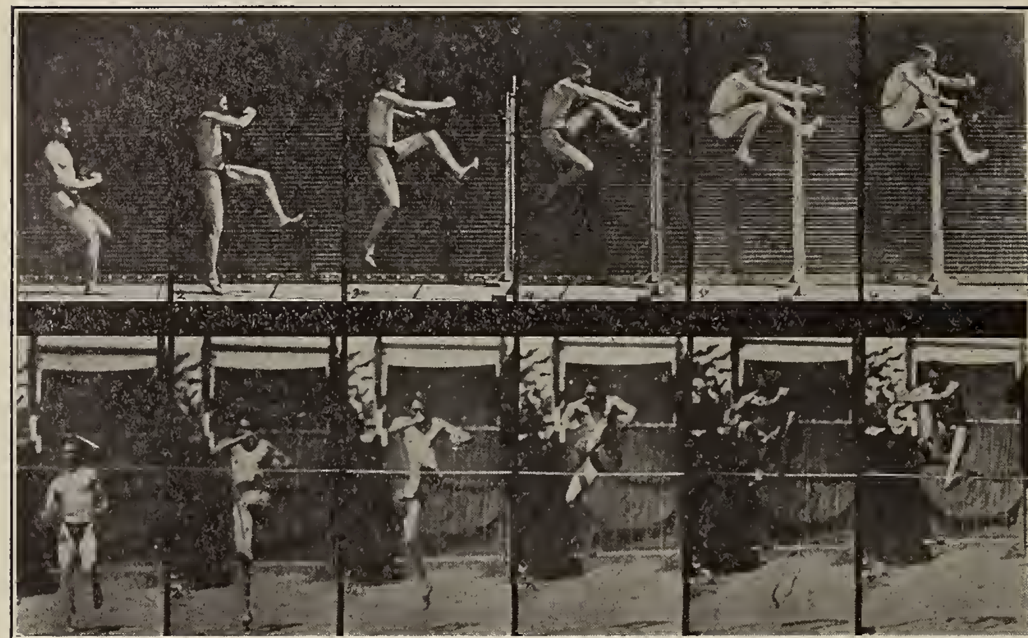
Muybridge, however, not only took the first photographs of moving objects but also first projected them on a screen, thus leading directly to the modern exhibitions of moving pictures. This he did in lectures, beginning in 1880, and on a large scale at the Chicago exposition of 1893, where a building was especially erected in which he exhibited flocks of birds flying across a screen, athletes wrestling and similar moving pictures. In 1886 Muybridge consulted the inventor of the phonograph with a view to reproducing simultaneously visible actions and auditory words. Neither method of reproduction was, however, at that time sufficiently advanced, and it was necessary to wait until last year, when Mr. Edison was able to synchronize in a satisfactory manner the pictures and the sounds.

Although the reproduction of a play by moving pictures and the phono-



BACK VIEWS IN TWELVE POSITIONS.

graph is far from being perfected, it may be that before long such copies of plays and operas by leading actors and singers with the best possible stage settings may be more effective than the average performance, as the photographic reproduction of a great painting may have more artistic value than an inferior original. As much as $150,000 has been spent on the production of a single set of films, and leading actors, such as Madame Bernhardt and Sir H. Beerbohn Tree have acted before the film camera. At present most of the shows exhibit crude farces and melodramas, and it may not be altogether satisfactory that a third as much money is spent on them as on our entire public school system. We may hope, however, that the moving-picture show will make possible a democratic development of art and become an educational institution of the greatest possible consequence.



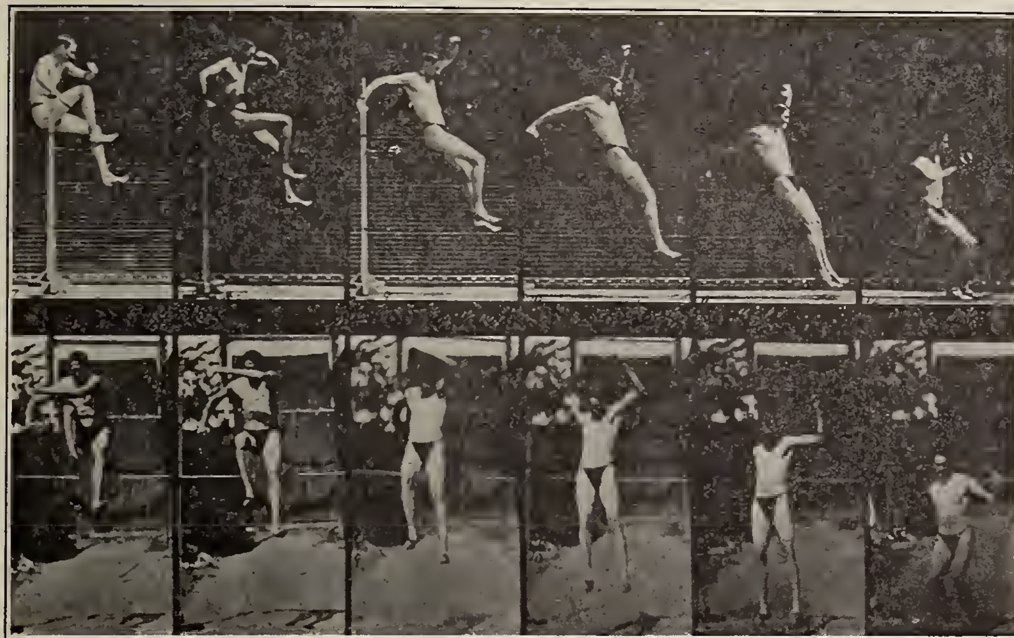
Athlete Making Standing High Jump.

LEGAL LIMITATIONS OF MARRIAGE

A Pennsylvania law became operative in August, requiring those wishing to marry to appear at the license bureau and answer under oath some fifty questions. It is rather absurd to swear that one is not an imbecile, and a physician's certificate, as required by a law passed by the last Colorado legislature, is a better guard against communicable disease than a statement of the patient. Still such a law may be of use, though not so much in punishment following its violation as in the reflections and precautions which it may occasion in those who propose to marry. The laws of the different states limiting marriage relations have recently been summarized in a bulletin prepared by Dr. Charles B. Davenport and issued by the Eugenics Record Office. They are more numerous and complicated than most people suppose.

Marriages of idiots and the insane are illegal in about half the states and these marriages are presumably invalid everywhere, as such persons can not make contracts. On similar grounds in three states a marriage is invalid when one of the parties is intoxicated. Only five states forbid the marriage of those suffering from venereal disease. It should surely be made as serious a crime to communicate diseases as to commit larceny or assault and battery, and public sentiment would probably uphold legislation to this effect. In only a few cases have laws been passed with direct reference to the eugenic aspect of the case. Connecticut and Kentucky forbid illicit union with imbeciles, the latter state under penalty of twenty years' imprisonment. In Delaware a child of a parent insane before it was born can not marry. In Utah, an epileptic woman may marry after the age of forty-five, but not before.

Laws limiting closeness of relationship in marriage are based on social rather than on biological considerations. Indeed we have no scientific knowledge that would enable us to prescribe limits of consanguinity within which marriage is undesirable from the point of view of heredity or eugenics. The marriage of first cousins is illegal in about half of the states, including Pennsylvania and Illinois, yet such marriages have been and are common in all classes of society. The most distinguished family known to the writer



Front and Side Views of Twelve Positions.

are the seven children of Charles Darwin, who married his first cousin. The royal families of Europe are closely inbred, but form a superior group. A consideration of their heredity shows, as might have been anticipated, that both desirable and undesirable qualities are enhanced by the marriage of those related by blood.

The social reasons making it desirable to forbid the marriage of those who become related through marriage are not urgent; indeed they have practically disappeared since segregation of the sexes has been largely abandoned. The limitations do not exist in many of the states and in others are curiously inconsistent. Marriage with a deceased wife's sister is not prohibited, but in West Virginia a man may not marry his deceased wife's step-daughter and in Massachusetts he may not marry his deceased wife's grandmother.

The laws in regard to intermarriage of races differ greatly in different states, as does public sentiment. Just now southern newspapers are urging the dismissal of a university professor because in an article in this journal he spoke kindly of the mulattoes. In Maryland whites and negroes or mulattoes who intermarry "are deemed guilty of an infamous crime," and are subject to ten years' imprisonment, while a mile away such marriages are legal. Apparently a white person and a mulatto who marry in Pennsylvania can return to live in Maryland, but would be subject to five years' imprisonment if they went to Texas. In California and in several other states marriage of a Caucasian with a Mongolian is illegal, and several states have laws against marriage with a North American Indian.

The diversity of the laws of the different states, marriages that are legal and approved by public sentiment in one part of the country being crimes elsewhere, indicates that it may be less difficult to apply eugenics in practise than it is to determine which kind of eugenics it would be desirable to apply.

SCIENTIFIC ITEMS

We record with regret the death of Dr. Reginald Faber Fitz, professor emeritus in the Harvard Medical School; of Dr. John Green Curtis, from 1876 to 1909 professor of physiology in Columbia University; of Professor Lucien Augustus Wait, emeritus professor of mathematics in Cornell University; of Dr. Alexander Macfarlane, of Chatham, Ontario, known for his contributions to vector analysis and quaternions; and of Dr. Charles Lester Leonard, professor of roentgenology in the University of Pennsylvania, who died from X-ray dermatitis, contracted in the course of his work nine years ago.

The British Association for the Advancement of Science has accepted an invitation to hold the meeting of 1915 at Manchester. It will be remembered that next year's meeting will be held in Australia under the presidency of Dr. William Bateson.—The University of Birmingham on September 11 conferred its doctorate of laws on the following foreign representatives in attendance at the meeting of the British Association: Madame Curie (Sorbonne, Paris), Professor H. A. Lorentz (Leyden), Professor Keibel (Freiburg), Professor R. W. Wood (Johns Hopkins) and Professor Svante Arrhenius (Stockholm).—On the occasion of the meeting of the International Geological Congress at Toronto, the University of Toronto conferred the degree of doctor of laws on the following geologists: T. C. Chamberlin, U. S. A.; W. G. Miller, Canada; P. M. Termier, France; R. Beck, Germany; J. J. Sederholm, Finland; T. Tschermyschev, Russia, and A. Strahan, England.

The government through Secretary of Commerce Redfield has decided to change the sale of all the government catch of seal, fox and other Alaska furs, from London to St. Louis. At the present time St. Louis is said to be the largest primary fur market in the world. It is estimated that three fourths of all the furs trapped on the North American Continent are shipped to St. Louis houses to be sold.

The Popular Science Monthly

Entered in the Post Office in Lancaster, Pa., as second-class matter.

CONTENTS OF THE SEPTEMBER NUMBER

CONTENTS OF THE OCTOBER NUMBER

PRESS OF THE NEW ERA PRINTING COMPANY

6413

Vol. LXXXIII, No. 6 DECEMBER, 1913

THE POPULAR SCIENCE MONTHLY

EDITED BY J. McKEEN CATTELL

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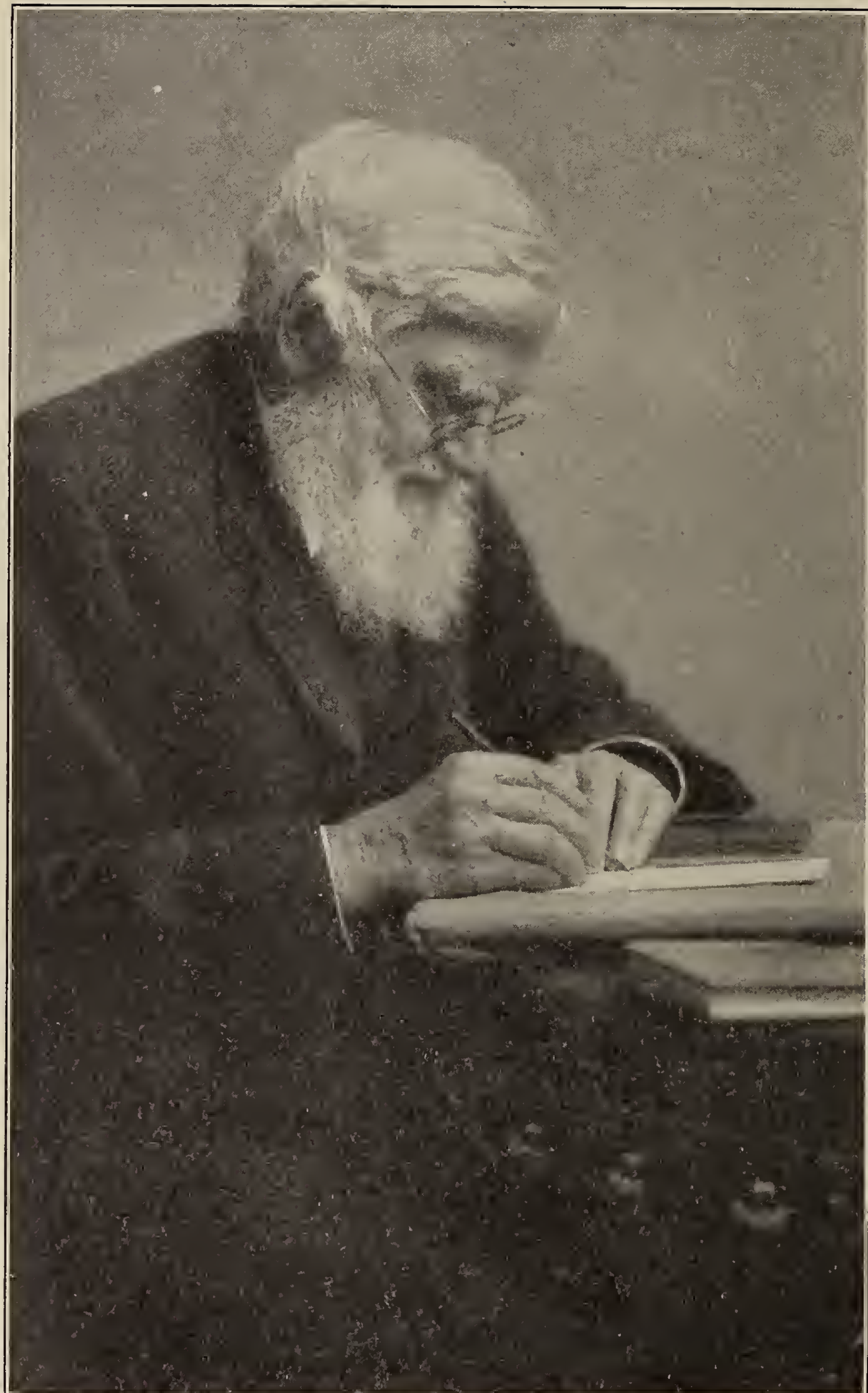
THE SCIENCE PRESS

LANCASTER, PA. GARRISON, N. Y.

NEW YORK: Sub-Station 84

Single Number, 30 Cents Yearly Subscription, $3.00



Alfred R. Wallace

THE POPULAR SCIENCE MONTHLY.

DECEMBER, 1913

ALFRED RUSSEL WALLACE, 1823–1913[1]

By Dr. HENRY FAIRFIELD OSBORN

RESEARCH PROFESSOR OF ZOOLOGY IN COLUMBIA UNIVERSITY

ALFRED RUSSEL WALLACE, the last survivor of the great group of British naturalists of the nineteenth century, passed away on November 7, 1913, in the ninety-first year of his age and the sixty-fourth year of active service and productiveness. He followed by only a few months another member of the group, Sir Joseph Hooker, who introduced the famous Darwin-Wallace papers on Natural Selection to the Linnæan Society in 1858.

Lyell, Darwin and Wallace were three successive but closely kindred spirits whose work began and ended with what will be known as the second great epoch of evolutionary thought, the first being that of the precursors of Darwin and the third that in which we live. They established evolution through a continued line of attack by precisely similar methods of observation and reasoning over an extremely broad field. As to the closeness of the intellectual sequence between these three men, those who know the original edition of the second volume of "The Principles of Geology," published in 1832, must regard it as the second biologic classic of the century—the first being Lamarck's "Philosophie Zoölogique" of 1809—on which Darwin through his higher and much more creative vision built up his "Journal of Researches." When Lyell faltered in the application of his own principles, Darwin went on, and was followed by Wallace.

The two elder men may be considered to have united in guiding the

[1] An abstract of this biographical sketch appeared in *Nature*, Thursday, June 13, 1912, Vol. 89, No. 2224, entitled, "Scientific Worthies. XXXVIII.—Dr. Alfred Russel Wallace, D.C.L., O.M., F.R.S." The writer had the pleasure of receiving a letter from the veteran naturalist June 16, 1912, in which he wrote: "I thank you very much for the complete and careful account of my scientific work and for the great honor you have done me in linking my name with those of Lyell, Darwin and Galton. Your article is by far the best account of my work and of the various influences which determined its direction and the conclusions at which I have arrived. . . ."

mind of Wallace, because the young naturalist, fourteen years the junior of Darwin, took both "The Principles" of Lyell and "The Journal" of Darwin with him on his journey to South America, during which his career fairly began. From his record of observations during his life in the tropics of America and of Asia Wallace will be remembered not only as one of the independent discoverers of the theory of natural selection but next to Darwin as one of the great naturalists of the nineteenth century. His range and originality are astounding in these days of specialization. His main lines of thought, although in many instances suggested to his mind somewhat suddenly, were developed and presented in a deliberate and masterly way through the series of papers and books extending from 1850 to 1913. The highest level of his creative life was, however, reached at the age of thirty-five when with Darwin he published his sketch of the theory of natural selection. This outburst of original thought, on which his reputation will chiefly rest, came as an almost automatic generalization from his twelve years in the tropics.

Nature and nurture conspire to form a naturalist. Predisposition, an opportune period, and a happy series of events favored Alfred Russel Wallace.

Wallace was the son of Thomas Vere Wallace, of Hanworth, Middlesex, England, and Mary Anne Grennell, of Hertford. His ancestry is obscure. On the paternal side he is probably descended from one of the branches of Sir William Wallace, the popular national hero of Scotland, but nothing is known back of his grandfather, who was probably keeper of the inn on the estates of the Dukes of St. Albans, of Hanworth. The burial records of Hanworth mention an Admiral James Wallace. In his mother's family on the paternal side is the name Greenell, of Hertford, probably the "Greenaile" in 1579, French huguenot refugees after the massacre of St. Bartholomew. Her grandfather was for many years alderman and twice mayor of Hertford. One of the Greenells was an architect.

Wallace's father took up the profession of the law, but did not continue, and up to his marriage lived the life of a fairly well to do middle class gentleman. After his marriage he essayed the publishing of two magazines apparently devoted to art, antiquities and general literature, which were failures. He then moved from Marylebone to more rural districts where living was less expensive, first to St. Georges, Southward, and then to Usk, Monmouthshire. In this village Alfred Russel Wallace was born on January 8, 1823.

When about six years of age the family moved to Hertford, and Wallace's education was begun in the old grammar school, which dated back to 1617. He left school too young to begin Greek but he studied Latin, and next to Latin grammar the most painful subject he learned was geography, principally because of the meaningless way in which it was taught. During the last year of study at the grammar school as the family were then in very straitened circumstances, he assisted in the teaching of the younger boys in reading, arithmetic and writing.

Wallace considered that his home life in Hertford was in many ways more educational than the time spent at school. His father was a man who enjoyed the pleasure of literature, and belonged to a book club through which a constant stream of interesting books came to the house, from which he read aloud to the family in the evenings. The father earned a small income tutoring and as librarian of a small library, and the son Alfred spent hours reading there, also.

At the age of 13 or 14 young Wallace left school, with a view to learning land surveying. He stayed in London a short time with his brother John, who was apprenticed to a master builder, and their evenings were most frequently spent in the "Hall of Science," a kind of mechanics institute for advanced thinkers among workmen. Here he heard many lectures by Robert Owen, the founder of the socialist movement in England, and took up philosophical reading, beginning with Paine's "Age of Reason" among other books. In the summer of 1837 he went with his brother William into Bedfordshire to begin his education as a land surveyor, and practised for seven years in various parts of England and Wales.

After a time it was decided that he should try to pursue the clock-making business as well as surveying and general engineering, and Wallace considered that this was the first of several turning points in his life, because changes in the business of the clock-making concern with which he was connected at Leighton prevented his continuing this work for more than a short period. He was delighted to take up again in 1839 the employment of land surveying because of the opportunities it afforded for out-of-door life.

While at Neath in Wales there was not much demand for surveying, and Wallace occupied himself in constructing a rude telescope with which he was able to observe the moon and Jupiter's satellites, and he developed much interest in studying astronomy and in the development of astronomical instruments. But he says that he was chiefly occupied with what became more and more the solace and delight of his lonely rambles among the moors and mountains, namely, his first introduction to the variety, the beauty and the mystery of nature as manifested in the vegetable kingdom.

His earnings were very meager, and he had little money for the purchase of books. During the seven years he worked with his brother he says he "hardly ever had more than a few shillings for personal expenses." It was during this period while most occupied out of doors with the observation and collection of plants that he began to write down more or less systematically his ideas on various subjects that interested him. His first literary efforts all bear dates of the autumn and winter of 1843, when he was between nineteen and twenty years of age. One of his first productions was the rough sketch of a popular lecture on botany addressed to an audience supposed to be as ignorant as he was when he began his observation of the native flowers. A second of these early lectures was on the subject "The Advantages of Varied Knowledge," which he considered of interest chiefly as showing the bent of his mind at the time and indicating a disposition for discursive reading and study. He also wrote at this time on the manners and customs of the Welsh peasantry in Brecknockshire and Glamorganshire, and put the matter in form for one of the London magazines, but it was declined.

These early and serious studies in botany, continuing for four years, prepared him for the plant wonders of the tropics. At the age of twenty-one he came to London. He afterward regarded his difficulty in obtaining employment as a great turning point in his career, "for otherwise," he writes, "it seems very unlikely that I should ever have undertaken what at that time seemed rather a wild scheme, a journey to the almost unknown forests of the Amazon in order to observe nature and make a living by collecting."

In his autobiographic volumes of 1905, "My Life, a Record of Events and Opinions," there is also an interesting sketch of his state of mind at this time.

> I do not think that at this formative period I could be said to have shown special superiority in any of the higher mental faculties, but I possessed a strong desire to know the causes of things, a great love of beauty in form and color, and a considerable, but not excessive desire for order and arrangement in whatever I had to do. If I had one distinct mental faculty more prominent than another it was the power of correct reasoning from a review of the known facts in any case to the causes or laws which produced them, and also in detecting fallacies in the reasoning of other persons.

Elsewhere in his autobiography he observes that whatever reputation in science, literature and thought he may possess is the result of the organs of comparison, causality and order, with firmness, acquisitiveness, concentrativeness, constructiveness and wonder, all above the average, but none of them excessively developed, combined with a moderate faculty of language which

> enables me to express my ideas and conclusions in writing though but imperfectly in speech. I feel, myself, how curiously and persistently these faculties have acted in various combinations to determine my tastes, disposition and actions.

Wallace shared Darwin's strong sentiment for justice as between man and man, and abhorrence of tyranny and unnecessary interference with the liberty of others. His retiring disposition enabled him to enjoy long periods of reflection, receptiveness and solitude, both at home and in the tropics, out of which have come the sudden illuminations or flashes of light leading to the solution of the problems before him. As to this wonderful mechanism of induction, Wallace observes:

> I have long since come to see that no one deserves either praise or blame for the *ideas* that come to him, but only for the *actions* resulting therefrom. Ideas and beliefs are certainly not voluntary acts. They come to us—we hardly know *how* or *whence,* and once they have got possession of us we can not reject or change them at will.

Apart from Darwin's education in Christ's College, Cambridge, as compared with Wallace's self-education, the parallel between his intellectual tendencies and environment and those of Charles Darwin is extraordinary. They enjoyed a similar current of influence from men, from books and from nature. Thus the next turning point in his life was his meeting with Henry Walter Bates, through whom he acquired his zest for the wonders of insect life, which opened for the first time for him the zoological windows of nature. In a measure Bates was to Wallace what the Rev. John S. Henslow had been to Darwin. It is noteworthy that the greater and most original part of his direct observations of nature were upon the adaptations of insects.

Darwin and Wallace fell under the spell of the same books, first and foremost those of Lyell, as noted above, then of Humboldt in his "Personal Narrative" (1814–18), of Robert Chambers in his "Vestiges of the Natural History of Creation" (1844), of Malthus in his "Essay on the Principle of Population" (1798).

It was, however, Darwin's own "Journal of Researches," published in 1845, and read by Wallace at the age of twenty-three, which determined him to invite Bates to accompany him on his journey to the Amazon and Rio Negro, which filled the four years 1848–52. In this wondrous equatorial expanse, like Darwin he was profoundly impressed with the forests, the butterflies and birds, and with his first meeting with man in an absolute state of nature. Bates, himself a naturalist of high order,[2] was closely observing the mimetic resemblances among insects to animate and inanimate objects and introducing Wallace to a field which he subsequently made his own. Bates remained several years after Wallace's departure, and published his classical memoir on mimicry in 1860–61. Wallace's own description of his South American experiences entitled "Narrative of Travels on the Amazon," published in 1853 when he was thirty years of age, does not display the ability of his later writings, and shows that his powers were slowly developing.

His eight years of travel between 1854 and 1862 in the Indo-Malay Islands, the Timor Group, Celebes, the Moluccas and the Papuan Group brought his powers to full maturity. It is apparent that his prolonged observations on the natives, the forests, the birds and mammals, and

2 See his principal work, entitled "Naturalist on the River Amazons," 2 vols., 8vo, John Murray, London. 1863.

especially on the butterflies and beetles, were gradually storing his mind for one of those discharges of generalization which come so unexpectedly out of the vast accumulation of facts. "The Malay Archipelago" of 1869, published seven years after the return, is Wallace's "journal of researches," that is, it is to be compared with Darwin's great work of this title. Its fine breadth of treatment in anthropology, zoology, botany and physiography gives it a rank second only to Darwin's "Journal" in a class of works repeatedly enriched by British naturalists from the time of Burchell's journey in Africa.

Wallace's first trial at the evolution problem was his essay sent to the *Annals and Magazine of Natural History* in 1855, entitled "On the Law Which has Regulated the Introduction of New Species." This paper suggested the *when* and *where* of the occurrence of new forms, but not the *how*. He concludes:

It has now been shown, though most briefly and imperfectly, how the law that "*Every species has come into existence coincident both in time and space with a preexisting closely allied species*," connects together and renders intelligible a vast number of independent and hitherto unexplained facts.

In February, 1858, during a period of intermittent fever at Ternate, the *how* arose in his mind with the recollection of the "Essay" of Malthus, and there flashed upon him all the possible effects of the struggle for existence. Twenty years before the same idea, under similar circumstances, had come into the mind of Darwin. The parallel is extraordinary as shown in the following citations:

DARWIN

In October, 1838, that is, fifteen months after I had begun my systematic inquiry, I happened to read for amusement, "Malthus on Population," and being well prepared to appreciate the struggle for existence which everywhere goes on from long-continued observations of the habits of animals and plants, it at once struck me that under these circumstances favorable variations would tend to be preserved, and unfavorable ones to be destroyed. *The result of this would be the formation of new species.* Here, then, I had at last got a theory by which to work; but I was so anxious to avoid prejudice that I determined not for some time to write even the briefest sketch of it. In June, 1842, I first allowed myself the satisfaction of writing a very brief abstract of my theory in pencil, in thirty-five pages,

WALLACE

In February, 1858, I was suffering from a rather severe attack of intermittent fever at Ternate, in the Moluccas; and one day, while lying on my bed during the cold fit, wrapped in blankets, though the thermometer was at 88° Fahr., the problem again presented itself to me, and something led me to think of the "positive checks" described by Malthus in his "Essay on Population," a work I had read several years before, and which had made a deep and permanent impression on my mind. These checks—war, disease, famine and the like—must, it occurred to me, act on animals as well as man. Then I thought of the enormously rapid multiplication of animals, causing these checks to be much more effective in them than in the case of man; and while pondering vaguely on this fact there suddenly and this was enlarged during the summer of 1844 into one of 230 pages.—Darwin's Autobiography, Chap. II.

flashed upon me the *idea* of the survival of the fittest—that the individuals removed by these checks must be on the whole inferior to those that survived. In the two hours that elapsed before my ague fit was over, I had thought out almost the whole of the theory; and the same evening I sketched the draft of my paper, and in the two succeeding evenings wrote it out in full, and sent it by the next post to Mr. Darwin.—Wallace's "My Life," p. 212.

Darwin had been working upon the verification of the same idea for twenty years. We owe to Sir Joseph Hooker and to Lyell the bringing together of these independent but strikingly similar manuscripts. The noble episode which followed of the joint publication of the discovery was prophetic of the continued care for truth and carelessness of self, of the friendship, mutual admiration and cooperation between these two high-minded men, which affords a golden example for our own and future ages. Each loved his own creations, yet undervalued his own work; each accorded enthusiastic praise to the work of the other.

It is a striking circumstance in the history of biology that Wallace's rapidly produced sketch of 1858 "On the Tendencies of Varieties to Part Indefinitely from the Original Type" not only pursues a line of thought parallel to that of Darwin, except in excluding the analogy of natural with human selection, but embodies the permanent substance of the selection theory as it is to-day after fifty-four years of world-wide research. It may be regarded as his masterpiece. The attempt has been made by De Vries and others to show that Wallace in his "Darwinism" of 1889 differed from Darwin on important points, but whatever may be true of this final modification of the theory, a very careful comparison of the Darwin-Wallace sketches of 1858 shows that they both involve the principle of discontinuity; in fact, fluctuation in the sense of plus and minus variation was not recognized at the time; the notion of variation was that derived directly from field rather than from laboratory notes. This is repeatedly implied in Wallace's language and especially in the concluding sentence of his "Sketch" of 1858:

> . . . that there is a general principle in nature which will cause many *varieties* to survive the parent species, and to give rise to successive variations departing further and further from the original type, and which also produces, in domesticated animals, the tendency of varieties to return to the parent form. . . .
>
> Most or perhaps all the variations from the typical form of a species must have some definite effect, however slight, on the habits or capacities of the individuals. Even a change of color might, by rendering them more or less distinguishable, affect their safety; a greater or less development of hair might modify their habits. . . . The superior variety would then alone remain, and on a re-

turn to favorable circumstances would rapidly increase in numbers and occupy the place of the extinct species and variety.

The *variety* would now have replaced the *species*, of which it would be a more perfectly developed and more highly organized form. . . . . Here, then, we have *progression and continued divergence* deduced from the general laws which regulate the existence of animals in a state of nature, and from the undisputed fact that varieties do frequently occur. . . . Variations in unimportant parts might also occur, having no perceptible effect on the life-preserving powers; and the varieties so furnished might run a course parallel with the parent species, either giving rise to further variations or returning to the former type. . . . In the wild animal, on the contrary, all its faculties and powers being brought into full action for the necessities of existence, any increase becomes immediately available, is strengthened by exercise, and must even slightly modify the food, the habits and the whole economy of the race. It creates, as it were, a new animal, one of superior powers, and which will necessarily increase in numbers and outlive those inferior to it. . . .

We see, then, that no inferences as to varieties in a state of nature can be deduced from the observation of those occurring among domestic animals. . . . Domestic animals are abnormal, irregular, artificial; they are subject to varieties which never occur and never can occur in a state of nature: their very existence depends altogether on human care; so far are many of them removed from that just proportion of faculties, that true balance of organization . . . will also agree with the peculiar character of the modifications of form and structure which obtain in organized beings—the many lines of divergence from a central type, the increasing efficiency and power of a particular organ through a succession of allied species, and the remarkable persistence of unimportant parts, such as color, texture of plumage and hair, form of horns or crests, through a series of species differing considerably in more essential characters. . . . This progression, by minute steps, in various directions, but always checked and balanced by the necessary conditions, subject to which alone existence can be preserved, may, it is believed, be followed out so as to agree with all the phenomena. . . .

It is true that Wallace subsequently modified his theory, adopted the selection of plus and minus fluctuations, and became a determined opponent of the mutation hypothesis of De Vries.

The distinctive features of the later development of the theory in Wallace's mind were his more implicit faith in selection, his insistence on utility or selection value of new or varying characters, his flat rejection of Lamarckism, his reliance on spontaneous variations as supplying all the materials for selection. This confidence appears in the following passages from his militant reply in the volume of 1889 to the critics of Darwinism:

The right or favorable variations are so frequently present that the unerring power of natural selection never wants materials to work upon. . . . The importance of natural selection as the one invariable and ever-present factor in all organic change and that which can alone have produced the temporary fixity combined with the secular modification of species.

The principle of discontinuity is less clearly brought out than in the first sketch of 1858; the selection of fluctuation is favorably considered. The laws and causes of variation are, however, assumed rather than taken up as a subject of inquiry. These opinions of 1889 were the summation of twenty-nine years of work.

To return to the life narrative, the autumn of 1860 found Wallace in the Moluccas reading the "Origin of Species" through five or six times, each time with increasing admiration. A letter of September 1 to his friend George Silk contains the key to the subsequent direction of his research, namely, his recognition of the vast breadth of Darwin's principles and his determination to devote his life to their exposition:

I could *never have approached* the completeness of his book, its vast accumulation of evidence, its overwhelming argument, and its admirable tone and spirit. I really feel thankful that it has *not* been left to me to give the theory to the world. Mr. Darwin has created a new science and a new philosophy; and I believe that never has such a complete illustration of a new branch of human knowledge been due to the labors and researches of a single man. Never have such vast masses of widely scattered and hitherto quite unconnected facts been combined into a system and brought to bear upon the establishment of such a grand and new and simple philosophy.

The discovery of "Natural Selection" again turned the course of Wallace's life. In his autobiography he writes:

I had, in fact, been bitten with the passion for species and their description, and if neither Darwin nor myself had hit upon "natural selection," I might have spent the best years of my life in this comparatively profitless work, but the new ideas swept all this away. . . . This outline of the paper will perhaps enable my readers to understand the intense interest I felt in working out all these strange phenomena, and showing how they could almost all be explained by that law of "Natural Selection" which Darwin had discovered many years before, and which I also had been so fortunate as to hit upon.

The coloring of animals as observed in the tropics and the Malayan Islands was the subject in which Wallace made his most extensive and original contributions to Darwinism. In his "Sketch" of 1858–9 he wrote:

Even the peculiar colors of many animals, especially insects, so closely resembling the soil or the leaves or the trunks on which they habitually reside, are explained on the same principle; for though in the course of ages varieties of many tints may have occurred, *yet those races having colors best adapted to concealment from their enemies would inevitably survive the longest.*

Returning from the Archipelago in 1862, he published in 1864 his pioneer paper, "The Malayan Papilionidæ or Swallow-tailed Butterflies, as illustrative of the Theory of Natural Selection," in which he at once took rank beside Bates and Müller as one of the great contributors to the color characteristics of animals. We see him step by step developing the ideas of protective resemblance which he had fully discussed with Bates, of alluring and warning colors, and of mimicry, pointing out the prevalence of mimicry in the female rather than in the male. The whole series of phenomena are believed to depend upon the great principle of the utility of every character, upon the need of color protection by almost all animals, and upon the known fact that no characteristic is so variable as color, that, therefore, concealment is most easily obtained by color modification. Protective resemblance in all its manifold forms has ever been dominant in his mind as a greater principle than that of the sexual selection of color which Darwin favored.

Here may be cited Wallace's own account of his famous observation of mimicry in the leaf butterfly from his volume of 1869, "The Malay Archipelago":

> The other species to which I have to direct attention is the *Kallima paralekta,* a butterfly of the same family group as our Purple Emperor, and of about the same size or larger. Its upper surface is of a rich purple, variously tinged with ash color, and across the fore wings there is a broad bar of deep orange, so that when on the wing it is very conspicuous. This species was not uncommon in dry woods and thickets, and I often endeavored to capture it without success, for after flying a short distance it would enter a bush among dry or dead leaves, and however carefully I crept up to the spot I could never discover it till it would suddenly start out again and then disappear in a similar place. At length I was fortunate enough to see the exact spot where the butterfly settled, and though I lost sight of it for some time, I at length discovered that it was close before my eyes, but that in its position of repose it so closely resembled a dead leaf attached to a twig as almost certainly to deceive the eye even when gazing full upon it. I captured several specimens on the wing, and was able fully to understand the way in which this wonderful resemblance is produced. . . . All these varied details combine to produce a disguise that is so complete and marvellous as to astonish every one who observes it; and the habits of the insects are such as to utilize all these peculiarities, and render them available in such a manner as to remove all doubt of the purpose of this singular case of mimicry, which is undoubtedly a protection to the insect.

In 1867, in a manner which delighted Darwin, Wallace advanced his provisional solution of the cause of the gay and even gaudy colors of caterpillars as warnings of distastefulness. In 1868 he propounded his explanation of the colors of nesting birds, that when both sexes are conspicuously colored, the nest conceals the sitting bird, but when the male is conspicuously colored and the nest is open to view, the female is plainly colored and inconspicuous. His theory of recognition colors as of importance in enabling the young of birds and mammals to find their parents was set forth in 1878, and he came to regard it as of very great importance.

In "Tropical Nature" (1878) the whole subject of the colors of animals in relation to natural and sexual selection is reviewed, and the general principle is brought out that the exquisite beauty and variety of insect colors has not been developed through their own visual perceptions, but mainly and perhaps exclusively through those of the higher animals which prey upon them. This conception of color origin, rather than that of the general influence of solar light and heat or the special action of any form of environment, leads him to his functional and biological classification of the colors of living organisms into five groups, which forms the foundation of the modern more extensive and critical classification of Poulton. He concluded (p. 172):

We find, then, that neither the general influence of solar light and heat, nor the special action of variously tinted rays, are adequate causes for the wonderful variety, intensity and complexity of the colors that everywhere meet us in the animal and vegetable worlds. Let us, therefore, take a wider view of these colors, grouping them into classes determined by what we know of their actual uses or special relations to the habits of their possessors. This, which may be termed the functional and biological classification of the colors of living organisms, seems to be best expressed by a division into five groups, as follows:

Animals.	1. Protective colors.	
	2. Warning colors.	*a.* Of creatures specially protected.
		b. Of defenceless creatures, mimicking *a.*
	3. Sexual colors.	
	4. Typical colors.	
Plants.	5. Attractive colors.	

Twelve years later he devoted four chapters of his "Darwinism" to the colors of animals and plants, still maintaining the hypotheses of utility, of spontaneous variation and of selection.

The study of geographic distribution of animals also sprang from the inspiration of the Malayan journey and from the suggestiveness of the eleventh and twelfth chapters of "The Origin of Species" which Wallace determined to work out in an exhaustive manner. Following the preliminary treatises of Buffon, of Cuvier and Forbes, and the early regional classification of Sclater, Wallace takes rank as the founder of the science of zoogeography in his two great works, "The Geographical Distribution of Animals" of 1876, and "Island Life" of 1881, the latter volume following the first as the result of four years of additional thought and research. His early observations on insular distribution were sketched out in his article of 1860, "The Zoological Geography of the Malayan Archipelago."

Here is his discovery of the Bali-Lombok boundary line between the Indian and the Australian zoological regions which has since been generally known by his name.

In these fundamental geologic and geographic works Wallace appears as a disciple of Lyell in uniformitarianism, and a follower of Dana as regards the stability and permanence of continental and oceanic areas, for which doctrine he advances much original evidence. He taxes his ingenuity to discover every possible means of dispersal of animals and plants other than those which would be afforded by hypothetical land connections; he considers every possible cause of extinction other than those which are sudden or cataclysmal.

The "Island Life" is in itself a great contribution to zoology and zoogeography, the starting point of all modern discussion of insular faunas and floras. His conservative theory of dispersal is applied in an original way to explain the arctic element in the mountain regions of the tropics, as opposed to the low-temperature theory of tropical lowlands during the Glacial Period; his explanation is founded on known facts as to the dispersal and distribution of plants, and does not require the extreme changes in the climate of tropical lowlands during the Glacial Period on which Darwin founded his interpretation. The causes and influence of the Glacial Epoch are discussed in an exposition of Croll's theory. In this connection may be mentioned one of Wallace's original geological contributions, in the article "Glacial Erosions of Lake Basins," published in 1893, namely, his theory of glacial erosion as a means of explaining the origin of valley lakes of glaciated countries.

The original trend of Wallace's thought as to the ascent of man is first shown in the three anthropological essays of 1864, 1869 and 1870, which were subsequently collected in the volume "Contributions to the Theory of Natural Selection." This work, published in 1871, includes all his original essays from 1855 to 1869 on selection, on color and human evolution, which foreshadow the later development of his speculative philosophy.

A suggestive anthropological contribution is the article entitled "The Expressiveness of Speech or Mouth Gesture as a Factor in the Origin of Language," in which is developed the theory of the origin of language in connection with the motions of the lips, jaws and tongue. With Wallace also arose the now widely accepted belief that the Australian aborigines constitute a low and perhaps primitive type of the Caucasian race.

In the article of 1864, "The Development of Human Races under the Law of Natural Selection," Wallace first advanced the hypothesis which has since proved to be untenable that so soon as man learned to use fire and make tools, to grow food, to domesticate animals, to use clothing and build houses, the action of natural selection was diverted from his body to his mind, and thenceforth his physical form remained stable, while his mental faculties improved. His subsequent papers on human evolution, "The Limits of Natural Selection as Applied to Man" of 1869, "On Instinct in Man and Animals" of 1871, mark the gradual divergence of his views from those of Darwin, for in his opinion natural selection is believed to be inadequate to account for several of the physical as well as psychical characteristics of man, for example his soft, sensitive skin, his speech, his color sense, his mathematical, musical and moral attributes. He concluded:

> The inference I would draw from this class of phenomena is that a superior intelligence has guided the development of man in a definite direction, and for a special purpose, just as man guides the development of many animal and vegetable forms.

It is also prophetic of his later indictments of the so-called civilization of our times that we find at the end of the closing pages of "The Malay Archipelago" the first statement of the feeling which so many travellers have experienced from a comparison of the natural and so-called civilized condition of man that "social evolution from barbarism to civilization" has not advanced general human welfare. These humanitarian and partly socialistic ideas are developed in a series of recurrent essays between 1882 and 1903, including "The Nationalization of Land," and "Studies Scientific and Social."

He returned to this subject in what we believe to be his last published essay, namely, his "Social Environment and Moral Progress" of 1913, wherein he considers the so-called "feministic" movement and future of woman:

> The foregoing statement of the effect of established natural laws, if allowed free play under rational conditions of civilization, clearly indicates that the position of woman in the not distant future will be far higher and more important than any which has been claimed for or by her in the past.
>
> While she will be conceded full political and social rights on an equality with men, she will be placed in a position of responsibility and power which will render her his superior, since the future moral progress of the race will so largely depend upon her free choice in marriage. As time goes on, and she acquires more and more economic independence, *that* alone will give her an effective choice which she has never had before. But this choice will be further strengthened by the fact that, with ever-increasing approach to equality of opportunity for every child born in our country, that terrible excess of male deaths, in boyhood and early manhood especially due to various preventable causes, will disappear, and change the present majority of women to a majority of men. This will lead to a greater rivalry for wives, and will give to women the power of rejecting all the lower types of character among their suitors.
>
> It will be their special duty so to mould public opinion, through home training and social influence, as to render the women of the future the regenerators of the entire human race.

In closing this review of a great life, we can not refrain from reflecting on the pendulum of scientific opinion. The discovery of a great truth such as the law of Selection is always followed by an over-valuation, from which there is certain to be a reaction. We are in the midst of such a reaction at the present time, in which the Darwin-Wallace theory of natural selection is less appreciated than it will be in the future when there comes a fresh readjustment of scientific values.

It is well to remember that we may not estimate either the man of science or his conclusions as of our own period, but must project ourselves in imagination into the beginnings of his thought and into the travails of his mind, considering how much larger he was than the men about him, how far he was an innovator, breaking away from the traditions of his times, how far his direct observations apart from theory are true and permanent, and how far his theories have contributed to the great stream of biological thought.

Our perspective has covered a long, honorable span of sixty-five years into the beginnings of the thinking life of a natural philosopher whose last volume, "The World of Life," of the year 1911, gives as clear a portrayal of his final opinions as that which his first essay of 1858 portrays of his early opinions.

We follow the cycle of his reflection beginning with "adaptation" as the great mystery to be solved; in the middle and sanguine period of life, "adaptation" is regarded as fully explained by natural selection; in the closing and conservative period of life "adaptation" is again regarded in some of its phases as entirely beyond human powers of interpretation, not only in the evolution of the mental and spiritual nature of man, but in such marvelous manifestations as the scales of butterflies or the wings of birds.

From our own intellectual experience we may sympathize with the rebound of maturity from the buoyant confidence of the young man of thirty-five who finds in natural selection the entire solution of the problem of fitness which has vexed the mind and aroused the scientific curiosity of man since the time of Empedocles. We have ourselves experienced a loss of confidence with advancing years, an increasing humility in the face of transformations which become more and more mysterious the more we study them, although we may not join with this master in his appeal to an organizing and directing supernatural principle. Younger men than Wallace, both among the zoologists and philosophers of our own time are giving a somewhat similar metaphysical solution of the eternal problem of adaptation, which still baffles and transcends our powers of experiment and of reasoning.

List of Books of Alfred Russel Wallace, O.M., F.R.S., etc.

Sent to the author of the present article in a letter of May 3, 1912.

''In accordance with your request I herewith send you a list of my published books. The delay has been caused by the only complete copy I had having been sent away for publication.

''I have always intended to make out a complete list of my various communications to periodical literature, but have hitherto been unable to find time to do so. All my scientific communications, however, will be found in the *Royal Society's* Catalogue of Scientific Papers which no doubt you have access to.''

1. ''Palm Trees of the Amazon and their Uses.'' Pub. 1853.
2. ''A Narrative of Travels on the Amazon and Rio Negro, with an Account of the Native Tribes and Observations on the Climate, Geology and Natural History of the Amazon Valley.'' Pub. 1853, new edition 1889.
3. ''The Malay Archipelago, the Land of the Orang-utan and the Bird of Paradise. A Narrative of Travel with Studies of Man and Nature.'' First edition 1869 (2 vols.). Tenth edition 1898 (1 vol.).
4. ''Contributions to the Theory of Natural Selection.'' Pub. as single vol. 1870. Pub. with ''Tropical Nature'' in 1 vol. 1891.
5. ''Miracles and Modern Spiritualism.'' Pub. 1874. Revised edition 1896.
6. ''The Geographical Distribution of Animals, with a Study of the Relation of Living and Extinct Faunas as Elucidating the Past Changes of the Earth's Surface.'' Pub. 1876 (2 vols.).
7. ''Tropical Nature and Other Essays.'' Pub. 1 vol. 1878. Pub. with ''Natural Selection'' in 1 vol. 1891.
8. ''Australasia.'' Stanford's Compendium of Geography and Travel. Pub. 1879, 3d edition 1883. New edition 1893, 1st vol., ''Australia and New Zealand.''

9. "Island Life or the Phenomena and Causes of Insular Faunas and Floras, including a Revision and Attempted Solution of the Problem of Geological Climates." Pub. 1880. Third and revised edition 1902.
10. "Land Nationalization, its Necessity and its Aims; being a Comparison of the System of Landlord and Tenant with that of Occupying Ownership in their Influence on the Well-being of the People." Pub. 1882.
11. "Bad Times. An Essay on the Present Depression of Trade, Tracing it to its Sources in Enormous Foreign Loans, Excessive War Expenditure, the Increase of Speculation and of Millionaires, and the Depopulation of the Rural Districts; with Suggested Remedies." Pub. 1885.
12. "Darwinism. An Exposition of the Theory of Natural Selection with Some of its Applications." Pub. 1889.
13. "The Wonderful Century. The Age of New Ideas in Science and Invention." Pub. 1898. New ed. revised and largely rewritten 1903.
14. "The Wonderful Century Reader." Pub. 1901.
15. "Studies, Scientific and Social." 2 vols. Pub. 1900.
16. "Man's Place in the Universe. A Study of the Results of Scientific Research in Relation to the Unity or Plurality of Worlds." Pub. 1903. Fourth ed. 1904 (revised).
17. "Is Mars Habitable? A Critical Examination of Professor Percival Lowell's Book 'Mars and its Canals,' with an Alternative Explanation." Pub. 1907.
18. "My Life, a Record of Events and Opinions." Pub. 2 vols. 1905. New ed., 1 vol., revised 1908.
19. "Notes of a Botanist on the Amazon and Andes, being Records of Travel on the Amazon and its Tributaries, the Trombetes, Rio Negro, Napis, Casiquiari, Pacimoni, Huallaga and Pastasa; as also to the Cataracts of the Orinoco, along the Eastern Side of the Andes of Peru and Ecuador, and the Shores of the Pacific, during the years 1849–64." By Richard Spruce, Ph.D., edited and condensed by Alfred Russel Wallace, O.M., F.R.S., etc., with a biographical introduction, portrait, illustrations and maps. 2 vols. Pub. 1908.
20. "The World of Life, a Manifestation of Creative Power, Directive Mind and Ultimate Purpose." Pub. 1910.

The Royal Society Catalogue of Scientific Papers, covering the years 1800–1883, lists ninety-five papers and books by Wallace, the first dated 1850, and his subsequent communications will be found in *The Zoological Record* and *The International Catalogue of Scientific Literature,* which cover the field from the time the *Royal Society Catalogue* ceased.

THE STRUGGLE FOR EQUALITY IN THE UNITED STATES

By Professor CHARLES F. EMERICK
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Introduction

THE student of public affairs finds much in the course of nineteenth-century development in which the friends of orderly progress may well take heart. For one thing, the world underwent a great advance materially. In 1800, the appliances for producing wealth and the modes of transportation did not differ greatly from those that had been in vogue for hundreds of years. If the men of the fifteenth century could have been brought back to life three centuries later, they would have found the world in these respects substantially what it was when they lived and died. The nineteenth century supplied the world for the first time with the conditions of comfortable living. But it did something more. It contributed greatly to the advance of knowledge and to the diffusion of enlightenment. It witnessed a tremendous increase in the spirit of humanitarianism and the sense of justice. More of the material comforts of life, greater knowledge and enlightenment, and a keener sense of brotherhood and justice have gone hand in hand. The three have, for the most part, been in accord, but occasionally the facts of the material situation have failed to conform to the demands of the other two. It is the purpose of these pages to consider how two or three of these conflicts have contributed to our progress as a nation, and more particularly to discuss certain phases of the existing situation.

The Declaration of Independence

Equality and private property are the two things dear to the American heart. The influence of frontier conditions where one man socially is as good as another and where every one is a potential, if not an actual, owner of land, has stimulated a high regard for the former. On the other hand, in addition to the need of property which civilized man the world over experiences, the environment has been peculiarly favorable in arousing in nearly every one the desire to better his economic condition. In the absence of titled rank, the acquisition of property has been the chief stepping stone to political and social recognition. Besides, immigration has added to our population large numbers in whom the acquisitive instinct is exceptionally strong. The very richness of the rewards open to men of energy and intelligence has given zest to the economic struggle. It may well be, therefore, that the desire to get on in life is stronger in the United States than in any of the countries of Europe. Relatively to the desire for equality, however, private property is held in no higher esteem here than elsewhere. The American people are no more disposed to sacrifice their ideals to the pursuit of money than are the people of other lands. Among other evidences that this is true are the numerous communistic societies that have sprung up from time to time in the face of repeated failure.

In the main, the passion for equality and the desire for property have not been incompatible. On occasion, however, the two have conflicted and an epoch-making event has occurred in our politics. Moreover, public opinion has not always held the two in equal esteem, but has at times been more devoted to the one and then again to the other. At the outset the emphasis was upon equality. "We hold these truths to be self-evident, that all men are created equal, that they are endowed by their Creator with certain inalienable rights, that among these are Life, Liberty, and the pursuit of Happiness," runs the Declaration of Independence. These words are not to be taken in the sense that every one should wear the same sort of clothes, live in the same kind of a house, eat the same quantity and variety of food, or receive the same economic rewards and social recognition in life. Common sense and the intense individualism of the times are both opposed to any such narrow view as this. The American ideal of equality never has called for a dead level of uniformity. Owing to the strong dislike for anything that savors of titled rank or caste, there was once a popular objection to the wearing of uniforms, even by railroad conductors, but the objection was withdrawn when the practical utility of such uniforms was perceived. The colonists were no less intent upon liberty than upon equality, and their conception of the latter included a generous measure of the former. Equal in some respects, namely, in the right to life, liberty and the pursuit of happiness, was Lincoln's interpretation.[1]

The Declaration of Independence was occasioned by the commercial restrictions of Great Britain. To secure freedom from these restrictions the right of self-government was asserted. More fundamental, however, than British commercial policy were the spirit of independence, the sense of self-reliance and the craving for freedom which isolation from the mother country and other conditions of frontier life helped to develop.

The colonists were more self-reliant than even the original, self-reliant British stock, since, broadly speaking, only selected men essayed the ocean journey. No aid from a hostile, Stuart-ruled England could reach the colonist, who, separated from his neighbors by miles of treacherous forest, was compelled to rely upon himself. With the aid of his family, he plowed his acres, shot his

[1] Debates of Lincoln and Douglas, published by Follett, Foster and Co., Columbus, Ohio, p. 63.

game, caught his fish, made his soap and candles, dressed and cured his leather, spun and wove, did his carpentering, and sometimes his smithing. He made what he ate, wore and lived in, and he made and held his own opinions. His philosophy was that of the lonely, self-contained farmhouse.[2]

This philosophy constituted the idealism of a nation and found expression in the Revolution. Fairly within the spirit of the times was the thought that every man should be given an even chance to realize the best there is in him, and that the strong ought not to use their strength or cunning to despoil the weak. This thought is implied in many of the grounds on which the king of Great Britain was indicted. To equality in some such sense as this the signers of the Declaration of Independence pledged their lives, their fortunes and their sacred honor.

The Constitution

The Revolutionary War was attended with a good deal of turbulence and insecurity of life and property. The property of many of the Loyalists was confiscated and they themselves were forced into exile. Nor was the condition of affairs satisfactory in the years following the treaty of Paris in 1783. The governmental system was notoriously out of accord with the demands of the economic situation. The central government was dependent upon the states for support and its credit was at low ebb. The revolutionary bills of credit reached the last stages of depreciation. Some of the states levied hostile tariffs against each other, or were at loggerheads over the control of the navigable rivers which separated them. The tariff policies and schedules of the several states were woefully lacking in unity. English statesmen questioned the ability of congress to enforce the provisions of any commercial agreement that might be entered into, and Spain continued to claim both banks of the Mississippi.[3] The result was that many tired of the ideal of equality. Moreover, the "hard times" which followed the Revolution and the return of some of the Loyalists contributed to the reaction.

The framing and adopting of the constitution were the logical outcome of the situation. The new government was given the unquestioned power to levy and collect the taxes needed for its own support, and was granted the exclusive power over interstate and foreign commerce. The treaty-making power and the control of the monetary system of the country were definitely and firmly lodged in its hands. These grants of power did much toward making the new government a tower of strength, and that property was thereby rendered more secure there can be no doubt. The cause of equality was also advanced. Federal control of interstate and foreign commerce opened wide the door of indus-

[2] Walter E. Weyl, "The New Democracy," p. 37.

[3] Katherine Coman, "Industrial History of the United States," new and revised edition, 1910, pp. 115–116.

trial opportunity, and a more stable political order made for the spirit of fair play among men. But in the main, the government instituted in 1789 appealed to the property-loving instinct rather than to the idealism of the nation. The assumption of state debts, the establishment of the United States Bank, the enactment of a protective tariff, policies espoused by Hamilton, all tended to enlist men of substance on the side of the government.

The mode provided for amending the constitution contributed to the same end. A two thirds majority of both houses of congress, or a convention called on application of two thirds of the states, is necessary to propose an amendment, and ratification either by conventions or legislatures in three fourths of the states is required for its adoption. The people have no direct voice either in proposing or in adopting amendments, and the obstinacy of a group of states containing a small minority of the population may effectually block the will of states containing an overwhelming majority. According to Walter E. Weyl, less than one fortieth of the voters may block the will of the remaining thirty-nine fortieths.[4] So difficult is the mode of amendment that with the exception of the first twelve amendments, the first ten of which were the price paid to secure the adoption of the constitution and all of which were added shortly after its ratification, the only others are the three resulting from the Civil War and the two recently added. But for military occupation of the southern states, it is doubtful whether all the war amendments would have been ratified by the requisite number of states. In no democratic country are property owners more secure against innovations in the organic law. In England, the power to amend the constitution is vested in the House of Commons. In France, an absolute majority of the two houses in joint session suffices. And in Switzerland, proposed amendments are adopted by a majority of all the votes cast at a popular election provided a majority in a majority of the cantons is at the same time received. The federal constitution of Australia has copied this provision.[5]

Our constitutional system further safeguards property by the system of checks and balances, a leading feature of which is the federal courts. The power to override an act of congress is exercised by an appointive judiciary holding office for life whose compensation "shall not be diminished during their continuance in office." The fifth amendment prohibits congress from depriving any one "of life, liberty, or property, without due process of law," and the fourteenth amendment imposes the same prohibition upon the states. Property is mentioned along with life and liberty implying that it is either on a par with or is necessary to them. As the watch-dogs of both these amendments stand the federal

[4] *Op. cit.*, p. 14.

[5] J. Allen Smith, "The Spirit of American Government," pp. 62–63.

courts. Moreover, judicial interpretation has given a scope to certain clauses of the constitution which no one suspected at the time of their adoption. In the Dartmouth College case in 1819, the Supreme Court held that a charter is a contract, and in a case involving the Southern Pacific Railroad in 1882 the same court interpreted the word "person" to include a corporation. In the former case, the court enlarged the conception of property, and in the latter case, in interpreting an amendment intended for the protection of the negro, the court included under its guardianship the property of artificial as well as of natural persons. The Supreme Court has well been termed "the bulwark of private property." President Hadley aptly remarks:

> When it is said, as it commonly is, that the fundamental division of powers in the modern State is into legislative, executive and judicial, the student of American institutions may fairly note an exception. The fundamental division of powers in the Constitution of the United States is between voters on the one hand and property owners on the other. The forces of democracy on one side, divided between the executive and the legislature, are set over against the forces of property on the other side, with the judiciary as arbiter between them; the constitution itself not only forbidding the legislature and executive to trench upon the rights of property, but compelling the judiciary to define and uphold those rights in a manner provided by the constitution itself.[6]

These remarks were originally delivered at Berlin University. To the average investor, both at home and abroad, they describe what appears to be an ideal situation. On the other hand, to a democracy seeking to possess more fully the reins of power they indicate a condition that is far from satisfactory.

Slavery

A short time after the election of Washington, a reaction set in against the party of property. The commanding personality of Washington and the high respect in which he was held for a brief period stemmed the reaction but could not avert it. The election of Jefferson marked the triumph of the party of equality, a triumph which the westward drift of population and the successive admission of trans-Allegheny states helped to perpetuate. Kentucky was admitted as a state in 1792, Tennessee in 1796, Ohio in 1802, and in the ten years ending with 1821, Louisiana, Indiana, Mississippi, Illinois, Alabama, Maine and Missouri joined the family of states, a greater number than in any decade before or since. The Louisiana purchase sealed the fate of the Federalist party. The ideal of equality in the United States is greatly indebted to the circumstances which have made it possible for such large numbers to become the owners of land in their own right. The liberalization of the terms on which the public lands were offered for sale in 1800, and in the years following, contributed powerfully to the growing prevalence of democratic equality. This found expression in the grad-

[6] *The Independent*, Vol. LXIV, 1908, p. 837.

ual broadening of the suffrage in the different states, in the abolishment of religious and property qualifications for office, in the election of Jackson and the spoils system, and in the war on the United States Bank.

The economic situation rendered the craving for property in the main at one with the ideal of equality. The one noteworthy exception was property in human chattels against which the forces of equality protested until the close of the Civil War. In colonial days African slavery was an American institution. But gradually slavery died out in the north, as the fact that it did not pay became more generally recognized, and even in the south, except in South Carolina and Georgia, the feeling against the institution as late as 1790 was strong. Two events, just at this juncture, the invention of the cotton gin and the introduction of short staple cotton adapted to the uplands of the south, made slave ownership much more profitable and changed the whole situation. The simultaneous introduction of spinning and weaving by steam-driven machinery greatly reduced the cost of manufacturing cotton goods and, aided by improved transportation, brought them into general use, enlarged the market for the product of the cotton fields, hastened the spread of slavery and helped to fasten it more firmly upon the south. Improved transportation also contributed to this result by rendering the interior of the south accessible to the cotton manufacturing centers. Likewise, the growing of slaves in the border states for the southern market became more profitable, and public opinion in these states which had been half way friendly to emancipation suddenly recoiled. As a consequence, slavery ceased to be a national and became a sectional institution. The explanation is at bottom economic, for while slavery as a method of applying labor disappeared in the north, the slave trade continued for some years, even after it had been made unlawful, and was the foundation of not a few fortunes in Newport and other northern cities. Slavery died out in the north because it did not pay, while northerners continued to traffic in slaves because it was profitable. Under the same economic conditions, the southerner is ethically the peer of the northerner.

Property in human beings conflicted with the ideal of equality. So long as one individual owns the body of another, the conception of fair play is set at naught. Not only is the slave denied the freedom necessary to the expression of his personality, but the effect upon the owner is apt to be degrading. The aspirations for better things of both master and slave are either restrained or suppressed. Clearly, slavery was inconsistent with the professions of democracy and was out of accord with the spirit of nineteenth-century civilization. The inconsistency was so glaring that the authors of the constitution scrupulously avoided the use of the words "slave" and "slavery" in framing that document. It would have been strange, therefore, if the restraint and abolition of slavery had not become the goal of the devotees of equality, especially since its inhumanity appeared more obvious and the situation more grotesque as the institution assumed greater proportions.

In the contest which ensued, the abolishment of the African slave trade was the first great event. The power of congress over foreign commerce was in this regard abridged by the constitution till 1808. But promptly upon the expiration of the time limit, the importation of slaves was prohibited. Subsequently, the antagonism between equality and property in slaves was seldom in abeyance, but the enactment of the Missouri compromise in 1820, its repeal in 1854, the Dred Scott decision, and the Civil War were the four events of chief importance. The first prohibited slavery in the territories north of 36° 30′. This was in keeping with the spirit of the ordinance of 1787, and marked a triumph for the advocates of equality. The second and third were victories for the defenders of property in slaves but proved to be only temporary triumphs. The crystallization of public opinion in the north against the spread of slavery in the territories, and the rapid growth of population in the free states threatened its very existence. The tide of events was so strongly against the institution that southern leaders felt that delay was fatal, and resolved to submit the issue to the sword. The fortunes of war turned against them and resulted in a loss of slave property of two thousand millions of dollars.[7] In the enthusiasm of the moment the tide toward equality was so strong that three amendments were added to the constitution. The first declared the negro a free man, the second made him a citizen, and the third aimed at giving him the ballot on a parity with whites. Doubtless the glamor of military success coupled with resentment toward the south and the desire to place the ballot in hands loyal to the federal government contributed to this result. None the less, the three war amendments suggest how dear the ideal of equality is to the American heart.

The Dred Scott Decision

It is worth while to pause long enough here to consider briefly two features of the Dred Scott decision. The first is the rule of judicial interpretation which guided the majority of the court. In the light of precedent and of the law narrowly and strictly interpreted, many lawyers to-day hold the decision handed down by Judge Taney to have been correct. But of those who subscribe to this view, a small but respectable minority maintain that the decision was none the less erroneous on the ground that it is the business of the courts to make precedents as well as to be bound by them and to this end to interpret and apply the law broadly in the light of the prevailing sense of justice. According to this view there is no such hard and fast line of cleavage between the func-

[7] Blaine, "Twenty Years of Congress," Vol. 1, p. 174.

tions of the legislative and judicial departments as is sometimes supposed, and in rendering decisions the courts on occasion make the law as well as declare what the law is. For the courts in their rulings to avoid any recognition of a higher sense of justice in the community until it has found expression in a legislative enactment seems a travesty upon justice to those who hold this position. There is little doubt that the unpopular reception accorded the Dred Scott decision was based upon some such view as this. In point of fact, there is a large body of judge-made law. Some decisions have even gone further and have amended the constitution by interpretation, a procedure which the difficulty of formally amending our organic law invites. In the opinion of many legal lights, Justice Harlan had good ground for accusing the majority of reading the word "reasonable" into the anti-trust act in the Standard Oil and American Tobacco Company cases.

The second feature of the Dred Scott decision to which it is desired to allude here is the storm of popular disapproval which greeted its announcement. The present age is familiar with the heated discussions to which the judicial determination of cases involving the ideals of democracy and the rights of property frequently give rise. Both parties to such controversies have so much at stake that it is hard for either to be a good loser. When anything that a man has once possessed himself of is placed in jeopardy, or when any ideal upon which the fortunes of humanity are supposed to rest is called in question, a complacent mood is too much to expect. Nor is this peculiar to this age. Those who assume that failure to acquiesce cheerfully in the rulings of the courts is without precedent in the past will do well to recall the attitude of Jefferson and Jackson, and especially the outburst of indignation which the Dred Scott decision called forth. As an example of what some look upon as treason to the courts, the contempt with which this decision was regarded has not been duplicated before or since.

The way in which Mr. Lincoln took the Supreme Court to task deserves a passing notice. He did not content himself with maintaining that the decision was bad law. In a speech at Springfield, Illinois, June 17, 1858, he boldly insinuated that Chief Justice Taney, Stephen A. Douglas, James Buchanan and Franklin Pierce conspired together in handing down the Dred Scott decision. After citing the successive points in the alleged conspiracy, he threw his indictment into the following classic:

> We can not absolutely know that all these exact adaptations are the result of preconcert. But when we see a lot of framed timbers, different portions of which we know have been gotten out at different times and places and by different workmen—Stephen, Franklin, Roger and James, for instance—and when we see these timbers joined together, and see they exactly make the frame of a house or a mill, all the tenons and mortices exactly fitting, and all the lengths and propor-

tions of the different pieces exactly adapted to their respective places, and not a piece too many or too few—not omitting even scaffolding—or, if a single piece be lacking, we see the place in the frame exactly fitted and prepared yet to bring such piece in—in such a case, we find it impossible not to believe that Stephen and Franklin and Roger and James all understood one another from the beginning, and all worked upon a common plan or draft drawn up before the first blow was struck.[8]

To this Judge Douglas replied:

It would be perfectly legitimate and proper for Mr. Lincoln, myself, or any other lawyer, to go before the Supreme Court and argue any question that might arise there, taking either side of it, and enforcing it with all our ability, zeal and energy, but when the decision is pronounced, that decision becomes the law of the land, and he, and you, and myself, and every other good citizen, must bow to it, and yield obedience to it. Unless we respect and bow in deference to the final decisions of the highest judicial tribunal in our country, we are driven at once to anarchy, to violence, to mob law, and there is no security left for our property, or our own civil rights. What protects your property but the law, and who expounds the law but the judicial tribunals; and if an appeal is to be taken from the decisions of the Supreme Court of the United States, in all cases where a person does not like the adjudication, to whom is that appeal to be taken? Are we to appeal from the Supreme Court to a county meeting like this?[9]

Douglas also denied the conspiracy charge. Not content with Douglas' denial, Lincoln renewed the charge, and while admitting that he did not "*know*" submitted the evidence upon which he "*believed*" it to be true.[10] Likewise, he objected to "the sacredness that Judge Douglas throws around this decision,"[11] and said:

If I were in Congress, and a vote should come up on a question whether slavery should be prohibited in a new territory, in spite of the Dred Scott decision, I would vote that it should.[12]

He also asked Douglas whether he would acquiesce in a second Dred Scott decision forbidding the free states from excluding slavery from their limits,[13] and stated that Douglas himself had approved of Jackson's refusal to be bound by a Supreme Court decision touching the constitutionality of the United States Bank. He went even farther and asserted that Douglas was once in favor of "adding five new Judges" to the Supreme Court of Illinois in order to reverse a decision of that court, and that "it ended in the judge's sitting down on that very bench as one of the five new judges to break down the four old ones."[14] In short, "Judge Douglas is *for* Supreme Court decisions when he likes and against them when he does not like them."[15]

[8] Debates of Lincoln and Douglas, *op. cit.*, pp. 3–4.
[9] *Ibid.*, p. 32.
[10] *Ibid.*, p. 79.
[11] *Ibid.*, p. 20.
[12] *Ibid.*, p. 20.
[13] *Ibid.*, p. 90.
[14] *Ibid.*, pp. 82–83.
[15] *Ibid.*, p. 62.

Lincoln distinguished sharply between the sense in which he opposed the Dred Scott decision and the sense in which he did not. He disclaimed any intention of resisting the decision in so far as it affected Dred Scott. "We let this property abide by the decision, but we will try to reverse that decision. We will try to put it where Judge Douglas would not object, for he says he will obey it until it is reversed. Somebody has to reverse that decision, since it is made, and we mean to reverse it, and we mean to do it peaceably." [16] Lincoln did not indicate how far he would go to attain his end. Judge Douglas charged him with intending to pack the court.[17] I am not aware that Lincoln ever entered a denial.

The controversy between Lincoln and Douglas in 1858 suggests present-day conditions. The Republican party at its origin was an uprising against those extremists who considered the right to property in slaves paramount to the rights of man. The stand which it took against the Dred Scott decision contributed much to its growth and influence. With its advent to power, however, the party became more and more closely identified with the clandestine work of arranging tariff schedules, getting valuable franchises for a song, looking after the "pork" in river and harbor and public building bills, and with voting the public money for pensions. The leadership of the party suffered the inevitable consequences of long years in power. The moral enthusiasm which attended its origin grew less and less. In striking contrast to 1860, the tendency to emphasize the rights of property and to object to any and all criticisms of court decisions which uphold property rights became more and more pronounced. With Lincoln's arraignment of Douglas for accepting a court decision not at all "on its merits," but because "it is to him a 'Thus saith the Lord,'" the party came to have less and less sympathy. The leadership more and more approximated that of Douglas, who cared not whether slavery was voted up or voted down, and nothing so well describes it as Lincoln's characterization of his distinguished opponent. Said Mr. Lincoln:

> Senator Douglas is of world-wide renown. All the anxious politicians of his party, or who have been of his party for years past, have been looking upon him certainly, at no distant day, to be President of the United States. They have seen in his round, jolly, fruitful face, post-offices, land-offices, marshallships and cabinet appointments, chargeships and foreign missions, bursting and sprouting out in wonderful exuberance, ready to be laid hold of by his greedy hands. . . . On the contrary, nobody has ever expected me to be President. In my poor, lean, lank face, nobody has ever seen that any cabbages were sprouting out.[18]

Happily, in recent years many of the more prominent leaders in the Democratic as well as in the Republican party who answered to this de-

[16] *Ibid.*, p. 20.
[17] *Ibid.*, pp. 33–34.
[18] *Ibid.*, p. 55.

scription have fallen "outside the breastworks." We have been going through a period of political housecleaning, and the politicians in response to an awakened public opinion have been showing fruits meek for repentance. Seldom have the leaders in every party been so much on their good behavior. Judged by the sort of measures that have been placed upon the statute books during the past year, the Democratic party in Ohio and the Republican-Progressive party in California have been about equally progressive. There is not much choice between the Democratic party in New Jersey under the leadership of Woodrow Wilson and the Republican party in Wisconsin under the leadership of Senator La Follette. When politicians in general are competing for the good will and support of the more decent and public-spirited portion of the community, as they are to-day, the friends of good government have much ground for encouragement.

Political parties, in common with individuals, are judged by the kind of company they keep and by the reputations they acquire. This accounts for the defeat of the Republican party and the appearance of the Progressive party in the presidential election of 1912. The Republican party has not been entirely irresponsive to the demands of a more exacting public opinion. A growing number of men truly progressive in spirit has become conspicuous in its counsels. Many salutary measures have been placed upon the statute books under Republican auspices. But in all of this there has been a certain hesitation, a reluctance to move forward save under compulsion, a tendency to death-bed repentance. The revision of the tariff at the hands of the Republican party is a conspicuous illustration. As a result, the party has failed to receive due credit for some of the forward steps which it has occasionally taken. This was especially true under the Taft administration when a number of progressive measures were enacted into law, while others, notably the recommendations of the President on conservation, failed to become laws partly because the public suspected the auspices under which they originated. The Republican party is suffering the consequences of not keeping properly abreast of the times. At a time when new problems were pressing for solution, it has sustained a reputation for "standing pat" and for "letting well enough alone." When it might have invoked the power of the national government to solve problems that are clearly nation wide in character, it has faltered and failed to prove true to the traditions of its origin.[19]

[19] The future of the Republican party is an interesting subject for speculation. On the one hand, it has a great past. Its early devotion to human rights has not been forgotten. It performed a great service in saving the Union and in freeing the slaves. It has repeatedly recognized the sense of nationality which we cherish as a people. Its very name is a household word, and its devotees are still numbered by the millions. Its alliances are by no means as unsavory as those that killed the Whig party, and it has an incomparably greater past. As a going

concern long in the field, it possesses certain substantial advantages which a new party can only painfully acquire. There is a legitimate place for a party that champions the interests of property within reasonable bounds. The differences between the Republican and the Progressive parties on the tariff and the trusts are by no means insuperable.

On the other hand, it is vulnerable in three respects. It distrusts the people, it has not identified itself closely enough with their interests, and it is on too intimate terms with those who participate in politics for private gain, three weaknesses that led to the downfall of the Federalist party. Its future depends on its ability to overcome these weaknesses and on the mistakes of its adversaries. The fact that the Democratic party managed to live down its associations with slavery and its highly questionable record during the Civil War indicates that the future of the Republican party is by no means hopeless. Competition normally leads even a conservative party to make a bid for popular favor, and but for the disposition of many of the Republican leaders to bank upon the mistakes of their opponents rather than upon setting their own house in order, one might confidently predict a field of future usefulness. The party has often profited by such mistakes in the past, but it is always poor strategy to rely upon the shortsightedness of one's opponents for success in any game. Sobered by the responsibility of power, the Democratic leaders may not be as obliging in the future as they have often been in the past, or the Socialist and Progressive parties may profit by their mistakes. If the Democracy rises to the occasion, it may be given a long lease of power. The schism in the Republican party is a more serious matter than many of its leaders realize. Fundamentally, it is not the work of a lot of "soreheads" or of Mr. Roosevelt, but the natural consequence of its own conduct.

ALCOHOL FROM A SCIENTIFIC POINT OF VIEW

II. The Relative Toxicity of the Various Alcohols

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IN a previous study on "The Discovery and Nature of Alcohol,"[1] we have seen that the various alcohols differ among themselves as to their molecular weights and boiling points. These two differences characterizing the alcohols are associated further with a difference in toxicity or poisonous effect. This we shall now consider.

The relation between the molecular weight of a substance and its toxicity was seen as early as 1837 by Black, but it was not until more than a quarter of a century later that Rabuteau was able to generalize this relationship. In his study of the metals he observed that the higher the molecular weight and boiling point, the greater the toxicity. This law experiment has shown often to be in default for the metals. For the alcohols, on the other hand, it has a striking application.

If greater toxicity be associated with a higher molecular weight and boiling point, it would follow that an alcohol such as amyl, with 88 atoms to the molecule and a boiling point of 138° C., would be more poisonous than ethyl alcohol with 46 atoms to the molecule and a boiling point of 78.4° C. Such, in fact, was early shown to be the case. But it may be objected that the difference between the two is extreme. It would be more convincing if two alcohols, such, for example, as ethyl and methyl, closely approximating in molecular weights and boiling points, complied with the law.

To a comparison of these we shall return.

We shall first consider the experimental evidence which has given to us a measure of the exact toxicity of the various alcohols.

Early Experiments on the Toxicity of Alcohol

Fr. Petit, who was among the first to busy himself with the study of the toxic effects of alcohol, showed that if alcohol is injected into the veins of an animal, a rapid death ensues. Following this simple experiment a considerable period of time elapsed before the subject was again taken up. The next work recorded is that by two Italian physiologists, Lussana and Albertoni.

These investigators, by a series of interesting experiments, esti-

[1] Pop. Sci. Mo., p. 567, June, 1913.

mated that 6 grams of pure alcohol for each kilogram of body weight is a lethal or killing amount when injected into the stomach of an animal.

This was the beginning of quantitative work to which a few years later Dujardin-Beaumetz and Audigé added a brilliant series of experiments. They studied not only the toxicity of ethyl alcohol, but also that of other alcohols as well. Briefly stated, the question that they proposed to themselves was: How much alcohol is necessary to kill a kilogram of living matter in *less than thirty-six hours?*

If, for example, in studying the toxicity of alcohol, we find that 77.5 grams of alcohol injected into the stomach of an animal of 10 kilograms weight produces death *in less than 36 hours,* the question then as to the amount necessary to kill per kilogram is easily determined, for if 77.5 grams kill the entire 10 kilograms, 7.75 grams is the amount necessary to kill per kilogram. This, in fact, was the amount of ethyl alcohol found by them to be the lethal dose. This amount, however, is considerably below the estimate of 6 grams by Lussana and Albertoni. This difference in amount may be explained in part by the difference in the time limit employed; for while 6 grams may eventually kill, 7.75 grams is necessary to kill within a limited period of thirty-six hours.

For the coefficient of toxicity of the *higher alcohols,* Dujardin-Beaumetz and Audigé found the following values: For propyl, the member of the series just above ethyl, 3.75 grams per kilogram; for butyl 1.85, and for amyl 1.50 to 1.60 grams per kilogram body weight.

The molecular weight, boiling point and relative toxicity of the alcohols of fermentation are briefly summarized in the following table:

Alcohol	Molecular Weight	Boiling Point[2]	Relative Toxicity
Ethyl	46	78.4° C.	7.75 gr. per kg.
Propyl	60	97.0° C.	3.75 gr. per kg.
Butyl	74	117.0° C.	1.85 gr. per kg.
Amyl	88	138.0° C.	1.50 to 1.60 gr. per kg.

From this table it is to be seen that the higher the molecular weight and boiling point, the smaller is the amount required to kill a kilogram of living matter. In other words, the higher an alcohol is in molecular weight and boiling point, the greater is its toxicity. This, as we have seen, is the law of Rabuteau with which the above facts of experiment are in direct accord.

In a study of methyl alcohol, on the other hand, Dujardin-Beaumetz and Audigé concluded that the toxicity is not in keeping with the law of Rabuteau. Though methyl alcohol has a molecular weight of 32 and a point of ebullition of about 66° C.—in both lower than ethyl alcohol—yet its toxicity was found by them to be greater—7 grams

[2] The boiling points are taken from Meyer and Jacobson's "Lehrbuch der organischen Chemie," Bd. I., 1906, p. 209.

being sufficient to produce death per kilogram, while, as we have seen, 7.75 grams of ethyl alcohol were required.

But the methyl alcohol of the time of Dujardin-Beaumetz and Audigé, as we now know, was far from pure—hence the failure to gain an accurate measure of its toxicity. To-day that methyl alcohol is produced in greater purity, we should be able to retest the question with greater accuracy. To this we shall soon return.

From the investigations of Dujardin-Beaumetz and Audigé we have, then, our first experimental evidence that while alcohols in large doses are poisonous, not all alcohols are equally poisonous. To them is also due the credit of showing that for the alcohols of fermentation the toxicity is directly in proportion to the molecular weight and boiling point; in other words, that they are in accord with the law of Rabuteau —the higher the molecular weight and boiling point, the greater the toxicity.

Difficulties Confronting Investigation of Toxicity

Concerning the difficulties confronting investigation in this subject, we have said nothing. Some of these we shall now consider.

Observation has been made by various investigators that different animals react differently to poisonous substances. From this observation arose the discussion as to "the choice of animal" best suited to a study of alcoholic poisoning. Morgan, who had experimented upon the dog, argued that it was the most acceptable animal for work of this sort. Laborde, who, on the other hand, had studied the guinea-pig, urged the use of this animal; while Colin (who had studied neither) was of the impression that the horse or the cow would be more susceptible than either. Daremburg, in considering the discussion, hopefully suggested that probably another contradictor would recommend either the giraffe or the elephant. This in fact might have been the plight had not the work of Joffroy and Serveaux appeared.

Joffroy and Serveaux have shown that while animals differ in susceptibility according to their kind, this difference is relatively constant and usually but slight. The choice of animals thus becomes, in great part, important in so far as one animal rather than another serves better the purpose of this or that investigator.

A question of more than passing importance in the measure of toxicity, however, is the method of administering the substance to be tested. It is a well-known fact that some substances which are extremely poisonous when injected under the skin, for example, snake venom, are in no sense poisonous when given by the stomach. On the other hand, other substances which show slight poisonous effects if given subcutaneously, act with extreme rapidity if added directly to the blood stream. These facts give to the ways and means of injection a high importance.

The difficulties in the way of injection may now be considered more fully. A lethal dose of alcohol injected into the stomach or under the skin of an animal becomes lethal only after it has been absorbed into and distributed by the blood stream. Hence the importance of knowing whether the alcohol is absorbed promptly so as not to undergo loss or change in the tissues. In a word the rate of absorption must be rapid.

If also by injecting a lethal amount of alcohol under the skin or into the muscles, serious secondary injuries, such, for example, as abscesses and the like, result, a source of error is possible; for a dose of alcohol under the toxic equivalent aided by these secondary influences might thus produce death.

It was evident to Joffroy and Serveaux that in order to prevent errors arising from the rate of absorption and to reduce to lowest terms the danger of secondary injuries, a method should be employed which would insure that the entire amount of alcohol be in the blood at the same time. This could be accomplished in only one way, that was by adding the alcohol directly to the blood stream. They therefore turned their attention to *intravenous* injections.

While this method of adding the alcohol directly to the blood stream would control the rate of absorption and largely allay secondary injuries, yet it was found productive of errors the overcoming of which was imperative to an accurate measure of toxicity. In the first place it has been shown that if alcohol be injected too rapidly injuries both to the veins and to the viscera arise. On the other hand, if it be added too slowly, a loss of alcohol may occur through the kidneys and other ways of elimination.

The first problem of Joffroy and Serveaux was to find a way by which the injection could be made at constant pressure. This was accomplished by substituting for the hypodermic syringe which had been generally used the "flaçon de Mariotte." This gave a constant pressure which was easily regulated at any time during the experiment. By injecting one cubic centimeter per minute for each kilogram of body weight they found no injury occurring either to the veins or to the viscera. With this rate it was also found that the entire amount could be injected before any considerable time had elapsed for elimination to take place.

With the error of rate of injection thus controlled they were ready to try the measure of toxicity. A series on rabbits gave discouraging extremes varying from 4.32 to 12.18 cubic centimeters per kilogram necessary to kill.[3] With variations so great as nearly 3 to 1 it was evident

[3] The exact amounts were as follows: 4.32 c.c., 8.92, 7.26, 12.18, 6.35, 8.44, 4.90, 7.54 c.c. per kilogram.

that the method was far from perfect. What in the method caused so great a variation?

An examination of animals that had died from small amounts demonstrated that death had been due to coagulation and to a consequent blocking of the blood stream. They then set about for a solution of the more serious problem—the prevention of coagulation. First, tests with various salts were made. But these were found to be of no service since a salt in order to be a non-coagulant had to be of sufficient strength itself to be toxic.

A second study hit upon an ingenious method of procedure. It has long been known that the blood of animals ingested by leeches is prevented from coagulation (in the body of the leech) by an anticoagulant. Haycroft demonstrated that an alcoholic extract of the buccal cavity of leeches injected into the arteries of rabbits or dogs prevents coagulation of the blood, and at the same time is productive of no observable injury. Joffroy and Serveaux determined upon testing its powers to prevent coagulation in a normal salt solution.

It is evident that the addition of so complex a substance as leech-extract to the blood of an animal must be made only with the most careful control. Two things were demanded of it: (1) It must serve its purpose, in this case prevent coagulation; (2) it must in no way injure the animal. In testing for its injurious effects it was found that the injection of enormous quantities[4] produced no injury. Since no coagulation followed they were in possession of an anticoagulant by the aid of which they could test the toxicity of a substance added directly to the blood stream.

Later Experiments and Units of Measure

(a) The Experimental Toxic Equivalent

Joffroy and Serveaux established as a convenient unit of measure the amount of alcohol that would kill per kilogram while the experiment was in progress. This they called the *experimental toxic equivalent*. This limit, as is evident, has the advantage of greater rapidity than that (36 hours) used by Dujardin-Beaumetz and Audigé. By injecting the alcohol and this anticoagulant into the blood, in a series of eight experiments, the following amounts of alcohol were found sufficient to kill per kilogram of body weight: 12.65 c.c., 12.18, 11.69, 10.32, 10.51, 11.99, 12.48, 11.70. This series shows a striking regularity with extremes varying only between 10.32 and 12.65 c.c., variations which would be readily accounted for by differences in age, race and the like of the rabbits used.

For ethyl alcohol, then, these authors have demonstrated that 11.69

[4] 1,185 c.c.—nearly 600 grams per kilogram—was injected; of this some was lost, but 425 grams per kilogram remained.

c.c. (9.36 gr.) is the amount sufficient to produce death during the operation, that is, it is the experimental toxic equivalent.

For methyl alcohol, which Dujardin-Beaumetz and Audigé had found more toxic than ethyl, the results of Joffroy and Serveaux are most interesting. Although the method of purification had been greatly improved since the time of Dujardin-Beaumetz and Audigé, yet methyl alcohols coming from different sources were still shown to vary in their poisonous effects. Thus three alcohols from different sources gave the coefficient of toxicity for the rabbit as follows:

23.75 c.c. per kg.
26.75 c.c. per kg.
25.55 c.c. per kg.

As an average of these three series we have an *experimental toxic equivalent* of 25.35 c.c. for methyl alcohol. The point of interest is not the degree of variation present, but the relatively slight toxicity of methyl alcohol when compared with ethyl alcohol. We shall see that the same is true when we study this as measured by another toxic limit.

For the entire series of primary alcohols which we have considered—methyl, ethyl and the higher alcohols—the following table summarizes the experimental toxic equivalent and its relation to molecular weight and boiling point.

	Chemical Formula	Molecular Weight	Boiling Point	Expt. Toxic Equivalent
Methyl............	(CH_3OH)	32	66.0° C.	25.35 c.c.
Ethyl.............	(C_2H_5OH)	46	78.4° C.	11.70 c.c.
Propyl............	(C_3H_7OH)	60	97.0° C.	3.40 c.c.
(Iso)-Butyl......	(C_4H_9OH)	74	117.0° C.	1.45 c.c.
Amyl..............	($C_5H_{11}OH$)	88	138.0° C.	0.36 c.c.

Such are the results when death is produced while the experiment is in progress. While this method has the advantage of rapidity it has also disadvantages.

It is clear that by adding alcohol up until the last inspiration more alcohol is given than is necessary to produce death. For this reason Joffroy and Serveaux realized that the experimental toxic equivalent has only a comparative value. For the exact measurement of toxicity the question is not how much alcohol will kill while the experiment is in progress, nor yet within a limit of 36 hours. The one question is, What is the amount necessary to kill?

(b) The True Toxic Equivalent

The amount necessary to kill may be determined in one of two ways: (1) By giving for a long period of time small amounts which will finally produce death, or (2) by giving at one time an amount sufficient to produce death within a brief delay. The second method was selected for experimentation. This amount was designated the *true toxic equivalent.*

By experiment it was found that for the dog when an amount less than 7.90 c.c. of commercially pure ethyl alcohol was given recovery followed, at or above 8 c.c. per kilogram death ensued. For the dog, hence, the true toxic equivalent was set as 7.95 c.c. (6.36 gr.). For the rabbit from amounts lower than 7.50 c.c. all survived; from amounts above 7.80 c.c. all died. For the rabbit, therefore, 7.75 c.c. (6.20 gr.) per kilogram was set as the true toxic equivalent. The average of 6.36 gr. for the dog, while seemingly differing considerably from that (7.75 gr.) found by Dujardin-Beaumetz and Audigé is in fact in close accord with it.

If in the experiments of Dujardin-Beaumetz and Audigé all animals that died within three or four days are substituted for all animals that died within 36 hours, the toxic equivalent for ethyl alcohol instead of being 7.75 gr. increases to about 6 gr. per kilogram. This is in agreement with what Lussana and Albertoni found, but it is slightly higher than that given by Joffroy and Serveaux (6.36 gr.) in the perfected method.

The work by Joffroy and Serveaux on the *true toxic equivalent* of methyl alcohol is most thorough. By the same procedure as for ethyl alcohol they have shown that for the dog amounts above 9.10 c.c. produce death. They have, therefore, established as the true toxic equivalent for the dog by intravenous injection 9 c.c. per kilogram. For the rabbit this is 10.90 c.c. per kilogram.

Two things of interest are made evident in the work on methyl alcohol. These are: (1) That for the dog methyl alcohol is more toxic than for the rabbit (the opposite was seen to be true for ethyl); (2) that for both the dog and the rabbit it is less toxic than ethyl alcohol, and is therefore in harmony with the law of Rabuteau.

From these various studies it is clear that alcohol in large quantities is a poison capable of causing death, the most toxic being amyl and the least toxic[5] methyl, and that the difference in the degree of toxicity follows the law of Rabuteau: A substance (alcohol) is as toxic as its molecular weight and boiling point are elevated.

[5] This does not take into account the latent ill-effects on man shown to be characteristic of methyl alcohol.

THE MOST REMARKABLE MONUMENT IN WESTERN CHINA

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IMAGINE, if you please, a low river bluff—thirty or forty feet high—faced with a masonry of red sandstone and crowned with warlike battlements, beyond which rise the tiled roofs of low-built houses and fantastic outlines of quaint old temples. Such is the picture presented to the traveler who visits the city of Jah-ding in western China. Behind those battlements are huddled the homes and shops and public buildings of a densely packed population, among whom many a quaint and curious custom still obtains, for modern civilization is being introduced but slowly.

Far in the interior of Asia, more than a thousand miles from the sea as the crow flies, that city is located. It stands on the banks of a gently flowing river. The dark red walls overlook the dull gray water, while overhead hangs a dull gray sky, since the province of Four Streams is renowned throughout all China as the land of clouds. Many travelers have visited that city, for the river which washes its walls is one of the principal waterways of western China. In fact, it is one of the headwaters of the Yangtze-kiang, the natural outlet of that country. To be precise, the town is located at the confluence of three streams, one of which comes from the capital of the province, the great city of Chentu. That capital is the goal of many a globe-trotter of adventurous disposition or scientific tendencies—the kind who write books. On leaving it he floats down stream in a native boat for twenty-four hours and ties up at the gates of Jah-ding (spelled Kiating on the maps), to make a visit to Mt. Omei, one day's journey to the west. That mountain is not only one of the natural wonders of the world, but is also a center of pilgrimage for all the Buddhists of China, as it marks the point where Buddhism first entered the country. Dotted with temples from base to summit, the mountain overtops the surrounding plain by nearly two miles, while on one of its faces a tremendous precipice descends almost unbroken for six thousand feet. It attracts the adventurous globe-trotter with an irresistible magnetism.

But it is not the writer's purpose to deal with Mt. Omei or any of its features. They have been portrayed in detail by others. The object of this account is to describe a curious relic, not far from Jah-ding, which well might attract the traveler's attention, but which has received scant notice. Permit me first to outline how travelers, one after another—men of literary and scientific attainments—journeyed in far western China, wrote of its scenery and its monuments, but neglected to visit and describe the most remarkable monument of them all.

In the late 70's, Colborne Baber, British traveler, drifted down the

The Great Buddha at Yong-hien in Western China. Mentioned, but not visited by the Count d'Ollone. See p. 196 of "In Forbidden China."

river Min and moored his boat at the gates of Jah-ding. Leaving the stream, he ascended Mt. Omei, and the resulting account, which he published in England, provoked the curiosity of the traveling and scientific world, for it was the first to call attention to that strange old mountain, with its clustering monasteries and temples, its noble bronzes, and its glorious natural scenery. But Baber found other wonders besides those of Omei which were worth recording. A few hundred yards from Jah-ding stands the ruin of an immense image of Buddha. Twelve hundred years ago, a niche two hundred feet high was cut in a cliff which stands by the side of the river. The recess extended the full height of the cliff, and in it was carved an immense image. Unprotected from the elements, and neglected by the people, time has done its work; practically all that is left consists of a few vestiges of the face. The entire niche is overgrown with brush; vegetation hangs from the features so as to give it the appearance of possessing eyebrows and mustache. Standing on the opposite bank, it is possible dimly to discern the outlines of a countenance; that is all.

Baber freely admitted that this old image is a ruin and a disappointment. He also admitted having been informed through a Russian traveler that a hill, two days' travel east of Jah-ding, had been hewn into a representation of the seated form of Buddha "several hundred feet high, which far overtops the roofs of surrounding temples." Here, it would seem, was something worth the effort to visit and describe, yet he made no attempt to do so.

About ten years later (1887), Virgil Hart, American missionary, followed in Baber's footsteps and duplicated his journey, collecting as he went the material for one of the most vivid, accurate and delightful books of travel that have ever treated of China. The volume which he published challenged attention and provoked admiration. Hart's flowing phrases were in striking contrast to the baldness and bareness of Baber's account. The reverend gentleman treated Mt. Omei with especial fulness and enthusiasm. He said:

> Mt. Omei is a center of natural and *artificial* wonders, the like of which may not be found elsewhere upon the globe. I speak advisedly. The world is large, and in regions like Switzerland and Alaska, nature seemingly has been taxed to the uttermost to produce a combination of natural objects of surpassing beauty and grandeur. Here, however, near the borders of Chinese civilization, we find a region of unequaled sublimity—a combination of lofty mountains, of swift rivers and of valleys of wondrous fertility. Then also of the works of man there are many—such as thousands of brine-wells, a great silk culture, a white wax industry, mountains chiseled into the forms of idols, colossal bronze statues, pagodas, and one temple wholly of rich bronze. Great Omei Mountain is scores of miles in circumference, rising 11,000 feet, its highest point enveloped in the everlasting clouds. All these wonders are within a radius of forty miles.

On another page, Hart quoted Baber's account of the figure sculptured in the river bluff above Jah-ding, and added (p. 176):

THE FACE OF THE GREAT BUDDHA AT YONG-HIEN. The features had been covered with gilding, which is peeling off, but is best preserved on the upper lip.

One would suppose Buddhist ambition to be satisfied with an undertaking of this magnitude, but we are told by a Russian traveler that it is a mere infant beside one a few days' journey distant. There he found a mountain—a small one, of course—fashioned by the hand of man into the form of Buddha.

Yet it does not appear from Hart's narrative that he made any attempt to visit and describe so remarkable a wonder.

In 1892, Archibald Little, English merchant, explorer and author, driven out of Chungking by the cholera epidemic, arrived at Jah-ding on his way to Mt. Omei, where he spent several weeks, afterwards embodying his experiences in a book, "Mt. Omei and Beyond." He made no attempt to locate the Russian traveler's find, although his wife secured an excellent photograph of the image on the river bank.

In 1906, R. F. Johnston, while collecting material for his work, "From Peking to Mandalay," arrived at Jah-ding, ascended Mt. Omei, and described its temples and antiquities in the most thorough guide-book style. Yet he seems never to have thought of seeking out the Russian traveler's great Buddha.

Early in 1908, the Count d'Ollone traveled in the same region. His experiences have appeared in a recent volume, "In Forbidden China," so called because most of his time was spent among the savage and independent Lolos. On page 188 of that volume, he says:

Kiating possesses one of the most astonishing, though not the most admirable, works of art ever produced by human hands. In a cliff overhanging the confluence of the Yah, the Ta-Tu-Ho and the Min, there is a Buddha, cut out of the solid rock, no less than one hundred and eighty feet in height. It is by far the largest statue in the world. It occupies a recess some sixty feet in width and depth. The god is represented sitting in European fashion.

It must be confessed, however, that this great statue is no longer effective. Under the action of the weather, the contours are worn and crumbling; great blocks have fallen away, and the vegetation—mosses, bushes and even trees—has attacked and is disfiguring what remains. Without being able to see how Colborne Baber failed to discover, except in the face, any trace of the sculptor's hand, we must admit no traces of actual art are now visible. It looks as though the hewers of stone had roughed out of the rock a rudimentary statue, like a snow man, which the artist never completed.

On the next page he goes on to describe the search for rock sculptures which his party conducted in the grottoes surrounding the city, where they had the good fortune to discover a group some miles to the north. On page 193 we find the statement:

Our unexpected discovery, that of rock sculpture of great antiquity and pertaining to a vanished art, filled us with delight, for it revealed a past which was practically unknown. The reader may imagine that we were always on the alert for anything that might put us on the track of fresh discoveries, but I must own that the results were constantly negative.

He then tells how his party was put on several false trails, but finally learned (p. 196) that there was a

very fine Buddha at Yong-hien, some fifty miles to the southeast. Yong-hien was too far from our route, and we had no intention of going in search of its Colossus. No doubt, had we gone, we should have been directed to another.

Detail of Chinese Temple Architecture at one End of a Temple in Yong-hien, the City below the Great Buddha. Notice two chimneys in the foreground, which disprove the statement that "in China proper chimneys are unknown."

This was the Buddha of whose rumored existence Baber and Hart had already made mention.

Thus I have outlined all that had been printed in English regarding this mysterious marvel. Travelers, of the book-writing sort, had ignored it or passed it by. Not one of them had the initiative to go fifty miles off the beaten track in order to picture and describe the most remarkable monument in that part of the world.

Early in 1910, the writer of this account visited Jah-ding and—although not anxious to pose as one "alert for anything that might put him on the track of fresh discoveries"—decided to do what the writers of books—Baber, Hart, Little, Johnston, d'Ollone—had neglected; to travel two days' journey to the east in order to definitely locate and describe the rumored marvel.

It was a narrow winding road which led across the hills and through the valleys, zig-zagging hither and yon. The customary method of travel in that region is by sedan chair, but, owing to the fact that the season was the Chinese New Year, it was almost impossible to obtain chair carriers; most of the distance had to be walked. Were I writing a story, it might be made entertaining by an account of wayside scenes and daily incidents of travel. I might describe the farmhouses with their low tiled roofs and their hedges of bamboo, the bridges built of massive masonry; the stone portals spanning the way to commemorate by their scriptions virtuous or useful lives, the tall pagoda rising from its hilltop in the distance to signalize the presence of a city. As this is not a story, let us hasten to the end of the fifty miles, and view the Great Buddha. At the end of two days of travel, we saw before us the colossal image in all its dignity; not nearly so large as rumor had made it out, but a Colossus still. Of course, the story of the whole hill having been hewn into a figure was a fabrication. The figure is on the same plan as the one on the river bank at Jah-ding. The upper half of the hill-side consists of a sandstone cliff, and in this a niche fifty feet broad had been cut, leaving a central core of stone, which was then carved into a figure seated in European style, not cross-legged as Buddha is so often represented. The writer measured the breadth of the opening; using that as a unit of measurement on the photograph, the height of the image is not less than one hundred feet, that of the hill not less than two hundred. As the camera was pointing upward at a small angle, the vertical distances must be greater than the figures given.

The reader will observe by glancing at the picture that a series of five tiled roofs, descending like a flight of steps, have been built before the image to protect it from the weather, so that only the face can be seen from without. But by going within, the location of the feet can be determined; they are on a level with the space between the two lowest roofs. A white-fronted structure may be seen below and to the right; it is a temple, and another temple crowns the height. As the writer and his men came in sight of the Great Buddha, we paused and rested from our journey at a point near one of the gates to the walled city which lies in the valley below. As our eyes turned to the great face, which has been gilded until it shines like metal, as the immense size and

A Wonderful Pagoda, with Tiled Roofs, in Western China.

perfect preservation of the idol made their impression, the thought that came to my mind was, "How far more marvelous is this than many of the world's boasted wonders." I thought of the Colossi at Thebes and the Sphinx. What are they? Scarred, ruined and defaced by the hand of man and the effects of time, they are scarcely recognizable as images. They are little better than lumps of battered rock. But far in the west of China sits this old Buddha, remote from the tracks of travel, unnoticed and almost unknown; yet greater in size than the Egyptian

Colossi, his proportions preserved in all their pristine freshness, temples above and below him, and priests in attendance to keep the incense burning at his feet. There he sits, grimly gazing out over the tiled roofs of the city which lies before him.

A Stone Portal Spanning a Road in Far-western China. This specimen was erected in 1906.

While exploring the temple, I asked one of the priests the age of the image. His answer came, "Gee chien nien. Some thousands of years." I give it for what it is worth.

Another thought which that monument inspired was in reference to a passage in one of Conan Doyle's delightful stories, which describes a party of tourists viewing one of the ancient temples of Upper Egypt. The author makes one of the characters say:

If one could come wandering here alone—stumble upon it by chance, as it were—and find oneself in absolute solitude in the dim light of the temple, with these grotesque figures all around, it would be perfectly overwhelming. A man would be prostrated with wonder and awe. But when Belmont is puffing his bull-dog pipe, and Stuart is wheezing, and Miss Sadie Adams is laughing—and that jay of a dragoman speaking his piece.

My thought was that, if such are Conan Doyle's preferences, he would enjoy a visit to the place before which I stood. The visitor would ascend to a broad stone platform that lies before the white front of the temple. He would enter a dimly lighted interior, where priests are tapping the drum and raising their rude chants before grotesque carven images of the types so common in China. Turning, the visitor would ascend to a platform built before the feet of the Colossus, below which he could stand and gaze with head thrown back at the giant bulk above him. There would be no danger of his being disturbed by the idle chatter and empty laughter of gaping tourists, for I have already intimated how scarce travelers are in that portion of the world. It would be as though time had rolled back twenty centuries and he stood in one of the temples of ancient Egypt.

To get a nearer view of the face of the Buddha, it would be necessary to circle the hill and ascend one of two trails which lead around the front of the cliff. Along these trails, life-size figures have been carved in the face of the sandstone. They are in a very ruinous condition and are only remarkable because of their belonging to the ancient Greek type of sculpture, so different from the modern Chinese type. They resemble the rock sculptures photographed and described by the Count d'Ollone (p. 196). Above the end of either trail a tablet containing a long Chinese inscription has been carved in the solid rock. No doubt these inscriptions contain much interesting information concerning the great Buddha, but the writer's limited knowledge of the language prevented him from deciphering them.

As we come to the end of this account it would be entirely reasonable for the reader to inquire why the missionaries—of whom there are many in western China—have not written any account of this image, if it is "the most remarkable monument in that part of the world." The missionary attitude toward such objects may be explained most easily by reference to a trifling incident in my own experience. On my arrival in western China, I met an American cleric who had been stationed in a very out-of-the-way corner of that country. Eagerly I asked him to tell me some of his experiences. What sort of a life had he and his family led? "Oh, Mr. Sprague," he said, "it was just like life anywhere else." From his point of view the answer was correct. For him, life did not extend one inch beyond the end of his nose. His interest in the external universe was nil. So it is, as a rule, with the missionary. Absorbed in his books, his family and his congregation, the world around him escapes his notice.

THE PLACE OF STUDY IN THE COLLEGE CURRICULUM

By Dr. P. H. CHURCHMAN

CLARK COLLEGE

IF some acute and unconventional enquirer should raise the question whether the governing ideal of the American college is and ought to be severely intellectual, the man who takes things at their face value would experience a shock. He has never supposed that any other sort of ideal was conceivable. Look at the catalogues; do they not give sufficient evidence of a passionate interest in things intellectual by their whole-hearted devotion to courses and honors, to admission and graduation, to fellows and faculties? Such a theory may perhaps be pardoned in one who is on the outside, but a bowing acquaintance with the realities would suffice to show that this opinion held by our trustful friend simply proves that he has not investigated the facts;[1] for, if he cared to take up such an investigation, scores of college teachers could provide him with interesting evidence indicating what many students, alumni and parents, and even some faculty members, really think about this matter. As the first exhibit in their case against the great academic illusion, critics might present a vigorous article on the subject of college "cutting," recently published in the *Harvard Graduates' Magazine*[2] by Dean Hurlburt, for therein the writer incidentally pays his respects to the intellectual ambitions of some students and parents whom it has been his rare good fortune to know. He cites one especially interesting case—that of a father whose son, in spite of notable success in athletics, had been dropped from college. This father was a college graduate, but the educational conception of the college does not seem to have troubled him greatly, and he appears to have been perfectly

[1] If any reader should feel that the position of this article is extreme, he is invited to read President William T. Foster's able book on "The Administration of the College Curriculum" (Houghton, Mifflin, 1911), Part II., *passim.* There he will find views no less radical—to say the least—than those defended in these pages, and he will also be supplied with a detail of argument and some scientifically marshalled evidence that are impossible in a brief article. President Foster's conclusions frequently agree strikingly with those of the present writer, but the fact that his book was not read until after this article was practically completed is sufficient proof that most of these coincidences are undesigned. Some of my contentions, however, have been considerably revised after reading his book, which, for this reason, and for the purpose of presenting the other accidental confirmations of my arguments, has been freely quoted in the notes.

[2] March, 1911, pp. 400 sq.

satisfied to have his son ignore it also. "My son's college life," said he to the dean, "has been just what I wanted it to be; of course," he conceded as an afterthought, "I wish that he had won his promotion." One case of that kind may not be conclusive, but some who know the college world are convinced that the instance is typical—that the conception of college life which subordinates study to athletics or to social success (or else ignores it altogether) is limited to no single group of individuals and to no one institution, that it seems to be the honest ambition of an appalling proportion of fathers and mothers who are sending their sons to fashionable colleges, in the same spirit that accompanies their daughters to fashionable finishing schools.

After hearing the testimony of parents, our investigator may do well to learn also how some alumni feel about college work. Let him listen, for instance, to an intelligent young physician who received the bachelor's degree from Princeton seventeen years ago, and who puts his ideal of a college career in somewhat this fashion: "Don't talk to me about making students work harder; work in itself is not only useless, it is degrading. There is but one thing of value to be got from college courses, and that is the ability to cram hastily into one's head a few essential facts, which comes from the passing of examinations. No man ought to be compelled to work hard and steadily at anything that does not interest him. You remember X; he was a grind in college and graduated near the head of the class but missed a lot of fun; Y, on the other hand, finished about as near the bottom of the class, but had a royal good time. Did it do the grind any good to work so hard? Both men are in medicine; is the loafer any the worse for his loafing?" We do not stop now to question data nor to analyze fallacies;[3] we merely note in passing that this feeling appears to be shared—though, perhaps,

[3] "Only one man in twelve years whose college record fell below C has contrived to change his habits sufficiently to graduate with honor from the [Harvard] Law School. . . . The same general truth holds for students in the Medical School. . . . These facts are quite at variance with popular opinion. Returns from several hundred Harvard undergraduates express the prevailing idea that success in college scholarship furnishes little or no indication of those intellectual qualities that men desire to possess. 'College life' is said to be the thing. The notion has spread that 'sports' in college settle down in the professional schools and surpass the men who in college were 'grinds.' Pity is often expressed for the unfortunate salutatorians and valedictorians who are supposed to be doomed to failure in life. Such notions must now go the way of many others, though some men will still comfort their mediocre college work by exalting opinions above facts. There are still people who believe that the earth is flat." W. T. Foster, *op. cit.*, pp. 230–232. See further President A. Lawrence Lowell's analysis of some interesting evidence along this line in *The Educational Review* of October, 1911 ("College Studies and Professional Training"). Possibly these facts will come as news to a good many of us who used to share the Harvard undergraduate's illusion in regard to the capabilities of "sports" and "grinds."

in less radical form—by hundreds of graduates who are men of reputable standing, and some of whom may be sending sons of their own to college. Talk to such graduates of loyalty to *alma mater*, and it will express itself in terms of getting money, recruiting students (especially athletes), coming back to reunions, putting up buildings and supporting the team; the educational aspect of the college is a negligible aspect—a subsidiary nuisance. In a gathering of "loyal" alumni of this stripe the man who would argue for even an approximation to the scholarly ideal is actually put upon the defensive—if he is not an object of derision.

If it be true that a great deal of parental and graduate opinion is openly hostile to the strenuous view of college work, no surprise should be excited by the discovery that the undergraduate atmosphere also is polluted;[4] nor that the school-boy has either already caught the disease before leaving school, or soon contracts it in the unhealthy atmosphere of the college. Hence, unless one be wholly in error in one's pessimistic verdict upon present conditions, it turns out to be less ridiculous than it may have seemed at first blush to ask whether the highest place in college is being given to severe intellectual discipline; the mere possibility that the situation is grave should arouse all serious educators, and the veriest honesty demands a frank answer to the enquiry from all responsible for the conditions.

The answer to be expected from some parents and alumni, as we have seen, would be that intellectual considerations are altogether secondary, and that the important business of the college is not study. Probably very few college professors and presidents would care to take their stand with these enemies of the intellectual; but certainly many such academic gentlemen would have to be ranked, with or without their own consent, among the compromisers. They may not explicitly condone loafing, but they preach that

'Tis better to have come and loafed
Than never to have come at all;

they may not disparage intellectual attainment, but they are unwilling to demand it of all of their students. The attractive creed of such educators might be formulated somewhat as follows: "College is a place of large opportunities, among which the purely intellectual are not necessarily the greatest. We should, of course, aim to develop and instruct the minds of our students, but we must not forget that one of the greatest educational forces in college is the life itself, and it is by no means incumbent upon us to insist that all of those in residence shall

[4] At a recent conference of educators the following motto, which had been found hanging upon the wall of a student's room, was produced: "There is just this advantage about study, that it shows by contrast the value of those things for which we really come to college."

be real students." This is the view which—possibly unjustly—we are apt to associate with the typical Oxonian frame of mind; and it is by no means wholly indefensible, especially when contrasted with its Continental opposite of young pedants who, in spite of much learning, may be arrant fools.

It is to be feared, however, that some of the commonest reasons for loose dealing with idle students are not particularly creditable. The least deplorable, perhaps, is an uncritical good nature, weakly consenting to allow the deficient student to continue his life of delightful indolence, and cheerfully indifferent to the effect of leniency upon the delinquent and his fellows. Perhaps, too, this attitude is not always easy to distinguish from lack of courage in those for whom popularity is the first great test of professional success. Now popularity, honestly won, is among the most precious things in the world. When coupled with just severity it is an ideal attribute in the college professor. But popularity in the man who is also notorious for "snap" courses, or who is always "on the side of the students" in matters disciplinary and scholastic—on the side of the undesirable students, that is to say—this sort of popularity will bear a deal of scrutiny.

Toleration of poor work is sometimes due, furthermore, to a desire to keep up numbers; we must retain enough students to pay our bills, and we must not let our "competitors" get ahead of us in size. Either of these motives is unworthy of gentlemen and scholars. To be sure, financial habits of mind may be strong in boards of trustees, but the merest business sense should teach us that the last place to economize is in the quality of our finished product. If we can not save or otherwise secure enough money to make us independent of the tuition fees of those who ought to be dropped, then let us by all means redeem our credit (monetary and moral) by a small increase in the *per capita* charge: a very little arithmetic will prove that a ten per cent. addition to the fee charged each student will enable us to dispense (if need be) with nearly one tenth of the student body, without reduction of income. The "competition" argument is one that it is difficult to discuss politely. Upon what basis, forsooth, are we "competing" in this business of education—upon the number of men that we manage to keep enrolled, or upon the quality of the education acquired by those honestly entitled to attend our courses? Can a self-respecting college aspire to a "success" that is measured by an increase in numbers, which, in its turn, may be due chiefly to a low standard? Is there anything more honorable in educational "competition" than wholesome and courageous pruning?[5]

[5] "Every fall we hear that this college and that has made great gains in numbers. And yet we have no idea whether there have been gains in any vital sense until we know first, what proportion of those admitted are qualified to

None the less discreditable is a sympathy with idle students arising from a similar spirit of idleness in the professor—and yet one is tempted to believe that the real cause of such sympathy is often a kind of unconscious fellow feeling. In few other professions is it easier for the strenuous man to be overworked or for the opposite kind of man to appear to fill his post; so much of the teacher's labor is elusive and impossible to fit into an exact schedule of hours that practically nothing but conscience or ambition can call him to account for loafing, and nothing but his nerves warn him when to rest. Hence arises the fatal risk that—given fallible humanity—this liberty may be abused, and that bridge, golf or literary browsing may take the place of real work; hence, too, the danger that the instructor who is living this delightful life of ease in Zion may not hold before his student the ideal of tireless effort, particularly when he finds that the only sure road to the goal lies through the horrid drudgery of frequent conferences or written papers.

Some of the causes of unwise leniency toward inefficient students which we have been discussing are administrative rather than pedagogical; such are not always conspicuously operative in the creation of "snap" courses. But ignorance of bad conditions—be it perverse or innocent—is harmful in both directions at once; it militates against the toning up of weak courses as well as against honest dealing with obviously worthless students. Take for instance the amiable or uncourageous pedagogue who conducts a "popular" course year after year without making the slightest effort to discover why it is so popular—to determine, that is to say, whether he is exacting a decent amount of collateral work week by week, or whether he is simply delivering an innocuous series of lectures followed by an examination which practically any student can pass after four or five hours over a printed syllabus; and who, if some base traitor hints at inefficiency, is eloquent with denials in regard to conditions which he has never taken the trouble to investigate. And yet it would seem a quite easy matter to discover why our courses appeal to the student body. For instance, we might enquire of graduates (for they are beyond fear or favor)

pursue the courses offered, and, second, whether there has been a corresponding increase in the number and efficiency of the faculty. Of late the only institutions that exhibit much loss in registration are Princeton and Harvard, yet some believe that few institutions have made greater gains in efficiency. This is not a mere coincidence. The dropping of 680 incompetents in six years at Princeton, and the loss of 50 'specials' at Harvard in 1910, has a meaning in progress precisely opposite to the so-called great gains of some colleges. We must rid ourselves of the notion that there is any credit *per se* in enrolment gains. Any college—without exception—can increase its numbers if it is willing to pay the price; just as, on the same terms, jailbirds can be elected to political office in some American cities. Conversely, any college, without exception, can increase its efficiency if it is willing to pay the price, which under present conditions is likely to be a falling off in numbers.'' W. T. Foster, *op. cit.*, 320–321.

whether, in the course which is on our conscience, they ever did any reading before examination time, and how much they found it necessary to do then. Another interesting test[6] would be to compute and compare the average standing of the men who take the different courses year after year, not forgetting to calculate also the average of passes (or perhaps of all the marks) in the various courses. It would not cause great surprise to some observers if such a scrutiny of the facts should indicate that birds of the D feather flock together under those generous trees from which the fruit (the passes, not the intellectual profit) falls with the least coaxing. But it would seem that we are in for a long wait before some administrators and instructors will care to collect facts in regard to scholastic conditions. The snap course goes on, the lazy student stays in college, and the snap professor flourishes like the green bay tree. Evidently this complacent faith of the academic stand-patter in the utter loveliness of the local landscape is a greater breeder of popularity than is the restless spirit of doubt, criticism and reform.

Almost imperceptibly we have been led, in this discussion of academic toleration, from a consideration of its causes to an analysis of its fallacies and its harmful effects. It may have been noticed, also, that, in some important particulars, the influence of the educator who has been characterized herein as a compromiser is in harmony with that of the alumnus or the undergraduate who is altogether hostile to the severely intellectual ideal; for the objection—if any there be—to the comfortable creed of compromise lies not in its toleration of scholarship, but in its friendly feeling for ignorance and sloth, in which gracious capacity it is in complete sympathy with the out-and-out negative. For this reason we may treat these two types together in our further attempt to point out others of their common weaknesses.

In the first place it is quite justifiable to note a little inconsistency. What shall we say of men who despise the intellectual in its practical application to their own college experiences, but who reject with indignation the accusation of laxity in scholastic conditions in the *alma mater?* Is it consistent and honest to boast before strangers of the distinction of scholars whom at home we scorn as students or hamper as administrators? It is said that the late Professor Child, a scholar of whom any university in the world might have been proud, was a butt in the class-room for ill-bred students who took his courses with no desire to learn; it would be interesting to discover whether or not some of these "students" are to-day boasting of the distinction which Professor Child brought to Harvard. And if an officer in a college deliberately takes a stand for a policy of compromise with idle students, what just cause has he to grow angry with critics whose arraignment of

[6] Suggested by President Foster, *op. cit.*, pp. 297–303.

his easy-going methods is simply a bald statement of the truth? Is there no danger that some of our students and faculties may desire to bear the reputation of scholarliness without paying its honest price in hard work or in unpopular justice? One is tempted to point out in this connection the grave injustice that may be done by over-tolerant college authorities to teachers of the strenuous type in their employ. Sometimes it would almost seem to be the explicit belief of these easy-going presidents and heads of departments that the function of the instructor, be he never so promising a scholar or so skilful a teacher, is to spend his time and energies in a vain attempt to cajole illiterate and contemptuous "gentlemen" into the absorption of microscopic doses of learning. To be sure, small wonder should be aroused by the fact that bloodless pedantry and academic priggishness meet with ill success in their contact with lively undergraduates; but, in some institutions, men who are neither prigs nor pedants must either descend to the "popular" level or else court disaster. Some of these mistaken idealists may begin their teaching with a fine ambition to make their courses count, perhaps even with the knowledge that trifling was rampant in their own student days and the determination that it shall not disgrace any of the classes for which they are responsible. And yet their training, their enthusiasm and their ideals are likely to be unappreciated even if they are not positively unpopular; they must either forget these things and drift with the genial majority, or fight a discouraging battle on the side of a minority disliked by colleagues and students. Perhaps it may not often occur to candidates for college positions, nor to heads of departments seeking instructors, to determine whether this lack of harmony exists; but it is quite possible that an honest agreement in regard to the question whether one is expected to teach or to amuse might prevent a certain number of misfits.

Secondly, if the ideal of a college is to be anti-intellectual, or even a policy of compromise, it is only fair that the fact shall be squarely and publicly admitted, so that ambitious parents and conscientious students shall not be deluded. It is merely honest to define our position; if we are conducting a country club with practically optional opportunities for intellectual development, the public should know it. Such institutions should advertise along these lines: "Blank University offers to young men of good disposition four years of pleasant life, combined with social and athletic advantages. Any who are so inclined may attend some of our large assortment of easy and attractive courses; and, if, in addition, they will do a small amount of work, the bachelor's degree will be conferred upon them." With the ideal thus frankly defined, the situation would become clearer, and we could leave institutions of that sort to conclude for themselves whether the social by-products of an unintellectual college life really warrant the four precious years squandered. If no existing college dares to take quite that stand, then let some benefactor found the University of Dolce Far Niente. Such a venture would not demand much money for libraries and laboratories; and the salary account could be kept very low, since the faculty would not need to be either large or distinguished. A few "interesting" lectures—to keep up the "college degree" illusion and to provide relief from the monotony of serious occupations—would be the only necessary equipment. But this university would be provided with all the attractive decorations of "college life," free from the incubus of work; there would be clubs and "frats," dances and dramatics, beer nights and bonfires—even athletic teams, if the discipline of training and practise could be tolerated. Such an institution would be doubly beneficial; it would provide the ideal place for the idle to prolong their boyhood amid pleasant surroundings, and it would rid educational colleges of material that is now clogging the wheels of progress. Seriously, why not? Why do even the enemies of study prefer universities of distinction to the mere companionship of the club? We may admit that age and tradition often play a large part in this preference, but is it not also true that many idlers find their way into colleges that are by no means old? What then would the University of Dolce Far Niente lack? What but that noble prestige which quickly develops in an atmosphere permeated by the serious ideals of men who, however much they may have delighted in the diversions of the college, have regarded work as its first business? What right, therefore, in such an institution has any man who will not play the game, who will not contribute his share to the maintenance of that tradition, who acts the part of parasite upon the body intellectual?

Life's choices are relative, not absolute; play will be welcomed in the University of Work, and the University of Play will perhaps continue to work between busy days. It is, therefore, largely a question of emphasis, but it is an emphasis which sets off species from species. Hence we can not insist too strongly upon the necessity for frankness in the declaration of our ideal, whatever may be the ultimate merit of the debate over the business of the college. This is vital, for by a confusion of ideals wrong may be done to men of parts eager for an education, but who discover too late that the easy-going institution is not the place to get it. As an illustration of this danger we may quote the remark of a man who was graduated with highest honors from one of the most charming old universities in this country, and who has begun to win more dearly bought success in surgery; his regretful comment upon his college "training" was something like this: "The first thing I had to learn when I got to the medical school was that trifling does not win honors in a serious institution." What that man looked upon as trifling was accepted by his college instructors as honor work; how much more justifiable are the regret and resentment of the graduate who looks back upon college years that he was allowed utterly and obviously to waste.

In this connection, it may be legitimate at least to raise the question whether a courageous insistence upon real attainment in scholarship would result in the exclusion from college of a substantially larger number of men than the present weaker method does, or whether the result might not be simply to spur to greater effort large groups of gifted fellows who are now floating along the line of least resistance. Would such a policy exclude any men really worth keeping? The belief that college is a place primarily for study implies no contempt for the unscholarly type of man, who is frequently more attractive and occasionally a bit more able (along some lines) than the good student is. But that concession does not alter the obvious fact that only the man who can and will study has any right to be in an educational institution; an ignoramus or an idler is no more in place there than a poet in the supreme court or a college professor in the steel trust.

Finally, this great question of the college ideal is not solely an individual matter; it is altogether pertinent to look at it from the national point of view. So we may solemnly ask the exponent of the country-club ideal whether or not he believes that the American nation should expect her institutions of higher learning to demand hearty devotion to work from absolutely all of those who are preparing for life within their walls and who are supposed to be the material from which her leaders will come in the future. Perhaps we may even go so far as to suggest that a toning up of the intellectual life is one of the great needs of America to-day, and to ask whence this intellectual salvation is to come if not from our centers of education.

It is reasonable to believe that most college teachers do not subscribe to the anti-intellectual creed held by so many parents, alumni and undergraduates; nor do they all, by any means, approve of the policy of compromise of which some of their colleagues are guilty—though it may be that not all of those who believe in the severer standard are sufficiently honest and strong to fight for it. Moreover, it is not unduly optimistic to hold that there has been, speaking broadly, a general toning up of our educational standards in the last ten or twenty years. A great deal of the credit for this improvement may be due to some of our younger and less distinguished institutions, in which a desire for real mental training and for a large acquisition of knowledge is taken for granted, and where creditable intellectual attainments are demanded of every student, either by the spirit of the institution or by the courage of the administration. One can not but wonder whether these modest colleges will not train the Lincolns of the future—in spite of their lack of Oxfordian prestige. But the importance of the non-intellectual influences that have contributed to the formation of that most attractive and valuable type called the "college-bred man" should never be overlooked even by the most earnest advocate of scholarliness. The traditions of the English university and of more than one fine old college in this country, the atmosphere of ancient culture and public service, the social and even the athletic interests, are of inestimable worth. Hence it is a mistake to maintain that the activities of the man who does not study are always altogether futile. In his favor it is argued—and with great justice—that he may be learning to know life better than he would by close attention to books; and it does not take great faith to believe that some men are actually benefited by an almost wholly unintellectual college life. They play on the field, they manage the team and the fraternity, they sing with the glee club, they write editorials for the daily and stories for the monthly, they sit and chat with their smoking chums, perhaps they even read an occasional book that is not in the curriculum. Still the admission that all is not hopeless does not involve the belief that all is well; the meliorist still stands half way between the pessimist and the optimist. Some incorrigibly cheerful observers who have discovered likable traits in the American undergraduate treat with airy scorn the insinuation that he is unscholarly. This is the attitude of a contemporary magazine writer who, having learned that two mere college presidents (A. Lawrence Lowell and Woodrow Wilson) deplore the low estate of scholarship in our college world, proceeds to show that he knows better. He finds that our undergraduates are enthusiastic (especially in sport), energetic (in non-scholastic activities), honorable, and bent upon reality—ergo everything is lovely. We admit these qualities and rejoice in them; *c'est magnifique*—but it is not the point. Likable qualities doubtless abound in a tribe of American Indians or in a drove of blooded horses; possibly they are more plentiful there than among scholars or artists or successful business men. But it would be as reasonable to pretend that such children of nature could paint a Velázquez or finance a railroad as to imagine that merely likable qualities can take the place of intellectual education. The point is not the charm that groups of clean young men of cultured families are almost bound to possess, but whether these men are developing in college in that domain which is preëminently the business of the college. And this, in spite of all the charming avocations, is primarily intellectual, both by reason of its profession before the world and by its high duty toward these young men; even though it should sacrifice social and athletic activities it must be true to its profession and its calling. But there is no need that it should sacrifice them; it should retain them and vitalize them intellectually. Six hours a day for study and classes is not a schedule likely to lead to nervous dyspepsia; but six hours a day for six days a week would mean that each lecture and class of a fourteen-hour-per-week schedule would be accompanied by one hour and a half of preparation; college teaching would be paradise if two thirds of that time were regularly given to study by every student. Should we not, then, ponder a little before we glibly sacrifice to "college life" this wonderful, but really easy, opportunity to introduce young men to the world's wisdom, to create a habit of thoughtfulness, and to teach the secret of work? A moment ago we were admitting the possibility of benefit from the better sort of non-intellectual college activities, but the unvarnished truth is that a large proportion of our college shirks do not spend their time in such commendable ways; most of them devote it to aimless idleness and not a few to downright vice. One of the greatest reasons, therefore, why these young fellows should be kept steadily at their studies, regardless of the nature of the knowledge acquired, is that those four precious years between the ages of eighteen and twenty-two are, for many, life's last obvious opportunity to conquer the demon of laziness. And it may be true, too, that a little more study will act as a deterrent to other vices.

The pity of it all is that the delightful accessories should crowd out what was once thought the chief business of educational institutions. But a renaissance of the old belief in the worth of intellectual endeavor and in the power of wisdom seems to be coming; there would appear to be a revival of the antiquated tendency to admire the college administration which declares roundly that the young man who has no taste for knowledge and no desire for intellectual power will not be allowed to waste four years of their time and his—a recrudescence of the old doubt about the wisdom of retaining in college those who will not respond to the demands of a severe intellectual standard, since it is quite uncertain whether such an experience does the trifler a world of good, and altogether likely that his presence does his comrades considerable harm.

At any rate, those who take the honest view of the intellectual life of a college need hardly worry at present about the defense of their position; they need only to proclaim their faith and await results. If they are not rewarded by a distinct increase in the respect felt for them by the community, they may then begin to doubt the wisdom of their choice. Meantime it is important for them to seek to impress more clearly upon their students the value and charm of hard mental labor. Some youngsters may have to take this value on faith for a time; but, even so, we need not wait for these lofty young gentlemen to begin hard work of their own spontaneous choice. Diligence and interest, however, are likely to come hand in hand; where there is a high standard set there is apt to be developed sufficient comprehension of the subject to make it interesting, and interest spurs to effort. After all, why should there not be a real pleasure, even for a normal American boy, in the growth of the mental powers and in the acquisition of interesting and useful knowledge? Is it preposterous to assume that a healthy-minded undergraduate should be interested in the great thoughts of the ancients and of the moderns, in the mysteries of biology and of physics, in the great creations of art and of literature? If your college student be wholly unresponsive to these stimuli, is it not more or less questionable whether he deserves a place in an educational institution, no matter how delightful he may be as a club mate? To be sure, real attainment of any kind—even in athletics—involves drudgery and discipline; but this condition does not preclude the possibility of a large amount of enthusiasm in the class-room as well as on the field, when once the business of the former shall be taken seriously. And when we remember the microscopic amount of work that now meets requirements in some of our most distinguished colleges, it would not seem to indicate abnormal cruelty on the part of the faculties if they should take a stand for a distinctly more strenuous working day and the benefits to be derived therefrom.

There are, of course, two obvious ways of keeping up our standard —inspiration and compulsion. A few students will respond to the former alone, but for far too many it is—at present, at least—a mere question of "the amount of neglect of his studies permitted an undergraduate without interruption of the privilege of residence." As Dean Fine said to the Princeton alumni a short time ago:

> The typical boy entering a college like Princeton in these days is much more vitally interested in other boys and in sports than in books. To him the lure of college is not in its studies but in its life. By aid of the preceptorial system and other means we are having a good deal of success in transforming these careless young fellows into fair students. But a considerable proportion of them find the undergraduate life and activities so absorbing that in respect to study they will respond to no other impulse than compulsion.[7]

Like the preceptorial inspiration, this compulsion—to be genuinely valuable—should be exerted continuously and not semi-annually. For the ordinary college course no sort of examination has yet been invented which an intelligent crammer can not circumvent by midnight diligence at the end of the term. The reward of this diligence is not always a mere pass; frequently it is an honor mark. Classmates of a brainy Princeton man will recall his "first group" in psychology after a two-hours' session with some printed notes; others will point to the Harvard tutor who secured an idler a B in zoology as a result of five hours' coaching.[8] To be sure, examinations and even the right sort of cram-

[7] "Innumerable devices to coax boys to work have failed in cases where the one thing needful was to convince them, by the evidence of enforced discipline, that they must work or leave college." W. T. Foster, *op. cit.*, 321.

[8] Both of these statements have been verified by the principals. The first is literally true as it stands; the following letter gives the exact details of the

ming may have their uses; but the essential thing is the gradual growth of intellectual power that comes from steady effort distributed over a long period and from frequent discussions with other alert and informed minds. A course which is satisfied by mere attendance through the term is a sorry affair, no matter how much cramming may be needed to pass the examination. Monthly tests go part way towards decency. But ideal conditions are approached only when some test of regular work may be imposed without warning at any moment and when such tests actually do occur frequently.

In addition to preceptorial encouragement and to compulsion born of administrative courage, it would seem altogether wise and possible to spur to greater scholastic activity by the introduction of flexibility into the time factor in education, demanding of those whose work is below par more frequent class meetings or conferences, and consequently lengthening, if need be, their time in residence by a term or two—in other words by establishing a kind of sliding scale in college requirements, adapted to variations in industry and ability.[9] This is a novel idea but a valid one. Any human attainment is the result of intelligence and effort; diminish either and you diminish the result. Unless we are wholly indifferent to the quality of our result, and are content to gradu-

second case:

"The facts of my sin in psychology are these. When I began that course, I was very much bored, . . . and yielded very easily to the temptation of taking things easily in Junior year. As you may remember, the class was very large, so I changed seats with a man who sat in the back of the room, and I used to spend my time in the lecture room reading. I never did a particle of work in the course during term time. As I remember, there were two examinations in the course, one in October and one in February. Someone in [the class of] '94 or '95 had prepared an excellent printed syllabus of the lecture course and the text-book. Having the power of quick memorizing, I worked hard with this syllabus for a few hours before each examination. Not liking the course, I had no desire for any grade, but merely wanted to pass. To my surprise and the demerit of the lecture system, I found that I had secured a first group in both examinations. I really felt more ashamed of this than if I had failed to pass the examinations, for I had learned little about the really fascinating subject, and cared less.

"If ever there is an argument in favor of Wilson's preceptorial system, it is my record in this course.

"You are perfectly welcome to make use of these facts in any way that you wish."

Sometimes it may happen that local patriots will admit the existence of these bad conditions in a remote period in the past, but such a confession would usually be a mere prelude to an airy assertion of absolute virtuousness at present. As a corrective to such optimism it might be well for the complacent to ask themselves whether they ever joined the reformer in his assault upon *contemporary* evils (during their period of power), and whether their inmost soul really loves progress when it involves merciless criticism of the *status quo*.

9 This proposition is presented in detail by the author in *The Educational Review*, June, 1912.

ate side by side men who are years apart in mental attainment, why do we not endeavor to lessen the gap? Why do we not administer to weaker students smaller and more frequent doses of each subject even though we should thus lengthen their time of residence? If this were done we should have something like a standard, and men would know that they will be kept in the mill until their grist is ground. Then professorial inspiration and compulsion would assume a totally different significance; for, in the last analysis, they would be but spurs. The ultimate cause of prompt success in winning the degree would be the student's own quality.

THE PROTECTION OF DOMESTICATED ANIMALS

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ALTHOUGH we depend to a large degree upon lower animals for food and clothing, the necessity for their protection and the best methods of caring for them do not seem to be fully appreciated. If the Biblical statement concerning the creation is accepted as it is usually interpreted, namely, that man is the foreordained master over dumb creation, our responsibility for its protection is clear. Starting from early time, it is easy to understand that as the human family multiplied it came to require, as it does to-day, a large part of the earth's surface for its activities, thereby exterminating some species of animals and forcing others from a life of natural independence in forest and plain to one dependent upon the action of man. In the evolution of civilization the animals that were needed by the human family were subjected to conditions of life foreign to their original existence and to some extent contrary to their natural instincts. Thus they have been, for no fault of their own, driven from the freedom of the wild to become the property of man, to be bred, to be fed and housed, to be protected or maltreated according to the will of their owners. They are in a certain sense our slaves and must from their very nature continue as such. There is, however, a growing feeling that the hardships which often accompany their servitude should be lessened. There is a demand for their emancipation from the heartless treatment of cruel men. The spirit that is permeating the hearts of people relative to the humane treatment of animals was expressed in the somewhat homely statement of a negro in New Orleans when he first saw an electric car and was told that it came from Boston. "Law me! The Yankee came down and freed the 'niggers' and now he comes down and frees the mules."

An important element that exerts a strong influence toward the better care of dumb creation is a genuine affection which exists on the part of many people for their animals. The devotion of animals to their masters often touches the heart of man and impels him to a humane treatment of his charges. In caring for them it is well to remember that many of the kindest acts from the human standpoint are often out of harmony with the nature of the animals receiving such attention. This frequently results in disease, suffering and death where only health and physical comfort were intended. Many a lad caresses his dog and feeds it the best of his sweets without realizing how much the poor dog longs for a bone.

In pointing out the reasons why domesticated animals should have better treatment and in considering the means or methods of obtaining for them more complete and efficient protection it is necessary to take into account several somewhat distinct topics, namely:

1. The value of domesticated animals as servants of man and producers of food and clothing for the human family,

2. The sanitary significance of the diseases of animals communicable to man, and

3. The methods best adapted to afford them better conditions of life as determined by the accumulation of knowledge concerning their hygienic and physiological requirements.

If we consider the place animals actually occupy as servants of man and as factors in our economic and living conditions we shall at once recognize the necessity for their proper protection. The dog, ox and horse have served as the great burden bearers in nearly if not all the important industries that have to do with the production and distribution of food. This service will continue to be important. In 1873, when this country was swept with an epizootic among horses, commerce was paralyzed, crops were unharvested, and had this disease been of long duration much human suffering would have prevailed.

The value of animals in the food-producing and other industries can perhaps be best understood from a few statistics concerning the place of animals and animal products in agriculture. The agricultural products of New York state for 1911 were valued at $350,000,000 of which $141,000,000, or nearly two fifths, of the total was of animal origin. More than this, the hay and forage, which constitute one third of the vegetable products of the state, are valuable only because of animals. In Massachusetts, of the annual farm production of $59,000,000, $27,000,000 are credited to animals and dairy products. If we take the United States as a whole, we find that in 1910 the total annual income from agriculture was $8,500,000,000 of which $3,000,000,000, or more than 35 per cent., belongs to the animal kingdom.

It is difficult to appreciate the magnitude of the animal industry of this country. The last census report states that there were in the United States 24,148,580 horses; 61,803,866 cattle, of which 20,625,432 were milch cows; 52,447,861 sheep and lambs; 58,185,676 swine and 292,880,000 fowls. Although these numbers are large, the report shows a decrease since 1900 of 3,485,971 beef cattle, 8,011,326 sheep and 4,682,000 swine. There has been an increase in the number of dairy cows, horses and poultry. The total value of farm animals in 1910 was $5,296,422,000 or about 12 per cent. of the value of all farm property, including land, buildings and equipment ($40,991,000,000).

The report of the chief of the Bureau of Animal Industry shows that the federal meat inspectors in 1911 passed for food 52,776, 855 carcasses of cattle, sheep and swine. In addition to the fresh meat consumed, there were processed under inspection 6,934,233,214 pounds of meat and meat products. This enormous quantity is only the part that came under federal inspection in 936 establishments located in 255 cities. It is estimated that the packing houses having federal inspection kill only about 60 per cent. of the animals that are used annually for food. Of the remaining 40 per cent. about one half is under municipal or state inspection and the remainder is judged by the butchers only. It is not necessary to go further into figures to emphasize the importance of domesticated animals in the business of the country and their more personal value to us as producers of food and clothing.

In addition to the burden-bearing and the food-producing animals, the pets in dumb creation can not be ignored. The bird, cat and dog have gained a recognized place among the objects of human interest. The breeding of the best species and varieties of these animals has become a large industry. Veterinarians who are specializing in the diseases of pet animals are becoming numerous and many of them have large and well-appointed hospitals.

An investment of such vital importance to mankind as that in domesticated animals should be looked after in a business-like manner. Yet we find in this country that the conditions which tend toward the efficiency and comfort of animals are far from ideal. The necessary precautions by way of food and shelter to safeguard animals against general diseases and to protect them from various forms of infection are not observed by animal owners as fully as would be expected from the present knowledge of those subjects. The losses from disease resulting directly from the lack of such protection are estimated at between three and four hundred millions of dollars annually. Besides this enormous financial waste there is the physical suffering and death of hundreds of thousands of animals. These losses are of more significance than even their totals suggest. The death of a few hens, a hog or a milch cow means but little to the country, as a whole, but to the unfortunate owner it brings not infrequently positive privation. Of productive property there is none more widely distributed among the poor than fowls, swine and milch cows. In thousands of instances these animals constitute the only source of income. When they fall victims of disease, the suffering of their owners for want of food and clothing is often more severe than can be appreciated or understood by those who have not witnessed it. These losses, therefore, in addition to their effect upon the economics of the nation, have a very direct influence upon the physical well-being of thousands of people. The difficulty does not stop here, for the spread of the diseases themselves from animal to man has been the cause of much suffering and many deaths in the human family.

The interrelation of the diseases of man and animals has been the subject of many researches, dissertations, laws and regulations. The Mosaic laws are among the earliest of those for protecting man against infection from animals. In these it is not clear whether or not the regulations against the use of meat from animals affected with certain diseases were based on the observation that such carcasses were injurious to the consumer or on a religious rite of a somewhat indefinite origin. From the earliest times certain disorders of the human family have been attributed with more or less evidence to infection from animals.

The discoveries of recent years have shown that the specific cause or microorganisms that produce certain transmissible diseases will attack both man and one or more species of lower animals. The most common of these microorganisms are those of glanders, rabies and tuberculosis, although anthrax, cowpox and foot-and-mouth diseases are not infrequently transmitted directly from cattle to man. The studies that have been made concerning the identity of human and animal diseases and the channels through which the infecting microorganisms pass from one species to another have indicated very clearly the limitations of the intercommunicability of disease between man and animals. It has been shown that the channels of infection render it relatively easy for the virus of a few diseases to pass from infected animals to their attendants, but that the reverse is not necessarily true. Thus, there are reported many cases of anthrax, glanders and rabies in man that were caused by direct infection from diseased animals. The cases are very rare where animals have been infected with these diseases from man. This is not because the virus is unable to infect animals, but because from the nature of things the opportunity for it to pass from infected people to animals does not usually exist. There seems to be a popular misunderstanding on this subject. Let me illustrate by rabies. A mad dog may bite several persons, some or all of whom may develop rabies, or hydrophobia, and die. Dogs or other animals are not infected in turn by rabid people. If, however, animals should be properly inoculated with the brain of a person who had died of rabies they would develop the disease and die. The natural method of infection in rabies is through the bite of the infected individual. An instinct of the dog is to bite and when rabid this natural tendency is accentuated, and consequently many dogs, other animals and people may become infected. Biting is not a dominant instinct of man and consequently the rabid person is not liable to bite dogs or other animals. More than this, his environment prevents him from doing so. While the possibility of transmitting the disease exists, experience shows that animals are rarely, if ever, infected with rabies from man. In like manner, anthrax and glanders may be transmitted from animals to their attendants or to those who may examine their dead bodies, but the infected man does not usually come into contact with the animals in such a way that the virus can escape to them. It is natural that man should attend his animals when they are sick, but when he himself is afflicted he does not, as a rule, look after his flocks. In former times there were large numbers of people infected with anthrax, which they contracted from handling the wool taken from sheep that had died of that disease; likewise many were infected with foot-and-mouth disease which was transmitted to them through the milk of infected cows. There are a few reports that diphtheria has been contracted by the pet cat from the sick child; that birds, especially parrots, have contracted tuberculosis from their attendants; and that poliomyelitis has been transmitted to dogs; but these reports are few in number. There is considerable literature on the transmission of tuberculosis from man to fowls, but the evidence is largely circumstantial. In recent years, large quantities of human tuberculous material have been fed to fowls with negative results. In like manner, the reports of the transmission of tuberculosis from man to cattle are based on circumstantial evidence, and they were made before the knowledge of the varieties of tubercle bacteria had been acquired.

In addition to the infectious diseases, there are a number of parasites which infest people through the medium of pet animals and meat.

The facts seem to be clear that the danger in the inter-communicability of diseases is from animals to man and not from man to animals. This means that in the protection of animals they should be cared for in such a way that their diseases can not pass from one to another, and that those who attend diseased animals should take the necessary precautions to protect themselves. The very definite knowledge of the cause of the communicable diseases makes it possible to minimize the danger to man in caring for infected animals.

To be able to properly care for animals one must understand their physiological requirements. For economic reasons several species of animals have become so numerous and so restricted in their liberties that they must rely entirely upon man to furnish them food and shelter. Presumably they have lost, through continuous living in an artificial environment, much of their original sagacity for self-preservation, and it is not unlikely that they are acquiring a certain amount of adaptation to the new conditions. This intensifies the necessity of inquiring into the best methods to follow in order to give dumb creation the physical protection that rightly belongs to it.

The protection of animals is not different in principle from the protection of man. The problems encountered are similar to those in ascertaining what is best for the physical well-being of the human species. If we could trace the evolution of the present knowledge of hygiene and the physiological requirements of man from his early existence until now, we should find that the influences most effective in bringing about our present conception of living conditions are the results of the study of those physical and biological sciences which combined make up what is known as the medical curriculum. These sciences have interpreted the needs of the body and brought to our assistance the best we now possess of hygiene and the care of the sick and injured. In like manner the best we know of the nature, care and protection of animals has been derived from the study of the same group of sciences, which are those that make up the veterinary curriculum. We must remember, however, that the care of animals, like that of children, will be guided by the knowledge of those who have them in charge. The task, therefore, is to provide adequate means for ascertaining the nature of the different species and their physiological needs and to have this knowledge made available for and acquired by the owners and caretakers of animals.

The work that is being done in the state experiment stations and agricultural colleges in testing various kinds of forage and food rations is bringing into practical form the results obtained by chemists and physiologists relative to the nutritive needs of different animals. These same institutions are investigating the questions of ventilation, stabling, exercise and other topics pertaining to the best possible care of the healthy animal.

The results of these experiments are published in bulletins for free distribution. Consequently it is possible for all animal owners to profit by the findings.

With animals, as with man, it is the sick and injured that suffer most in the absence of skilled attendants. This fact was observed by Claude Bourgelat who in 1762 established the first veterinary college in the world at Lyons, France. He recognized the need of men trained in the care of injured and diseased horses in the cavalry. He believed that men could be educated in these lines and that a new profession could be developed for the purpose of caring for afflicted animals. A little later there was established a second veterinary school at Alfort with the additional purpose of studying methods to prevent the epizootic diseases that were devastating the animal world. Then other schools arose until a large number of well-equipped veterinary colleges were established in Europe. In this country there are now twenty-one veterinary colleges, of which seven receive state support.

In 1884 the Bureau of Animal Industry was established in the United States Department of Agriculture for researches into the nature of animal diseases. Again, state boards of health and live stock sanitary boards are studying the same subjects. Thus we have in this country institutions to inquire into the nature of the diseases of animals for the purpose of devising methods for preventing them and veterinary colleges to teach men how to treat and to care for the sick and injured. The value of veterinary colleges in this connection is just beginning to be recognized. Until recently little money was available for this purpose and consequently the work was restricted to the teaching of veterinary medicine and surgery in a very narrow sense. During the last few years, however, more funds have been available for this work and much has been done to improve the teaching of veterinary medicine both in treatment and in general hygiene.

As an illustration, perhaps the most important advance in the humane treatment of suffering animals has been in the use of anesthetics. Formerly all operations were performed on animals without the use of any agent to deaden pain. To a considerable degree that practise is continued, but the more progressive surgeons use ether, chloroform, ether cocaine or other general or local anesthetics in painful operations. This is one of the blessings modern surgery has brought to dumb creation. The use of antiseptics in veterinary surgery is saving many animals from the painful and serious consequences of wound infection. The methods of restraining animals for operation are also being improved. Veterinary hospitals are increasing in number and popularity so that animals are receiving more humane treatment when it is necessary for them to come under the surgeon's knife. A like interest is being taken in the advancement of internal medicine. Methods of nursing sick animals that will give to the patient the greatest comfort possible are coming into use. The treatment in veterinary medicine is becoming as rational and as scientific as it is in human medicine. The unwarranted medications for animals that were reported in former times are rapidly disappearing.

With the development of the work in veterinary colleges, all will be done that is possible by way of teaching efficient and humane methods of treatment. However, in the application of modern methods in veterinary medicine there are serious difficulties to be overcome. The veterinarian needs the moral support of the public in applying his art. The condition confronting him is complicated. The afflicted animal is conscious of pain. The operation necessary to restore it to usefulness is severe. The operator equips himself with disinfectants, sterilized instruments and proper dressings. Thus prepared he meets the owner. Shall the animal be restrained in the quickest way possible and operated upon without an anesthetic or shall the comfort of the animal be considered? Here the responsibility of the owner enters, for it is he who orders the work to be done and it is he who bears the expense. The use of anesthetics involves additional cost that some one must pay. It is in this particular that the efforts of the veterinarian to minimize suffering are often checked. What is true of surgery applies to medicine when the proper care calls for additional expense. As the worth of the patient is usually measured in dollars, the amount to be expended for its recovery has its limitations. But a strong effort for humane treatment on the part of practitioners is tending to adjust many of these differences. However, society should take a positive stand on this subject in order to encourage those who are striving for better and more humane methods in treating sick and injured animals. A veterinarian of my acquaintance recently received, in addition to his fee, a very substantial check from an appreciative client to enable him to use anesthetics on animals whose owners would not pay for it.

This brings us to a very troublesome subject in the protection of animals, namely, the disposition of worn-out horses, homeless cats and dogs and the hopelessly injured. The humane impulse is to destroy them at once. This, so far as we can determine, is the proper course to pursue. It is believed that death is preferable to continued suffering. The question arises, how shall the animal be destroyed? Individuals, and even societies for the prevention of cruelty, frequently impose a method of execution that is not always the easiest for the animals to endure. The insistence upon the use of some anesthetic often imposes upon the animal a more disagreeable death than a well-directed bullet would cause. Yet we often find this and other methods of painless destruction excluded. It would seem that when it is decided that an animal is to be killed the method should be chosen that will give the least suffering.

The slaughter of animals for human food is a disagreeable task, but one that must be performed so long as meat is used. Many investigations have been made to determine the method that will dispatch the animal with the least fright and pain. The conclusion prevails that with cattle at least the most humane method is to stun them before bleeding. This method is observed except in those packing houses where for religious reasons the methods of the ancients are still observed. It is gratifying to note that in one city through the efforts of the humane society and the federal meat inspection, many of the cruelties of the "Kosher" killing have been minimized. In justice to the large packers it should be stated that they welcome any improvement along these lines. If we are consistent in our contention that domesticated animals should be cared for in a humane manner, should not their slaughter, which is for man's benefit, be as easy and painless as it is possible to make it? With the development of new knowledge and better methods many religious rites have been modified. It is hoped that in the near future the Jewish methods of slaughtering animals that have been handed down from early days to the present may in like manner be subjected to certain revisions. As I have already stated, the cruelties of the method have been minimized in one city. Certainly these changes should be made general. Our people can not be too much in earnest relative to the enforcement of methods of slaughter that will protect as far as possible innocent animals from unnecessary pain. This applies not only to the procedures in the larger packing houses, but also to the small butcher and the individual owner who now and then kills animals for food. In the methods of all these there are opportunities for improvement.

In the protection of animals there is need for a more efficient service in the eradication of infectious and epizootic diseases. Advancement is being rapidly made, but before the desired results can be attained much additional knowledge must be acquired. Those engaged in this kind of investigation are constantly encountering difficulties by way of limited facilities and funds. The greatest danger, however, that threatens progress in the prevention of disease is the propaganda against vivisection. The time has passed when unnecessary pain is to be tolerated in experimental work. The men and women who are engaged in work requiring the use of animals are sensible of their discomforts. Nevertheless, in the grim warfare against suffering and disease it is often necessary to utilize a few animals for diagnosis. A larger number are required for the preparation of serums and vaccines for therapeutic and immunizing purposes. No one fails to appreciate the importance of minimizing the number of deaths among animals, thereby checking the unnecessary loss from disease. To accomplish this it is sometimes necessary to sacrifice a few individuals in order that epizootics may be checked. In all great crises the lives of a few have been willingly sacrificed in order to save the many. Thus the few animals that were used in the investigation of the nature of Texas fever in cattle and the means by which its virus is transmitted have saved thousands and thousands of cattle from suffering and death from that disease. It is to be hoped that eventually science may give us a substitute for experimental animals. However, the protection against disease that is afforded the flocks and herds of our country warrants the most hearty and loyal support of the principles underlying the present methods of control.

It is impossible in the limits of a single article to discuss adequately all of the essential factors involved in bringing about the desired protection of domesticated animals. Great improvement has been made in the methods usually referred to under the term of the care of animals, such as gentle handling, proper exercise, suitable food and shelter. Betterments along these lines will be made as fast as the acquisition of new knowledge of their physiological requirements permits. Better care of the sick and injured will follow as fast as the owners come to a realization of their obligations to their animals. The suffering and losses from infectious and epizootic diseases will decrease in direct proportion to the application of rational methods for their prevention. The organized efforts to do away with cruelty are more rational and more effective because they are based on scientific principles. The ideal conditions to be attained will come only through the growth of knowledge of the requirements of animals and a deeper consciousness of man's responsibility over dumb creation.

THE FORESTS AND FORESTRY OF GERMANY

By Professor WILLIAM R. LAZENBY
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DURING the past year I have had the rare opportunity to observe the forests and to learn something of the general forest policy of various European countries. My interest in this subject prompts me to present a few notes. I am glad to do this because in this country the subject of forestry is now claiming, and is bound to receive, greater attention than has heretofore been given to it.

The increasing scarcity of timber within the first half of the second century of our nation's history, in spite of the variety and richness of its sylva and extent of its primitive woodland, is a condition that calls for earnest consideration and should invoke the interest of every public-spirited citizen. From the standpoint of administration and thorough system the German forest service is not paralleled elsewhere, and its intensive development is nowhere surpassed. Such being the fact, I shall confine myself mainly to what I have seen in Germany.

Why has Germany developed a more systematic, a more advanced forest policy than any other nation? Let us briefly consider. In the first place, it should be clearly understood that the German empire in its federal capacity has nothing whatever to do with its forests. The control of the forests is exclusively in the hands of the various states, which in their confederated form make the nation called Germany. Each state government directs the forest policy of its own state and the national government has never interfered in any way or manner with this procedure.

Speaking of Germany as a whole, the great impetus to a general forestry movement was received about 1750. At that time the population was rapidly increasing and nearly all of the strictly agricultural land had been cleared. Coal had not then been discovered, or was not available for use. There was no fuel, oil or gas, comparatively little peat, and no means of transporting fuel wood from the mountain forests. A succession of winters of unusual severity caused much suffering and the imminence of a general fuel famine stared the people in the face. From this time the art of forestry developed with great rapidity. Everybody was interested because everybody needed fuel. Within a comparatively short time most of the state governments had formulated some forest policy, the principal feature being an effort to secure a continuously sustained yield of fuel wood and timber from all forest lands. One fundamental principle was that no more wood

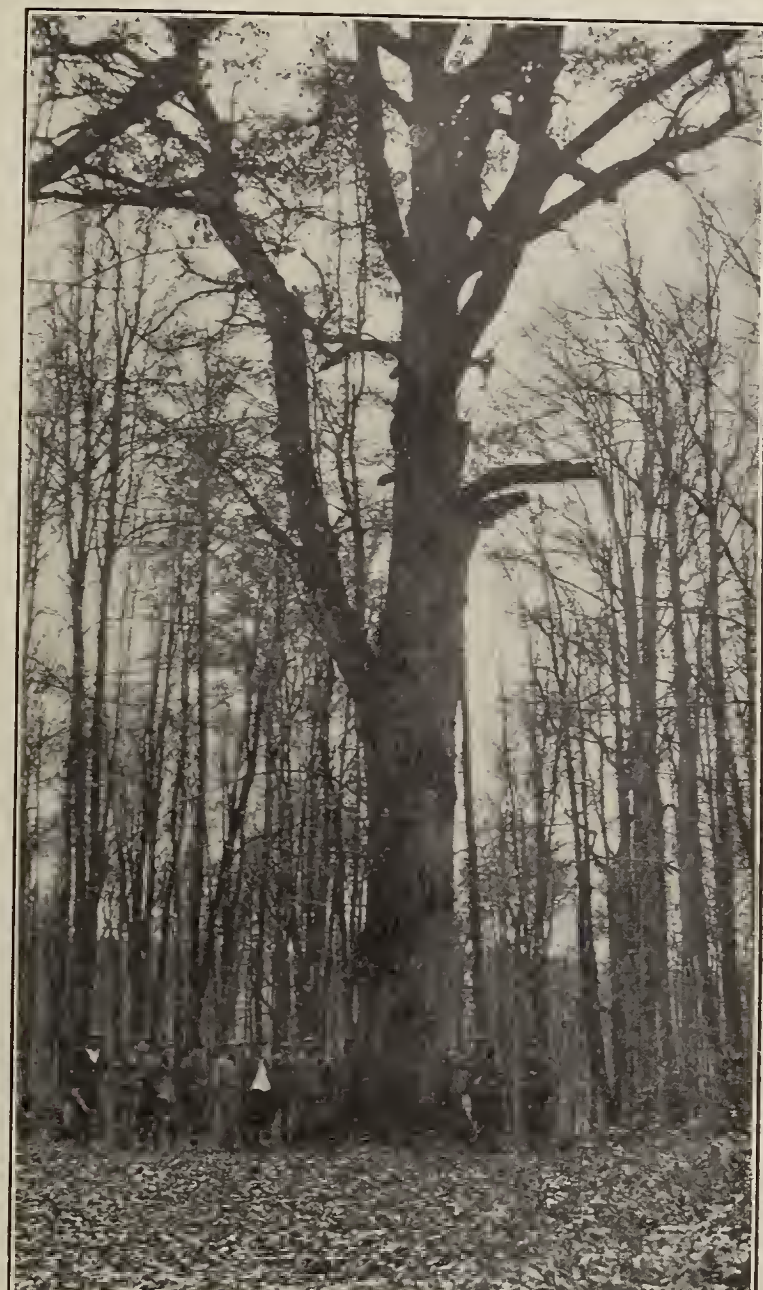
Fine Growth of Spruce near Kronach, Germany. A Sliding Road in the Forest.

should be cut in any one year than was produced the same year. After the coal mines were opened and with the better means of transportation, all fear of a fuel famine passed away, but the practise and conception of conservative, as well as constructive forestry, had taken such a deep hold upon the public mind, that it is small wonder the art has reached a stage of intensive development that no other nation can rival. Through generations of practical tests and experiments, with many failures at first, but with a persistency worthy of the cause and characteristic of the race, German sylviculture has attained a high degree of perfection. Attention is called to a few typical forest areas that were among those visited by the writer.

Spruce and Fir Stand in a Typical German Forest.

The Frankenwald in northern Bavaria is famous for its spruce and fir. The forests of this region are regenerated from self-sown seeds and the system which is carried out with signal regularity is simple to understand and easy to work. It may be said in passing that it produces a marvelously beautiful landscape, one that can not fail to appeal to every lover of nature. The system permits of no clear cutting, so that the harvesting and the growing of trees go hand in hand. Frankenwald is a rugged region, and the hills with their steep acclivities are cut out, or cut over in strips about 300 feet wide. The strips run with the contour, and the logging is started at the top of the hills and thence proceeds downward to the valleys. Thus the second growth is situated above the old growth, and is not further damaged by the continuance of the logging operations. The rotation is 120 years, and at this age the trees average about 15 inches in diameter, and usually cut four logs to the tree. The logs are sent down dirt chutes known as "Lassen." The valleys of the Frankenwald visited are drained by three main creeks, uniting near the old town of Kronach. These creeks are used for transportation, and drives of logs, as well as small rafts, have come down them for hundreds of years. I was fortunate enough to witness the driving and splashing operations, and followed the logs to the mills located along the river.

Another of the large state forests of Bavaria is that of the Spessart Mountains, near Rohrbrun. This is one of the regions where the Bavarian kings and other royal sportsmen are wont to hunt the wild boar. The white oak of this particular forest, which appears to be identical with the English white oak, is justly famous throughout the world. So fine and even is its texture that it yields oak veneer logs of the highest value. Although there is a large amount of this timber, the owner, which in this case is the state of Bavaria, or the whole people, absolutely refuses to sell more than a small annual percentage of the entire stumpage. In this way what appears to be phenomenal prices are secured. For illustration, the price of prime oak logs in the woods, twelve to eighteen miles from a railway, has now reached an average figure of $280 per thousand feet, board measure. Please note that this is the average. The very best logs are selling at $585 per thousand feet board measure. As one who has a hearty love for trees, and one who appreciates the quiet, persistent, marvelous forces of nature set in operation by their growth and development, I felt like taking off my hat when I saw specimens of these oak trees that had individually a cash value in the market of more than a thousand dollars. Under these conditions it is readily understood why the state is eager to reproduce this oak by all means at its command. As 1911 happened to be an unusually good so-called "oak mast year," the writer had the good fortune to see something of the energetic activities of the



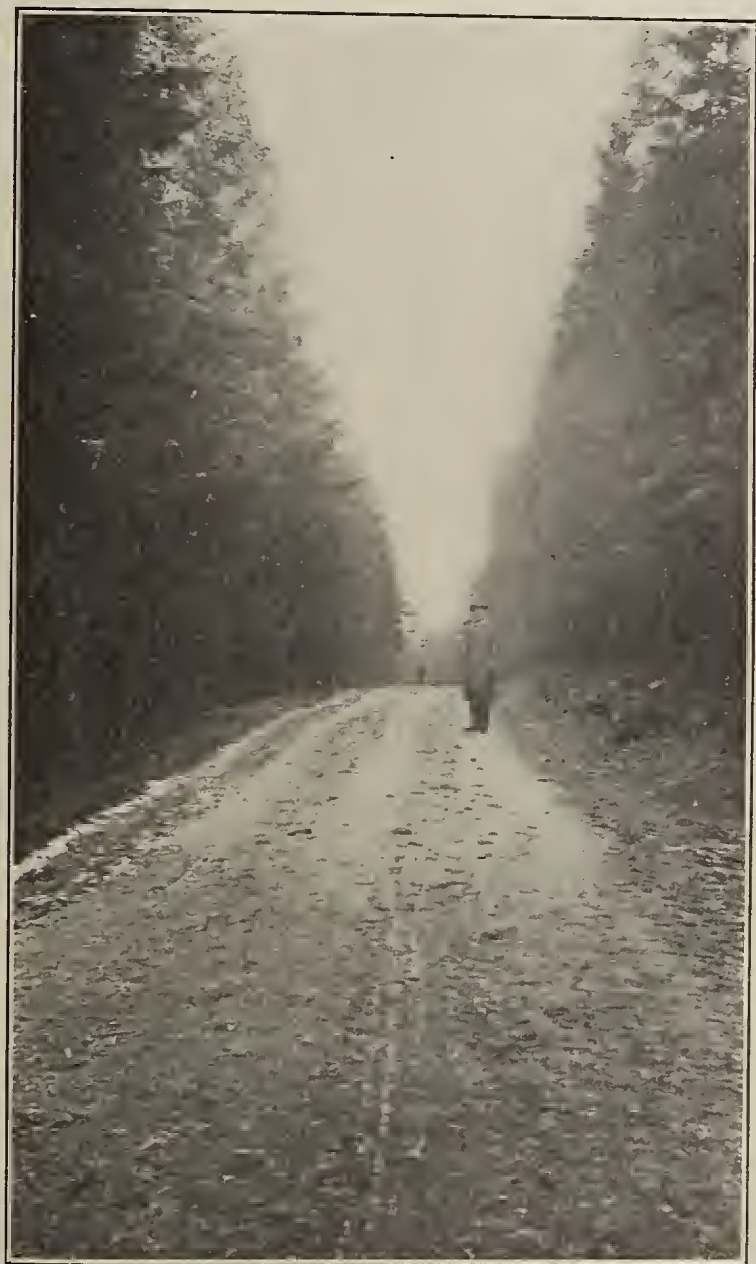
What is Called the 'Thousand-year Oak," left as a memorial or curiosity, Spessarto Mts., Bavaria, Germany.

Bavarian foresters in this line of work. Hundreds of acres were thickly planted with white oak acorns, and more hundreds of extra employees were kept busy for six weeks to take full advantage of an infrequent but blessed mast year.

Probably no state has developed a more intensive forestry system, or has done more to place forestry on a sound financial basis than Saxony. This has been due to several causes. Among these may be mentioned, first, the individual work of Heinrich Von Cotta; who is justly regarded as the greatest forester that the world has seen. Second, the forest school at Tharandt, which was founded by Von Cotta in 1811, and is the first technical forestry school ever established. It has always stood in the front rank of forest schools. Again, the forestry of Saxony is associated with, and has been largely influenced by, Dr. Max Pressler, the father of forest finance and the inventor of many efficient forest implements.

The average rate of revenue from all the state forests of Saxony is close to 2½ per cent. It should not be forgotten that the Saxon forests have gradually risen in value during the past 100 years at an annual rate of 3 per cent.; that is, the total income, counting both cash returns and latent revenue, amounts to 5½ per cent. One of the largest and most progressive lumbermen in the United States has declared he could not see a cash revenue of more than 2 per cent. in forest growth in our country under the most favorable conditions. The lesson from the experience of Germany is that conservative forestry is fairly remunerative at least, when the price of stumpage increases steadily. At present the most all-around valuable timber species in Saxony is the spruce. There is practically an unlimited demand for this wood in the rapidly developing local industries. The spruce is raised in a rotation of 80 years. Clear cutting is practised and the succeeding crops are started by transplanting seedlings from the nurseries. The expense of planting (outplanting) averages about $10 per acre. The Saxon forester, instead of concentrating his logging operations and the subsequent replantings in one place, has a large number of cutting series; that is, he removes a small strip of the oldest trees in each of a large number of places at short intervals of time. Although this increases the cost of logging, the advantages are more than balanced by a lessened loss by windfall in the older stands, and better conditions in way of shade and moisture, decrease of insect injury, etc., for the young plantations. Owing to the short rotation the trees in the Saxon forests are much smaller than are usually seen in Germany. Inasmuch as small timber, saplings and poles, are in great demand, it is found that the smaller sizes are more remunerative investment than the larger trees of a longer rotation.

As an example of a completely rejuvenated forest, the one owned and operated by the city of Heidelberg presents an impressive illustration. A little more than a century ago, this forest, which is on absolute forest or non-agricultural land, was a worthless wilderness. The few straggling trees were decrepit and diseased. The whole forest had been practically ruined, by the combined action of fire, pasturing and reckless cuttings. To-day there are few better or more remunerative forests in Germany. It is an interesting picture, and shows what the art of foresty can accomplish when based on the principles, and operated by the methods, of science. There was one feature of this forest that presented a peculiarly interesting, not to say fascinating, picture to an American forester. It was some experimental plantations of American trees begun some 30 years ago. In these plantations, as they are seen to-day, are fine stands of Douglas fir, Engleman spruce, Western cedar, hemlock, white pine and many other American species. Careful measurement of the annual growth of these trees have been



A Forest Macadam Road in a Saxony Forest, showing a fine growth of Spruce on either side near Swartzenberg, Saxony.

taken. The results are equally interesting and instructive. In 1911 the increment per acre, including the branchwood, was, for the Douglas fir, something over two cords, and that of the hemlock was a little more than three cords, while the white pine, which stood the highest on the list, gave a yield of very close to four cords per acre. Whether these remarkable figures of productiveness will be maintained we can not say. We can say, however, that the German foresters are watching this experiment with lively interest.

No report of German forestry and forests, however brief, could omit to make some mention of the Schwarzwald; one of the most famous forests of southern Germany, commonly known as the "Black Forest." This is a region of enchantment, the recreation ground of Europe, and the delight of all visitors. Here one comes in contact with new economic conditions, new silvicultural types and new ideas in the utilization of forests. While esthetics and sentiment are coming to play an important rôle, the purely commercial aspect of the production of timber is not overlooked. Not many years ago this was the wilderness of Germany. Destructive forestry, not unlike the past, and for the most part even present, American methods of lumbering, was practised in the Black Forest. I visited the holdings of a forest stock company with an historical record covering more than 300 years. In the early days splash dams were made in the rocky, turbulent streams, and the accessible timber was removed and splashed down to the mills located on the river Rhine. The waste was enormous. Since the advent of the railways conditions have changed. The whole forest is a network of excellent macadam and skidding roads. Destructive forestry has given place first to conservative, and then to constructive forestry. The advance of stumpage prices and the introduction of better forestry methods are rewarded by increased revenue. The net income from some of the holdings of this great forest area is better than that of any other forest that I have had the pleasure of visiting. The regeneration is all by natural seeding, and planting is only practised in case of severe windfalls or necessary clear cutting. The two prevalent types of natural reseeding are what are technically called "shelterwood compartment type" and "selection cutting."

In the first type, the regeneration is carried on over large areas, and the standing seeding and shelter trees are removed gradually during a period of from 40 to 50 years. In the "selection cutting type" the regeneration is in patches and the process of seeding is continuous. That type is selected that is best adapted to the prevailing local conditions. The logging operations in some parts of the Black Forest are unique. On the steep slopes the large logs, scaling from 600 to 1,000 board feet, are let down to the roads by means of a long rope one end of which is wound a few times around a near-by standing tree and then fastened to the large end of the log, by a strong ringed spike. The log is started and the rope is drawn around the tree. The man or men who play out the rope hold it loosely or tightly, according to the weight of the log and the steepness of the descent, and the velocity of the log is under perfect control. The logs are guided past the trees and rocks that may be in their way by woodsmen who are both active and expert in this work.

Group of American Forest Students and German Oberförsters in a German State Forest.

Even in Germany the forester has his troubles. There are still difficulties to overcome, and more or less serious questions to face. I became acquainted with one of the problems of the Saxon state forest. This was near Schwarzenberg, practically in the manufacturing center of Saxony. Here the damage done by the sulphur fumes and other poisonous gases that came from the smokestacks of numerous factories is enormous. No wonder the Oberforster was embarrassed, for the condition of a large area of the forest under his charge was desperate. Trees, dead and dying by the thousands. Fortunately, being of true German pluck and persistency he was not discouraged. He was making some well-directed experiments to determine the species least susceptible to smoke and poisonous fumes. It is now well known that conifers are more affected than broad-leaf species, and that the spruce is the most sensitive of the conifers. This later species is being removed as fast as possible and hardwood species are being substituted. Dr. Wislicenus, of the Saxon forest school at Tharandt, who is a distinguished investigator, has devised a perforated smokestack which he believes will greatly lessen the injury caused by smoke, sulphur fumes and other injurious gases.

Another difficulty of which many foresters bitterly complain is the injury done to seedlings and young trees by deer, rabbits and other forms of wild game. It is true that the revenue from the hunting licenses offset the injury in some degree, yet the absolute loss is often serious and irreparable. All known methods of efficient protection are expensive.

In some states the greatest difficulty of all lies in the exercise of certain prescriptive rights that are held and exercised by the common people. These rights include the pasturage of domestic animals, the removal of stumps and certain amount of brushwood, the removal of forest litter, etc. These inherited rights are being bought up as rapidly as possible, and the exercise of them is discouraged in every way. In many places where fully exercised anything like modern constructive forestry is impossible.

Still good will sometimes comes from what is generally regarded as evil. In a fine forest near Ysenburg, the ravages of the larva of the June bug made it impossible to plant successfully the seedlings of the pine in the areas to be reforested. It was found that the soil cover of these areas, which had been removed by the inhabitants, and the presence of an unusually large number of hogs, all due to certain prescriptive rights, were the main influences in causing a thoroughly successful natural seed regeneration. Thus was accomplished what had been regarded as impossible.

The financial success of German forestry depends mainly upon two factors. First, good means of transportation, and, second, the owners, whether they be states, cities, royal families, communities, associations or private individuals, only sell annually about the amount of wood that is produced each year. By so doing the market is never overstocked, the demand is always greater than the supply, and the price is kept above the cost of production. The German forest policy aims to reforest all waste or non-agricultural lands, and to gradually increase the forest area under direct state control. It aims to furnish good means of education and training in forestry at the state expense. It is seeking to extend the best possible means of protection, both from animate and inanimate enemies over all forest lands.

Another feature that we may well imitate is to encourage the largest public use of all forests as a means of health, recreation and enjoyment for all the people. While American forestry should not be content to merely follow European methods and teachings, if we would be really progressive, our leaders must acquaint themselves with the best achievements elsewhere, and up to this time no nation can show such results as Germany.

THE HISTORY OF OHM'S LAW

BY PROFESSOR JOHN C. SHEDD, OLIVET COLLEGE AND MAYO D. HERSHEY, U. S. BUREAU OF STANDARDS

Introduction

IN the historical development of any branch of science three steps may generally be traced. *First,* there is the growth, frequently in disconnected masses, of a body of data. A few of the more readily grasped

Dr. G. S. Ohm.

facts may find quantitative expression. These formulæ, whether expressed in words or in mathematical terms, prepare the way for the *second* stage, in which investigation is directed toward the discovery of connecting links between otherwise isolated observations. This inductive process of framing and testing hypotheses ends with that comprehensive generalization in concise mathematical form which constitutes a "fundamental" law. The *third* and final stage comprises the deductive application of the newly discovered law to the prediction of new phenomena. The first stage is generally the longest, the second the most contradictory and difficult, while the third is the most fruitful and may perhaps be regarded as the most interesting.

The branch of electrical science to which Ohm's law belongs is now so well advanced into the third stage, into which it may be regarded as having been ushered by Clerk Maxwell, that it is difficult to look back to stages one or two. Yet eighty-five years ago the theory of electricity was in the first stage, and the years from 1825 to 1860, in some respects, mark the limits of the second. This period includes Ohm's work and that of his immediate successors.

Ohm's work was made possible by the discoveries of Galvani, Volta, Oersted, Ampère, Seebeck and others, whose researches had so broadened the knowledge of phenomena connected with the galvanic circuit as to show the probability of a connecting theory. The formulation of such a connecting theory is the task to which Ohm set himself, approaching the problem from the experimental side. The workers of the early nineteenth century had already in a measure identified and separated the factors at play in the galvanic circuit. Examples of such factors are: the "contact force" at the terminals of the circuit, the "flow of current" along the wire, the "electroscopic force" between any two points of a circuit, the tendency of electricity to escape into the air, and the polarization of the electrodes. There was, however, a lack of definiteness of ideas, as well as of methods of quantitative measurement.

It is no small task to select the necessary from among the incidental factors and to express their relation in concise form. Upon this achievement rests Ohm's chief claim to fame. This is not, however, his only claim to consideration, for besides establishing the law which bears his name, he devised mathematical methods for determining the distribution of electricity in a complex system of conductors, for both steady and variable currents. He did much in clearing up the conception of such terms as electromotive-force, current and resistance. In fact, he did for Volta what Maxwell later did for Faraday. The contributions of Dr. Ohm to the theory of electricity were therefore many sided. They were accomplished because he was a trained mathematician, a skilled experimenter and a keen, logical thinker. A less trained man could not have completed his work; one less honest would have been misled ere the end was reached. Finally, it is interesting to note that recognition of the value of his labors and of the importance of his law came tardily. Like many others, his work was misunderstood and only late in life did appreciation and the ambition of his youth—a university appointment—fall to his lot.

A complete statement of the law discovered by Dr. Ohm involves two independent propositions as follows:

I. $$E/I = R. \quad (1)$$

In any given circuit, in a steady state, the current I will be directly proportional to the electromotive-force E, and the constant obtained by dividing the latter by the former is termed the resistance of the circuit.

II. $$R = \rho(l/A). \qquad (2)$$

The resistance of a homogeneous conductor of uniform cross-section is inversely proportional to its area of cross-section and directly proportional to its length. The constant ρ entering into the equation is termed the *specific resistance* of the conductor, since it is the value of R when l and A are unity. The first proposition states that whatever else the resistance may depend upon, it does not depend upon the current. The second proposition shows how circuits of an elementary type have their resistance affected by a change of dimensions. It would be wrong to infer that part two gives any information as to the effect of changing the material, or the physical state of the conductor; such considerations form the subject of the modern study of conduction, but the results form no part of Ohm's law.

In text-books of physics part I. is generally quoted as Ohm's law, while part II. is discussed under applications of the law. Whether part II. is to be supposed deducible from part I. or is to be regarded as self-evident is not made clear. Of course neither supposition is correct. Part II. must either be taken as the result of experiment, or be justified by some particular hypothesis as to the nature of the electric current. The student of physics taking up the subject of electro-kinetics after that of electro-statics, might, if left to himself, very naturally expect that resistance would vary inversely as the circumference of the conductor rather than as the cross-section. The true circumstances of current distribution are certainly the last which would occur to the student who, for example, conscientiously followed the suggestions in Watson's "Text-book of Physics," where it is asserted that current flow is a fiction, the only real flow being that of the energized field outside the wire. Whether it is or is not worth while in text-books to exercise more care in the elucidation of Ohm's law, in a historical discussion of the subject ambiguity can only be avoided by a precise statement of both propositions.

In the present discussion let it be remembered that the terms "resistance" and "potential" had not at the time under discussion been applied to electricity. The idea involved in the first term was introduced by Ohm, previous investigators speaking of "conducting power" or "conductivity"; while the term "potential" was brought into the subject later by Green, who borrowed it from Laplace. Ohm does not use it, but speaks of "electroscopic force" and "tension."

Experiments before Ohm.—The list of those who may properly be associated with the historical development of Ohm's law is a long one. Even when one omits those who studied the applicability of the law to electrolytes and gases, and confines it to those who contributed to the subject by the study of solids only, it includes the names of Cavendish 1750–1837, Priestley 1733–1804, Children 1777–1852, W. S. Harris 1792–1867, Davy 1778–1829, Barlow 1776–1862, J. Cumming 1777–1861, A. Becquerel 1788–1878, Ohm 1789–1854, G. Fechner 1801–1887, Pouillet 1790–1868, Lenz 1804–1865, S. H. Christie 1784–1865, Ritchie 1814–1895, C. M. Despretz 1792–1863, Kirchhoff 1824–1887, J. M. Gangain 1810–1878, Weber 1804–1891, Maxwell 1831–1878, A. Schuster 1851– and G. Chrystal 1851–.

The first person on record to investigate the relation between electromotive-force, current and resistance, afterwards formulated as part I. of Ohm's law, was *Henry Cavendish*, of England. His work was done prior to 1775, but remained totally unknown to the world until the publication of the Cavendish Researches by Maxwell, in 1879. Besides certain experiments on the relative conductivity of the human body, of iron and copper wire, and of various liquids, he made four series of experiments to determine "what power of the velocity the resistance is proportional to." In these experiments he employed a collection of wide and narrow glass tubes filled with a salt solution. As a source of current he used the discharge from a Leyden jar. The experiment consisted in adjusting the length of the column of liquid in the tube under test until it permitted the passage of a discharge of the same strength as that through a second tube selected as a standard. Under these conditions the resistances of the two tubes were regarded as equal. His method of determining equality of discharge was to place his own body in circuit with the condenser and test-tube, and then to judge by the sensation experienced. This is perhaps the only case on record where the human body has been used as a quantitative instrument in electrical measurements.

As a result of these experiments Cavendish concluded that the "resistance," in his sense of the word, varied as the 1.08, 1.03, 0.976 and 1.00 power of the "velocity" in the respective experiments. Maxwell tells us that by "velocity" Cavendish meant current and by "resistance" the total force opposing the current. This would make the Cavendish resistance equal to the total fall of potential around the circuit and is equivalent to saying that the resistance, in the modern sense of the word, is independent of the current. In his fourth experiment, which was the one most carefully performed, the result is in exact accordance with the modern view, and considering the crudity of his method all four results may be said to check within a reasonable margin of error. The work of Cavendish was on this basis regarded by Maxwell as an experimental proof of Ohm's law, and it was in this light that he left the matter in editing the Cavendish papers. No one since then seems to have done anything further than quote Maxwell.

Nevertheless, a closer examination indicates that Maxwell's statement that Cavendish's fourth experiment "is the first experimental proof of what is now known as Ohm's law," must be taken with some reservation. The conclusion one reaches is that Cavendish tacitly assumes part II. of the law. It is true that in 1775, two years after the above experiments, he states the law for the combination of resistances in parallel and in series though he does not state how he arrived at it, nor does he give any experimental data in proof of his statement. It can therefore hardly be regarded as part of his experimental proof of Ohm's law. With respect to the effect of cross-section on resistance Cavendish's only recorded experiment consists of a comparison of the shock received through nine small tubes with that received through one large tube of equivalent section and the same length. The fact that the two shocks were equal does not settle the relation between resistance and cross-section except for the case of round conductors. Ohm expanded the work to include sections of other shape. It would seem to be clear that Cavendish can not be credited with the establishment of both parts of the law, and strictly speaking it is an error to speak of him as the "discoverer" of Ohm's law. The most significant obstacle in the way of his doing this was, no doubt, the fact that no such thing as a steady current had as yet been discovered.

Subsequent to these, as yet unknown, experiments of Cavendish, but before the discovery of steady currents, work on the conductivity of different metal wires was undertaken by Van Marum, Priestley, Children and Harris. Using as they did the static discharge as a source of current, their work shows no advance over that of Cavendish either in results or in method. *Peter Barlow,* of England, was perhaps the first to attempt to use a steady current in the study of resistance. He did this by placing successive wires between the terminals of the same voltaic pile, determining the current strength from the tangent of the angle of deflection of the needle of a "multiplier" (galvanometer). The conclusion that he reached was that the resistance of a conductor is directly proportional to the *square-root* of the length and inversely proportional to the cross-section. In looking over the data of these experiments one finds discrepancies of 6° to 7° between the observed and calculated deflections based on Ohm's law. This makes it possible to estimate the resistance of the pile, which ought to have been, but was not, included in considering the resistance of the circuit. Such an examination of the data leads to the conclusion that Barlow's failure to reach correct results was due to this neglect of the resistance of his source of current. Had he included this he might have anticipated Ohm, at least to the extent that Cavendish did.

Cumming used the thermoelectric instead of the voltaic pile as a source of current, otherwise his experiments parallel Barlow's, including the same mistakes and reaching the same erroneous conclusions.

Davy: We now come to the first experimenter using steady currents whose results accord with those of Ohm. Sir Humphry Davy about 1820 used a voltaic pile and a divided circuit, one branch of which contained apparatus for the decomposition of water and the other the wire under test.

Fig. 1 shows the disposition of the apparatus.

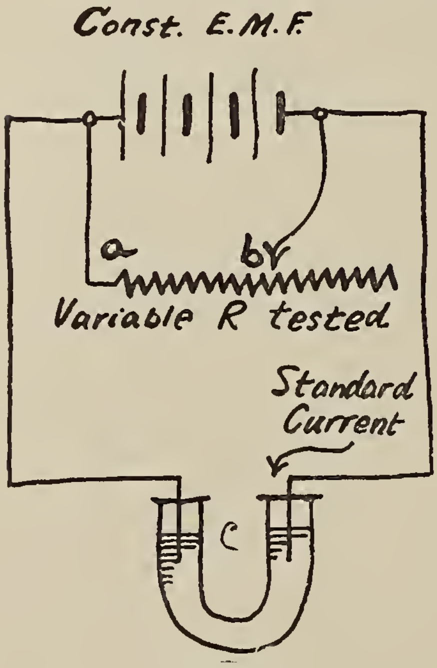


Fig. 1

The experiment consisted in adjusting the length of the wire *a–b* until its shunting effect was such as to make the potential difference across the water-cell just sufficient to cause electrolysis to begin. He found that wires having the same ratio of length to cross-section had the same resistance. This fact, while in accordance with Ohm's law, is a necessary but not a sufficient condition for its establishment. It is, in fact, the same result that Cavendish had reached forty years before.

Becquerel: Antoine Cesar Becquerel, the first of an illustrious line of French physicists, was the discoverer of part II. of Ohm's law. As his rival, Ohm must certainly have been incited by him to greater efforts in his own study of conduction, and in his earliest published papers Dr. Ohm accords to the work of Becquerel both recognition and criticism. Becquerel, like all of the predecessors of Ohm, overlooked the significance of the internal resistance of the source of current, but like Davy his use of a null method eliminated the necessity of taking it into account.

In his experiment Becquerel wound two wires simultaneously on to the frame of a "multiplier" (galvanometer). The terminals of the two coils thus formed being brought out separately could be connected so as either to increase or to oppose each other's effect. In the latter case what is known as a differential galvanometer is formed, the first one on record. Becquerel connected the coils differentially and in parallel. In order now that the coils shall exactly balance each other it is necessary not only that the number of turns of wire be the same on the two coils, but also that their resistance be the same. Since, however, the wires were of different diameter this could only be accomplished by increasing the length, outside of the instrument, of the coil of lower resistance. From one set of experiments Becquerel found, as had Davy before him, that all wires having the same ratio of length to cross-section had the same resistance. But to this experiment he added another showing that the conducting power varied inversely as the length of the conductor. The combination of these two results led for the first time without ambiguity to the conclusion that the conducting power varies directly as the sectional area and inversely as the length of the conductor, thus constituting a complete statement of part II. of Ohm's law. Becquerel also determined by direct experiment that the total current is the same in every part of a series circuit. This fact, so familiar to-day as to seem all but self-evident, was an important one, for without it Ohm's law would be meaningless.

Ohm's Experimental Investigations.—George Simon Ohm was born in Erlangen, Germany, on March 16, 1789. After attending the university of his native town he taught in Gottstadt, Neufchatel and Hamburg. In 1818 he became the teacher of mathematics and physics at the gymnasium at Cologne, where he remained for nine years. He was a superior instructor and looked forward with the ambition of securing a university appointment. Then, as now, the best, if not the only, path to preferment lay along the line of scientific research and discovery. To this endeavor Ohm brought three prime qualifications. His father, who was a lock-smith, had trained him as a lad in the use of tools; from his university he gained excellent training in mathematics; in himself he possessed a firm determination to do his best and a strong ambition to succeed. With scant leisure, few books and only the apparatus he himself devised and for the most part built, he had need of patience and perseverance. Difficult as was his progress, he was able in 1825 to publish three papers dealing with the galvanic circuit.

I. The first of these, entitled "Vorlaüfige Anzeige des Gesetzes, nach welchem Metalle die Contact-Elektricität leiten," occupies eight pages of *Schweigger's Journal für Chemie und Physik,* and describes experiments on the "loss of force" (*i. e.,* loss of potential) due to increasing the length of the wire in a simple circuit. In modern language it is the study of the effect on the terminal potential difference of varying the external resistance of the circuit. The results of these experiments were expressed by Ohm by the following empirical formula,

$$V = m \cdot \log\ (l + x/a). \qquad (3)$$

In this equation V is the loss of terminal potential difference, due to the insertion of an external resistance of length x, a is a constant depending on the length of the connecting wires, and m a coefficient depending (supposedly) upon the electromotive-force of the circuit, the cross-section of the wire and the constant a. The scheme of the experiment is shown in Fig. 2.

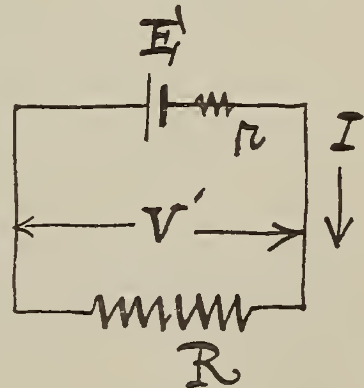


Fig. 2

In the light of Ohm's later work it is easy to see that this formula is absurd, a conclusion indeed soon reached by Ohm himself. It however marks one of the steps in the discovery of the law, and an examination of the experimental data shows that it represented these data very closely. Ohm was not however to be long misguided by an equation which could be easily checked by increasing the range of the experiment. He saw that, no matter how precise equation (3) might prove as an approximate formula, it could hardly represent a law of nature. He therefore prepared to test an external resistance fifteen hundred feet long. He does not seem to have published the result of this experiment, but he must have seen his mistake, for he promises to develop a new and correct equation. This he did a year later.

II. Two more papers were published by Ohm in the year 1825, as follows: "Über Leitungs-fähigkeit der Metalle für Elektricität," containing a preliminary announcement of his studies on the relative conductivities of different metals. The results were published the following year and are considered under paper IV.

III. "Ueber Electricitätsleiter." This was a discussion of the discrepancy between the results of Barlow and Becquerel, together with the acknowledgment of the inaccuracy of his own formula for the "loss of force" and an intimation of his intention to revise the formula. This closes the work for the year 1825. During these experiments he used for the source of current a Cu-Zn cell and measured the potential difference by means of a Coulomb torsion balance. The progress of the work is marked by a clearing of the way, by a grasp of the problem and a development of method rather than by positive achievement.

IV. Two papers appeared during the year 1826: the first of these was by far the most important and was a long one of twenty-nine pages, entitled "Bestimmung des Gesetzes, nach welchem Metalle die Contact-Electricität leiten, nebst einem Entwurfe zu einer Theorie des Voltaischen Apparates und des Schweigger'schen Multiplicators." While not so well known as his book on the mathematical theory of the circuit, published a year later, it is in reality his most important work and contains the following results.

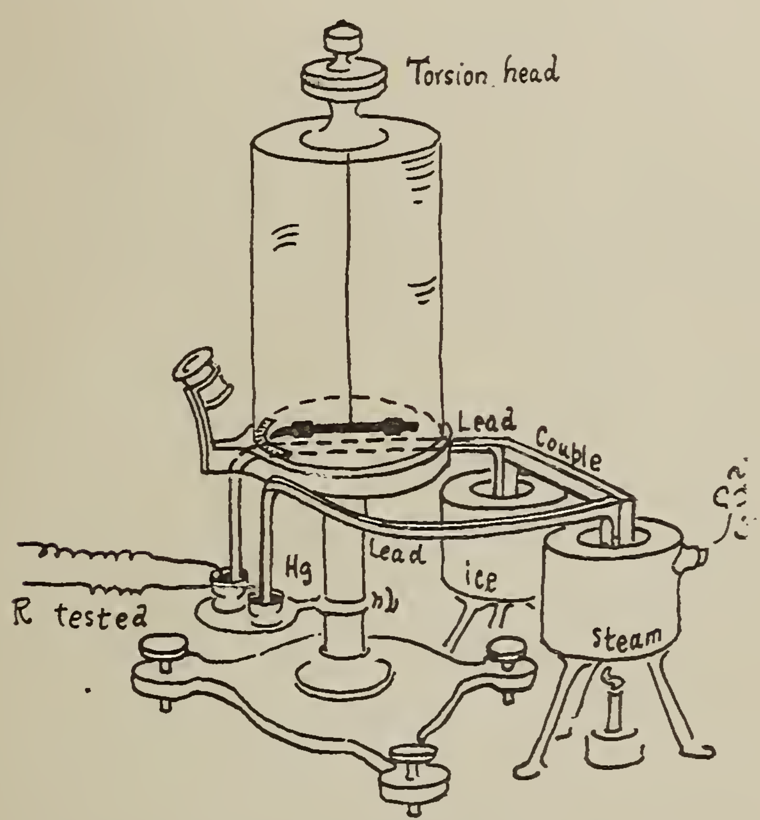
1. The data on relative conductivities promised in paper II. Ohm measured the relative conductivities of copper, gold, silver, zinc, brass, iron, platinum, tin and lead. Without going into the details of these experiments it is important to note that Ohm had gained a thorough appreciation of the significance of the specific conductivity of a conductor.

2. Experiments showing that the resistance of two conductors is the same when they have the same ratio of length to cross-section. Ohm's first experiments on cross-section proved the proposition which had already been proven by Davy and Becquerel, namely, that the resistance

depends upon the ratio of length to cross-section. The second experiments comprised the comparison of the currents flowing through two conductors of equal length and equal cross-section, one of which was of circular and the other of very flat section. The result showed that with the same electromotive-force the currents were also the same, thus proving the current to be uniformly distributed throughout the section. His third series of experiments gave a verification of the laws of parallel resistances. These results constitute a full experimental proof of part II. of Ohm's law, which, in its entirety, had not been given up to this time.

3. Experiments showing the relation between the magnetic effect of the current, the electromotive-force of the cell, and the length of wire in the circuit. This is the relation which we have denominated part I. of Ohm's law. He first presented it in the rather unfamiliar form of the following equation.

$$X = a/(b + x), \qquad (4)$$



Ohm's Torsion Balance and ThermoCouple

FIG. 3

where X is the magnetic effect of the current, a and b are constants depending respectively upon the electromotive-force and the internal resistance of the source of current; x is the length of wire constituting the external resistance under test. In modern language equation (4) may be written,

$$I = E/(r + R). \qquad (5)$$

The experiments by which these results were established constitute the most important of Ohm's work and they well repay careful study. After some preliminary experimentation his apparatus was reduced to the following essential parts: a Cu-Bi thermo-couple for generating a steady current and a specially constructed magnetic torsion balance for measuring the current strength. The apparatus and scheme of connections is shown in Fig. 3.

During the earlier part of his experimental work one thermo-juncture was surrounded by a steam-jacket and the other by an ice-jacket; during the latter part of the work the hot juncture was left at room temperature. The procedure for the experiment was as follows: The steam and ice jackets were first brought to their respective temperatures, the length of the test wire was then adjusted to the required length and lastly the torsion head turned until the magnetic needle was brought back to its zero position. The reading of the torsion head was then recorded and the experiment repeated with a new length of wire.

With the completion of these experiments Dr. Ohm had established both parts of his law, and may be said to have solved the problem to which he had set himself. As in the case of Sir Isaac Newton and the law of gravity, Ohm now found himself in the possession of a key to many doors closed to previous workers, and he proceeded at once to use it, as is shown by his theoretical paper of 1826 and his book of 1827.

V. This paper was published in the Poggendorf Annalen, is ten pages long and is entitled "Versuch einen Theorie der durch galvanische Kräfte hervorgebrachten elektroskopischen Erscheinungen." It is a purely theoretical paper and foreshadows the book which he wrote the following year. In this paper Ohm enunciates his complete law, contrary to the widely accepted statement that the law was first given in the book of 1827 (*e. g.*, Reed and Guthe, "College Physics," 1911). It also contained the correct formula based on this law, for the change of terminal potential difference due to a change in the external resistance. Finally the application of the law to many practical problems is discussed.

VI. The year 1827 furnishes the final paper of the series upon the galvanic circuit, followed by the appearance of the book elaborating the newly discovered relations. This paper appeared in *Schweigger's Journal* and was entitled "Einige elektrische Versuche." It is a paper of eight pages and contains the results of two experimental investigations confirmatory of the work of the previous year, as follows: (1) A verification of the conclusion as to the uniformity of the distribution of current over the cross-section of the conductor; (2) a verification of the formulæ for the combination of resistances in parallel. This may be said to close Ohm's experimental work in so far as it relates to the establishment of the law under discussion.

Ohm's Theoretical Work.—Turning to the mathematical interpretation which Dr. Ohm gave to the mass of experimental material already considered, we will first examine the paper of 1826 cited above under V. At the beginning of this paper is found the following expression of Ohm's law:

$$X = k \cdot w \cdot a/l, \tag{6}$$

where X is the current strength, k the specific conductivity of the wire, w the cross-section, a the electromotive-force of the source of current and l the length of the conductor. A second equation brings out for the first time the conception of "reduced length" or resistance. This equation is

$$X = a/L, \tag{7}$$

where L is the length of a hypothetical wire of unit conductivity and unit cross-section and takes the place of the terms $k \cdot w/l$ in equation (6). Equations (6) and (7) constitute Ohm's formal expression of the law.

In 1827 Dr. Ohm secured leave of absence from the gymnasium in Cologne, and proceeded to Berlin for the purpose of bringing out a book which should contain the theoretical conclusions which he had elaborated from his experiments. This book is entitled "Die Galvanische Kette, mathematisch bearbeitet," "The Mathematical Theory of the Galvanic Circuit." This book is the best known of his works. It contains a comprehensive theory of galvanic electricity, deduced from simple hypotheses and developed mathematically so as to cover a multitude of practical cases. The book may be divided into two parts, of which the first contains an introductory statement of principles on which the theory is based, together with applications to simple problems. Part two involves the use of differential equations and constitutes a more general development of the theory. The absence of a table of contents would seem to indicate haste in getting the book issued. An examination of the text gives the following partial outline of its contents:

Part One: 1. Discussion of the three fundamental hypotheses lying at the basis of his general theory and dealing with (*a*) the distribution of electricity in any element of a body; (*b*) mode of dispersion of electricity into the atmosphere; (*c*) law accounting for the generation of contact electricity. Of these three only the first is directly concerned with Ohm's law. Of it he says: "I have started from the supposition that the communication of electricity from one particle takes place directly to the one next to it. The magnitude of the transition between two adjacent particles under otherwise exactly similar circumstances, I have assumed as being proportional to the difference of potential between them."

In this passage it will be seen that Ohm proposed to follow, in the consideration of the flow of electricity, the lines laid down by Fourier and Laplace for the flow of heat. In fact Ohm does this throughout his book, and in a passage, unfortunately omitted by the English translator, he explains the analogy and acknowledges his debt.

2. After discussing the three principles Ohm applies them to a simple circuit of uniform section and material, in order to obtain a graphical representation of the potential gradient (*Gefalle*) and its discontinuities.

3. Applications to linear circuits of different material and varying section, with a generalization of the graphical method.

4. Equation for determining the potential at any point, consisting of an algebraic interpretation of the foregoing graphical method.

5. Relation of current strength to the potential gradient. This is Ohm's law expressed in terms of current, electromotive-force and ''reduced length'' or resistance. It is this statement of the law which is frequently, though wrongly, taken as the earliest expression of the law.

6. Applications of the conceptions of *potential gradient* and *reduced length* to special cases.

7. The effect upon the current strength of varying the resistance.

8. Properties of thermo-electric and hydro-electric circuits.

9. The effect upon the electromotive-force and resistance of the number of elements of a battery.

10. Adjustment of the resistance for the best action of a galvanoscope.

11. Divided circuits.

12. The decomposing power of an electric current.

The second part of the book is mathematical in character and need not be outlined here.

Discussion and Summary.—We are now in a position to summarize Dr. Ohm's work in the establishment of the laws of conduction, and to place his experimental work of 1825–26 in proper perspective with respect to his theoretical work of 1827. In doing this it will be necessary *first* to trace the development of ideas in Ohm's mind, and *second* to see how the scientific public received the same knowledge.

In tracing this development in the case of Ohm one must infer that the order of appearance of his various published papers marks the stages of growth of his own knowledge. Following this suggestion we find, *first,* that Dr. Ohm published in 1825 an incorrect empirical formula based upon inadequate experimental data. This paper would seem to show signs of undue haste caused perhaps by a fear that some other worker, Becquerel for example, might anticipate him. If this premature publication can not be placed to his credit his prompt acknowledgment of the error must be. *Second,* after further experimentation he announced the true law in 1826, in somewhat different form from that in which it is familiar to modern students. In the *third* place, he framed certain hypotheses from which the law could be deduced. This he does in his book of 1827. In doing this and in elaborating the law and in extending it to a large number of practical cases, Ohm leaves the reader to infer that he starts from the hypotheses and not from experiment. This is a serious mistake on the part of Ohm and it is hard to see just why he did himself this injustice. He may have assumed that the scientific public was familiar with all of his printed papers—an unsafe assumption at any time—and that direct reference to them was unnecessary. Ohm's book was only made possible by his experimental work and everything of value in it is the direct outcome of the laboratory, yet in the book Ohm writes as if the results reached were deductive and based on the three hypotheses cited above. In this Ohm laid the ground for the misunderstanding of his work by his contemporaries, who did not realize that its basis was experimental and therefore subject only to experimental proof or disproof.

Perhaps Ohm thought that the rather meager foundation of experimental data would be regarded as inadequate for the superstructure, or it may be that he really felt that the experiments had led him to the knowledge of the fundamental causes of the phenomena of conduction, and that his theory was more secure by being logically developed from these supposed fundamental truths. In either event he retarded rather than helped his cause. A third reason that might be assigned would be his desire, supposing him to have it, to be regarded as a *deductive* rather than as an *inductive* philosopher. He had, of course, imbibed some of the modern view of the importance of experimentation, else he would not have experimented, but he very likely still retained a good deal of the old Greek notion that by a process of pure reasoning one may reach new truth. In this case experimentation is not so much a source of new knowledge as a new form of thought stimulation. From such a viewpoint the experiments of Ohm had indeed served their purpose so soon as they were completed and he was quite right in ignoring them. Such a view of Ohm's position is strengthened by the fact that he seems to have taken no pains to remove the impression, universal in his day and which persists somewhat even to the present, that his laws were based on theory only and had no experimental origin or support.

So far then as Ohm is concerned we must conclude that however much he may have valued his experimental work for himself, he was well content that the public should consider his laws as being of theoretic and not of experimental origin.

The view which the scientific public early reached as to the value of Ohm's work is well expressed in the following paragraph taken from Cajori's "History of Physics" (pp. 230–1):

> The following year Ohm published a book entitled "Die Galvanische Kette, mathematisch bearbeitet." It contained a theoretic deduction of Ohm's law, and became far more widely known than his article of 1826, giving his experimental deduction. In fact, his experimental paper was so little known that the impression long prevailed and still exists that he based his law on theory and never established it empirically. This misapprehension accounts, perhaps, for the

unfavorable reception of Ohm's conclusions. Professor H. W. Dove, of Berlin, says that, "in the Berlin *Jahrbucher für wissenschaftliche Kritik*, Ohm's theory was named a web of naked fancies, which could never find the semblance of support from even the most superficial observation of facts." "He who looks at the world," proceeds the writer, "with the eye of reverence must turn aside from this book as the result of an incurable delusion, whose sole effect is to detract from the dignity of nature."

In seeking to explain how this extraordinary opinion came to be held the following facts will be of aid:

1. The paper containing Ohm's principal experimental results was published in a German scientific periodical and has never been translated, whereas his theoretical deductions, published in German the very next year, have since gone through two English and one French edition. The theoretical results were therefore far more widely diffused than were the experimental. Indeed it would be easy for a reader of both publications to confuse the priority of two so nearly simultaneous documents.

2. It was only by virtue of the recognition, tardily but distinctly rendered, on the part of Fechner in Germany, Lenz in Russia, Wheatstone and others in England, that Ohm came out of obscurity. Until this was the case and recognition was given by men of recognized standing, there was little reason why any more attention should be given Dr. Ohm and his meager set of experiments than to a number of equally reliable and equally little-known workers, whose results disagreed with his.

3. To whatever extent the English translation may be supposed to have supplied information as to the degree of interdependence of theory and experiment matters could not have been helped by an inexcusable error of translation of a sentence, the German of which is as follows: "Die Grosse des Überganges zwischen zwei zunachst beisamen elementen habe ich unter übrigens gleichen umständen dem Unterschiede der in beiden Elementem befindlichen elektrischen Kräfte proportional gesetzt." This sentence occurs near the beginning of the book and immediately after an intimation that his hypothesis depends in part on experiment, and a wrong rendering must have conveyed a false impression of the real character of the experiments, and therefore of their value. The rendition of this important sentence is: "The magnitude of the transition between two adjacent particles under otherwise exactly similar circumstances, I have assumed as being proportional to the difference of their temperatures."[1] How the word "temperature" came to be rendered for "elektrischen Kräfte" is difficult to see, and it can not be called an improvement on the original.

4. In his paper of 1826 Ohm did not very fully set forth part II.

[1] A correct translation is given on a former page.

of his law, the following being his expression: "Cylindrische Leiter von einerlei Art und verschiedenen Durchmesser haben denselben Leitungswerth, wenn sich ihre Langen wie ihre querschitte verhalten," which may be rendered: "Conductors of the same material have the same resistance if they all have the same ratio of length to cross-section." Now while this condensed statement is equivalent to the more elaborate statement contained in the book of 1827, this fact might easily be overlooked by a casual reader. It is also to be remembered that in the earlier stages of the discussion of Ohm's law part I. received general acceptance, while part II. was by no means universally agreed upon.

5. Lastly the fact that he wrote his book from a theoretical and not an experimental point of view invited the judgment passed upon it that his conclusions were "a web of naked fancies" without "the semblance of support from even the most superficial observation of facts."

From a modern point of view it may well be questioned whether the two propositions constituting Ohm's law could ever have been arrived at by any other than an experimental route. Weight is given to this conclusion by the following: (1) Our present knowledge of certain deviations from Ohm's law are accounted for only by the present corpuscular theory of electricity. Now Ohm, so far as he developed his ideas theoretically, did so on the basis of heat flow and the theory of heat was not corpuscular. While such ideas may not be opposed to the corpuscular conception, we can not expect an inadequate conception at the basis of a theory to lead, by a process of deduction, to correct predictions. The same partial conception may, however, prove of great value in an inductive process which is checked at every step by experiment. (2) In the formulation of a theory so essentially simple as is Ohm's law, one must look for a background of clear ideas, and we can admit of but one source of data for this purpose—namely, experiment. The absence of clear ideas of such terms as *current flow, resistance* and *electromotive-force,* at the time of, and their presence after Ohm's work is direct evidence of an experimental source of information. Thus the mathematical theory of electrostatics was based on Coulomb's law experimentally established, and a similar experimental basis was necessary for Ohm's law.

The discussion of the origin of Ohm's law may then be summarized as follows: Dr. Ohm carried along his experimental or inductive work simultaneously with the theoretical or deductive work; first the one then the other was to the front, until finally in 1826 he was able, from his experimental data, to announce the true law. In 1827 he ill-advisedly advanced his hypotheses as the origin of his theory without making it sufficiently clear that they were based on experiment. As an example of deductive reasoning the law means little, while as an example of inductive reasoning the law marks an important stage in the progress of science, and in its simple, generalized form is found to be identical with our present wider knowledge, so long as we avoid such phenomena as the skin effect, the Hall effect and conduction through gases.

Ohm's law thus experimentally discovered has stood the most exacting tests that modern methods have made possible. It has served as a firm basis for the progress of electrical science and marks the transition from the somewhat haphazard disconnected researches of those who preceded, to the well-directed, consistently developed labors of those who followed him. In a less degree and in a more limited field Ohm did for a branch of electrical science what at an earlier date Newton did for the great field of mechanics.

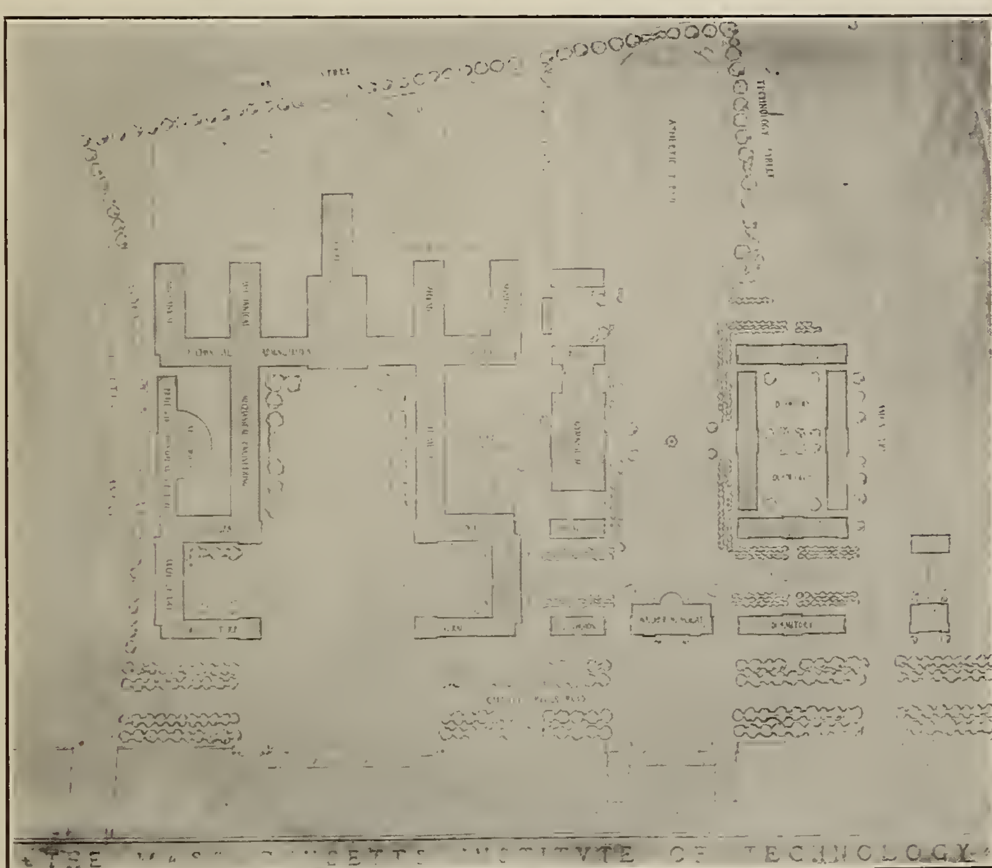
THE PROGRESS OF SCIENCE

THE NEW BUILDINGS OF THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

Work has begun on the new buildings for the Massachusetts Institute of Technology, and it is expected that they will be occupied two years hence. It will be remembered that after long discussion it was decided that a new site for the institute was required, and after the accession of Dr. Richard C. Maclaurin to the presidency and a gift of $500,000 from Mr. Coleman du Pont, land was purchased in Cambridge fronting the Charles River basin. An anonymous gift of $2,500,000, followed by another gift of $500,000 and an equal sum subscribed by the alumni, has enabled the institute to proceed with the construction. Six months ago, Mr. William W. Bosworth, of New York, a graduate of the institute of the class of '89, was selected as architect, and with the advice of the officers of the school of architecture of the institute and of the professors in the different departments, designs have been drawn up. The ground plan here reproduced shows the extensive scale of the plans, and some indication of the architectural treatment is given in the sketches.

The educational portion is a connected group of buildings of white Indiana limestone, three and four stories in height, clustered about the library, as the central feature. The great dome looks down on the court from a height of nearly two hundred feet. The central court, open to the river front, expands into two large, though minor courts, when near the esplanade. These openings, with the other courts interior to the buildings, ensure the necessary lighting of the rooms.

The pilaster tieatment, so effectively

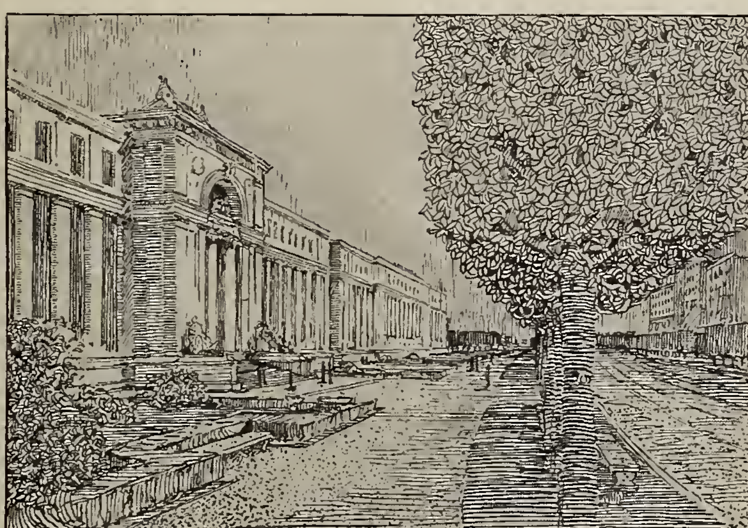


Ground Plan for the Massachusetts Institute of Technology.

The Library and Education Buildings from the Charles River.

used in the Harvard Medical School, has been applied as being most consistent with the needs of the work. Here light and air are the essentials and this construction permits the recesses to be almost entirely of glass. At the corners are pavilions, which satisfy the eye as to stability. In the buildings nearest the river, which here present long facades, the pilasters will be two stories in height with the third story really constituting the frieze. In the structures farther back there is a attic above the establature. This succession of buildings increasing in height from front to rear is a distinctive feature of the group, and furnishes grades and lines that converge towards the massive octagon from which rises the drum and its culminating dome.

The courts will be flanked by the department buildings and the latter are to be linked together so as to afford circulation throughout all portions of the vast structure. It will be unnecessary for the student to go out of doors in passing from one exercise to another. The comparatively narrow buildings will receive light from both sides and in addition it is planned to place all the draughting rooms on the top floor. Here, hidden by the parapets, there will be the standard saw-tooth skylights. The unit system is used in the interior, so that partitions can be readily rearranged. The departmtments can be extended as more space is needed and in the rear less expensive construction can be used.



THE PRATT SCHOOL OF NAVAL ARCHITECTURE AND THE MASSACHUSETTS AVENUE FACADE.

The frontage along the Charles River Esplanade is fifteen hundred feet, while the length along Massachusetts Avenue is about the same. Half of the site is to be devoted to the educational buildings; the other half, to the east, will be for the students and social facilities. It is the intention to develop a dormitory system surrounding the Walker Memorial, gymnasium, commons and other student features.

In the educational group the school of architecture will occupy the right angle at the corner of Massachusetts Avenue and the esplanade, the bridge being really a part of the avenue. On the third side of the court will be civil engineering, running parallel with the esplanade. Continuing along Massachusetts Avenue will be the Pratt School of Naval Architecture and Marine Engineering. Within the interior court behind the Pratt School is the great auditorium. Parallel with the Pratt School and bordering the central court will be hydraulic engineering and beyond this, mechanical engineering, with space for enlargement. This expansion will be towards the back of the grounds and towards the railway. Near this will be placed the laboratories that involve the handling of very heavy weights and the power plant.

Coming again to the esplanade the buildings that surround the minor court to the east will be devoted to general studies and biology, the latter occupying the inner wing parallel with the esplanade. Chemistry will occupy the long building on the farther side of the great court and mining, engineering and metallurgy will occupy the northeast corner. Electrical engineering finds its place behind the general library, and this situation will permit its incomparable collection of books to be essentially a part of the general library.

THE POSITION OF PROFESSORS IN THE MEDICAL SCHOOL

The Johns Hopkins University has played a great part in the development of higher education and scientific research in the United States. When Johns Hopkins established a university in Baltimore, he presumably had in mind an institution for boys of Maryland and the south such as Princeton or Amherst, but through the initiative of its first president, Daniel Coit Gilman, a university was created of the kind that has given Germany its leadership in scholarship and research. Each of the first professors—Gildersleeve in Greek, Sylvester in mathematics, Rowland in physics, Remsen in chemistry, Martin in physiology—was a man of distinction called to advance his science in his own way. Buildings, administration and routine teaching were subordinated to the personality of such men.

An advance of equal importance was made by the same university when the medical school was opened in 1893 and placed on a true university basis. Chiefly under the guidance of Dr. William H. Welch a faculty of distinguished men was brought together, and only students—including women, it may be noted—were admitted who were adequately prepared. At that time nearly all the medical schools in the United States were proprietary institutions conducted by the professors for the financial profit which the connection gave them in their practise. The Johns Hopkins University placed the laboratory sciences—physiology, anatomy and pharmacology—on a proper basis, and Dr. Welch led the way in this country in giving pathology a similar status. The clinical chairs were also filled by men of distinction, such as Dr. Osler and Dr. Halstead, and the medical school and the hospital formed an integral institution.

Other universities, notably, Harvard, have followed the lead of the Johns Hopkins Medical School, and remarkable progress has been made in medical education and research in the United States in the thirty years which have elapsed since the opening of the school in Baltimore. But in this country, as in Great Britain, and to a large extent in Germany and France, the professor who teaches in the medical school and has charge of the wards in the hospital, receives no salary or a nominal salary for these services and earns his living by his private practise. A few exceptional men have the force of character which enables them to limit their practise to cases which it is desirable for them to see in the interest of their university work. As a rule, however, the reverse holds and the university and hospital position is sought and used to promote a private practise and a large income. When a university professor travels forty-eight hours in the train for a consultation, one may be pretty sure that it is for the fee rather than for the service or for the experience.

At the present moment the Johns Hopkins Medical School and Hospital are undertaking to reform this unsatisfactory state of affairs. The General Education Board, endowed by Mr. John D. Rockefeller, has appropriated about one and a half million dollars to establish a William H. Welch fund. The revenue is to be used to enable the school to reorganize the departments of medicine, surgery and pediatrics so that the professors and their associates in the clinics and the laboratories shall be able to devote their entire time to their work. They are free to see and treat any one, whether inside or outside the hospital, but they will accept no personal fee for any such service.

The situation is clearly one of great difficulty. The professor of medicine or surgery may earn fifty to a hundred thousand dollars a year by his private practise. If he relinquishes this for a salary of $10,000, the income may appear ample to the young physician, but scarcely so to the consultant, to whom the automobile has become one of the necessaries of life. If the salary is made larger than $10,000, an apparent injustice is done to the professor of physiology or Greek having equal ability. Then any socialistic scheme of this character limits the freedom of action of the individual, and under the existing system of university organization the limitation may be irksome and may even be subject to a serious trade risk. There is danger lest the ablest men may not want the professorships in the medical schools under such conditions.

Still the movement is surely in the direction that must ultimately prevail. The physician should be paid by the state to preserve health rather than be employed by the patient for a service which it is usually beyond his power to provide. In the face of opposition from the larger part of the profession the British government has this year provided a wide-reaching system by which the physician is largely paid by the state in accordance not with the number of visits he makes, but in proportion to the number of persons who select him. It may be that before long under the control of the state officers of our railways and industrial trusts will receive salaries on condition that they do not engage in outside business. A medical school and hospital which provided the best attainable medical and surgical skill could properly charge the rich fees in accordance with their incomes and earn large amounts to be used for medical research and the promotion of the health of the community. It might not be advisable for all medical schools to adopt the qualifications for students and professors of the Johns Hopkins school, but it is well that there is at least one such institution in the United States.

SCIENTIFIC ITEMS

We record with regret the death of Dr. Philip Reese Uhler, since 1891 provost of the Peabody Institute, Baltimore, known for his contributions to entomology and geology; of Dr. Charles McBurney, formerly demonstrator of anatomy and professor of surgery in the College of Physicians of Columbia University; of Sir William Preece, the distinguished British electrical engineer; and of M. Charles Tellier, the inventor of the cold storage system.

It is announced from Paris that M. Charles Richet, professor of physiology in the university, has been awarded the Nobel prize for medicine.—Dr. George E. Hale, director of the Mount Wilson Solar Observatory, has been elected an honorary fellow of the Royal Society of Edinburgh.

Professor Willard C. Fisher, whose forced resignation from the chair of economics and sociology at Wesleyan on the alleged ground of his views on Sabbath observance will be remembered, has been appointed lecturer on economics at Harvard University for the current academic year.

In connection with the Sixth International Congress of Mathematicians, to be held in Stockholm in 1916, King Gustav V., of Sweden, has founded a prize, consisting of a gold medal bearing a portrait of Weierstrass and a cash sum of 3,000 crowns, for the best contribution to the theory of analytic functions.

THE American Association for the Advancement of Science and its affiliated societies will meet at Atlanta, Georgia, beginning on December 29, Dr. E. B. Wilson, professor of zoology, Columbia University, is the president for the meeting, and the address of the vice-president will be given by Dr. Edward C. Pickering, of the Harvard College Observatory. Other scientific societies will meet in different places; the zoologists in Philadelphia; the geologists in Princeton; the anthropologists in New York and the psychologists in New Haven.

NAMES OF CONTRIBUTORS ARE PRINTED IN SMALL CAPITALS

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The Popular Science Monthly

Entered in the Post Office in Lancaster, Pa., as second-class matter.

CONTENTS OF THE OOTOBER NUMBER

CONTENTS OF THE NOVEMBER NUMBER

PRESS OF THE NEW ERA PRINTING COMPANY