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THE RADIOMETER: A FRESH EVIDENCE OF A MOLECULAR UNIVERSE.[1]

By JOSIAH P. COOKE, Jr.,

ERVING PROFESSOR OF CHEMISTRY AND MINERALOGY IN HARVARD UNIVERSITY.

NO one who is not familiar with the history of physical science can appreciate how very modern are those grand conceptions which add so much to the loftiness of scientific studies; and of the many who, on one of our starlit nights, look up into the depths of space, and are awed by the thoughts of that immensity which come crowding upon the mind, there are few, I imagine, who realize the fact that almost all the knowledge, which gives such great sublimity to that sight, is the result of comparatively recent scientific investigation; and that the most elementary student can now gain conceptions of the immensity of the universe of which the fathers of astronomy never dreamed. And how very grand are the familiar astronomical facts which the sight of the starry heavens suggests!

Those brilliant points are all suns like the one which forms the centre of our system, and around which our earth revolves; yet so inconceivably remote, that although moving through space with an incredible velocity they have not materially changed their relative position since recorded observations began. Compared with their distance, the distance of our own sun—92,000,000 miles—seems as nothing; yet how inconceivable even that distance is when we endeavor to mete it out with our terrestrial standards! For, if, when Copernicus—the great father of modern astronomy—died, in 1543, just at the close of the Protestant Reformation, a messenger had started for the sun, and traveled ever since with the velocity of a railroad-train—thirty miles an hour—he would not yet have reached his destination!

[1] A lecture delivered in the Sanders Theatre of Harvard University, March 6, 1878.

Evidently, then, no standards, which like our ordinary measures bear a simple or at least a conceivable relation to the dimensions of our own bodies, can help us to stretch a line in such a universe. We must seek for some magnitude which is commensurate with these immensities of space; and, in the wonderfully rapid motion of light, astronomy furnishes us with a suitable standard. By the eclipses of Jupiter's satellites the astronomers have determined that this mysterious effluence reaches us from the sun in eight minutes and a half, and therefore must travel through space with the incredible velocity—shall I dare to name it—of 186,000 miles in a second of time! Yet inconceivably rapid as this motion is, capable of girdling the earth nearly eight times in a single second, the very nearest of the fixed stars, *a* Centauri, is so remote that the light by which it will be seen in the southern heavens tonight, near that magnificent constellation the Southern Cross, must have started on its journey three years and a half ago. But this light comes from merely the threshold of the stellar universe; and the telescope reveals to us stars so distant that, had they been blotted out of existence when history began, the tidings of the event could not yet have reached the earth!

Compare now with these grand conceptions the popular belief of only a few centuries back. Where we look into the infinite depths, our Puritan forefathers saw only a solid dome hemming in the earth and skies, and through whose opened doors the rain descended. They regarded the sun and moon merely as great luminaries set in this firmament to rule the day and night, and to their understandings the stars served no better purpose than the spangles which glitter on the azure ceiling of many a modern church. The great work of Copernicus, "De Orbium Cœlestium Revolutionibus," which was destined, ultimately, to overthrow the crude cosmography which Christianity had inherited from Judaism, was not published until just at the close of the author's life in 1543, the date before mentioned. The telescope, which was required to fully convince the world of its previous error, was not invented until more than half a century later, and it was not until 1835 that Struve detected the parallax of *a* Lyræ. The measurement of this parallax, together with Bessel's determination of the parallax of 61 Cygni, and Henderson's that of *a* Centauri, at about the same time, gave us our first accurate knowledge of the distances of the fixed stars.

To the thought I have endeavored to express I must add another, before I can draw the lesson which I wish to teach. Great scientific truths become popularized very slowly, and, after they have been thoroughly worked out by the investigators, it is often many years before they become a part of the current knowledge of mankind. It was fully a century after Copernicus died, with his great volume—still wet from the press of Nuremburg—in his hands, before the Copernican theory was generally accepted even by the learned; and the intolerant spirit with which this work was received, and the persecution which

Galileo encountered more than half a century later, were due solely to the circumstance that the new theory tended to subvert the popular faith in the cosmography of the Church. In modern times, with the many popular expositors of science, the diffusion of new truth is more rapid; but even now there is always a long interval after any great discovery in abstract science before the new conception is translated into the language of common life, so that it can be apprehended by the mass even of educated men.

I have thus dwelt on what must be familiar facts in the past history of astronomy, because they illustrate and will help you to realize the present condition of a much younger branch of physical science: for in the transition-period I have described there exists now a conception which opens a vision into the microcosmos beneath us as extensive and as grand as that which the Copernican theory revealed into the macrocosmos above us.

The conception to which I refer will be at once suggested to every scientific scholar by the word *molecule.* This word is a Latin diminutive, which means, primarily, a small mass of matter; and although heretofore often applied in mechanics to the indefinitely small particles of a body between which the attractive or repulsive forces might be supposed to act, it has only recently acquired the exact significance with which we now use it.

In attempting to discover the original usage of the word molecule, I was surprised to find that it was apparently first introduced into science by the great French naturalist, Buffon, who employed the term in a very peculiar sense. Buffon does not seem to have been troubled with the problem which so engrosses our modern naturalists—how the vegetable and animal kingdoms were developed into their present condition—but he was greatly exercised by an equally difficult problem, which seems to have been lost sight of in the present controversy, and which is just as obscure to-day as it was in Buffon's time, at the close of the last century, and that is, Why species are so persistent in Nature; why the acorn *always* grows into the oak, and why every creature *always* produces of its kind. And, if you will reflect upon it, I am sure you will conclude that this last is by far the more fundamental problem of the two, and one which necessarily includes the first. That of two eggs, in which no anatomist can discover any structural difference, the one should, in a few short years, *develop* an intelligence like Newton's, while the other soon ends in a Guinea-pig, is certainly a greater mystery than that, in the course of unnumbered ages, monkeys, by insensible gradations, should *grow* into men.

In order to explain the remarkable constancy of species, Buffon advanced a theory which, when freed from a good deal that was fanciful, may be expressed thus: The attributes of every species, whether of plants or of animals, reside in their ultimate particles, or, to use a more philosophical but less familiar word, *inhere* in these particles, which

Buffon names *organic molecules*. According to Buffon, the oak owes all the peculiarities of its organization to the special oak-molecules of which it consists; and so all the differences in the vegetable or animal kingdom, from the lowest to the highest species, depend on fundamental peculiarities with which their respective molecules were primarily endowed. There must, of course, be as many kinds of molecules as there are different species of living beings; but, while the molecules of the same species were supposed to be exactly alike and to have a strong affinity or attraction for each other, those of different species were assumed to be inherently distinct and to have no such affinities. Buffon further assumed that these molecules of organic Nature were diffused more or less widely through the atmosphere and through the soil, and that the acorn grew to the oak simply because, consisting itself of oak-molecules, it could draw only oak-molecules from the surrounding media.

With our present knowledge of the chemical constitution of organic beings, we can find a great deal that is both fantastic and absurd in this theory of Buffon, but it must be remembered that the science of chemistry is almost wholly a growth of the present century, while Buffon died in 1788; and, if we look at the theory solely from the standpoint of his knowledge, we shall find in it much that was worthy of this great man. Indeed, in our time the essential features of the theory of Buffon have been transferred from natural history to chemistry almost unchanged.

According to our modern chemistry, the qualities of every substance reside or inhere in its molecules. Take this lump of sugar. It has certain qualities with which every one is familiar. Are those qualities attributes of the lump or of its parts? Certainly of its parts. For, if we break up the lump, the smallest particles will still taste sweet and show all the characteristics of sugar. Could we then carry on this subdivision indefinitely provided only we had senses or tests delicate enough to recognize the qualities of sugar in the resulting particles? To this question, modern chemistry answers decidedly: No! You would before long reach the smallest mass that can have the qualities of sugar. You would have no difficulty in breaking up these masses, but you would then obtain not smaller particles of sugar, but particles of those utterly different substances which we call carbon, oxygen, and hydrogen, in a word particles of the elementary substances of which sugar consists. These ultimate particles of sugar we call the molecules of sugar, and thus we come to the present chemical definition of a molecule, "*The smallest particles of a substance in which its qualities inhere*," which, as you see, is a reproduction of Buffon's idea, although applied to matter and not to organism.

A lump of sugar, then, has its peculiar qualities because it is an aggregate of molecules which have those qualities, and a lump of salt differs from a lump of sugar simply because the molecules of salt differ from those of sugar, and so with every other substance. There are as many kinds of molecules in Nature as there are different substances, but all the molecules of the same substance are absolutely alike in every respect.

Thus far, as you see, we are merely reviving in a different association the old ideas of Buffon. But just at this point comes in a new conception, which gives far greater grandeur to our modern theory: for we conceive that those smallest particles in which the qualities of a substance inhere are definite bodies or systems of bodies moving in space, and that *a lump of sugar is a universe of moving worlds.*

If on a clear night you direct a telescope to one of the many star-clusters of our northern heavens, you will have presented to the eye as good a diagram as we can at present draw of what we suppose would, under certain circumstances, be seen in a lump of sugar if we could look into the molecular universe with the same facility with which the telescope penetrates the depths of space. Do you tell me that the absurdities of Buffon were wisdom when compared with such wild speculations as these? The criticism is simply what I expected, and I must remind you that, as I intimated at the outset, this conception of modern science is in the transition period of which I then spoke, and, although very familiar to scientific scholars, has not yet been grasped by the popular mind. I can, further, only add that, wild as it may appear, the idea is the growth of legitimate scientific investigation, and express my conviction that it will soon become as much a part of the popular belief as those grand conceptions of astronomy to which I have referred. Do you rejoin that we can see the suns in a stellar cluster, but cannot even begin to see the molecules? I must again remind you that, in fact, you only see points of light in the field of the telescope, and that your knowledge that these points are immensely distant suns is an inference of astronomical science; and further that our knowledge—if I may so call our confident belief—that the lump of sugar is an aggregate of moving molecules is an equally legitimate inference of molecular mechanics, a science which, although so much newer, is as positive a field of study as astronomy. Moreover, sight is not the only avenue to knowledge; and, although our material limitations forbid us to expect that the microscope will ever be able to penetrate the molecular universe, yet we feel assured that we have been able by strictly experimental methods to weigh molecular masses, and measure molecular magnitudes, with as much accuracy as those of the fixed stars.

Of all forms of matter the gas has the simplest molecular structure, and, as might be anticipated, our knowledge of molecular magnitudes is as yet chiefly confined to materials of this class. I have given below some of the results which have been obtained in regard to the molecular magnitudes of hydrogen gas, one of the best studied of this class of substances; and, although the vast numbers are as inconceivable as are those of astronomy, they cannot fail to impress you with the reality of the magnitudes they represent. I take hydrogen gas for my illustration rather than air, because our atmosphere is a mixture of two gases, oxygen and nitrogen, and therefore its condition is less simple than that of a perfectly homogeneous material like hydrogen. The molecular dimensions of other substances, although varying very greatly in their relative values, are of the same order as these.[1]

Dimensions of Hydrogen Molecules calculated for Temperature of Melting Ice and for the Mean Height of the Barometer at the Sea-Level.

Mean velocity, 6,099 feet a second.
Mean path, 31 ten-millionths of an inch.
Collisions, 17,750 millions each second.
Diameter, 438,000, side by side, measure $\frac{1}{100}$ of an inch.
Mass, 14 (millions ^{3}) weigh $\frac{1}{1000}$ of a grain.
Gas-volume, 311 (millions ^{3}) fill one cubic inch.

To explain how the values here presented were obtained would be out of place in a popular lecture,[2] but a few words in regard to two or three of the data are required to elucidate the subject of this lecture.

First, then, in regard to the mass or weight of the molecules. So far as their relative values are concerned, chemistry gives us the means of determining the molecular weights with very great accuracy; but when we attempt to estimate their weights in fractions of a grain—the smallest of our common standards—we cannot expect precision, simply because the magnitudes compared are of such a different order; and the same is true of most of the other absolute dimensions, such as the diameter and volume of the molecules. We only regard the values given in our table as a very rough estimate, but still we have good

[1] As some of the readers of this journal may be interested to compare these values, we reproduce the "Table of Molecular Data" from Prof. Clerk Maxwell's lecture on "Molecules," delivered before the British Association at Bradford, and published in *Nature*, September 25, 1873.

Molecular Magnitudes at Standard Temperature and Pressure, 0° C. and 76 c. m.

RANK ACCORDING TO ACCURACY OF KNOWLEDGE.	Hydrogen.	Oxygen.	Carbonic Oxide.	Carbonic Dioxide.
RANK I.				
Relative mass	1	16	14	22
Velocity in metres per second	1,859	465	497	396
RANK II.				
Mean path in ten billionths ($_{10}-^{10}$) of a metre	965	560	482	379
Collisions each second—number of millions	17,750	7,646	9,489	9,720
RANK III.				
Diameter in hundred billionths ($_{10}-^{11}$) of a metre	58	76	83	93
Mass in ten million million million millionths ($_{10}-^{25}$) of a gramme	46	736	644	1,012

Number of molecules in one cubic centimetre of every gas is nineteen million million million on 19 ($_{10}{}^{18}$).

Two million hydrogen molecules side by side measure a little over one millimetre.

[2] *See* Prof. Maxwell's lecture, *loc. cit.*; also Appletons' "Cyclopædia," article "Molecules."

grounds for believing that they are sufficiently accurate to give us a true idea of the order of the quantities with which we are dealing; and it will be seen that although the numbers required to express the relations to our ordinary standards are so large, these molecular magnitudes are no more removed from us on the one side than are those of astronomy on the other.

Passing next to the velocity of the molecular motion, we find in that a quantity which, although large, is commensurate with the velocity of sound, the velocity of a rifle-ball, and the velocities of many other motions with which we are familiar. We are, therefore, not comparing, as before, quantities of an utterly different order, and we have confidence that we have been able to determine the value within very narrow limits of error. But how surprising the result is! Those molecules of hydrogen are constantly moving to and fro with this great velocity, and not only are the molecules of all aëriform substances moving at similar, although differing, rates, but the same is equally true of the molecules of every substance, whatever may be its state of aggregation.

The gas is the simplest molecular condition of matter, because in this state the molecules are so far separated from each other that their motions are not influenced by mutual attractions. Hence, in accordance with the well-known laws of motion, gas-molecules must always move in straight lines and with a constant velocity until they collide with each other or strike against the walls of the containing vessel, when, in consequence of their elasticity, they at once rebound and start on a new path with a new velocity. In these collisions, however, there is no loss of motion, for, as the molecules have the same weight, and are perfectly elastic, they simply change velocities, and whatever one may lose the other must gain.

But if the velocity changes in this way, you may ask, What meaning has the definite value given in our table? The answer is, that this is the mean value of the velocity of all the molecules in a mass of hydrogen gas under the assumed conditions; and, by the principle just stated, the mean value cannot be changed by the collisions of the molecules among themselves, however great may be the change in the motion of the individuals.

In both liquids and solids the molecular motions are undoubtedly as active as in a gas, but they must be greatly influenced by the mutual attractions which hold the particles together, and hence the conditions are far more complicated, and present a problem which we have been able to solve only very imperfectly, and with which, fortunately, we have not at present to deal.

Limiting, then, our study to the molecular condition of a gas, picture to yourselves what must be the condition of our atmosphere, with its molecules flying about in all directions. Conceive what a molecular storm must be, raging about us, and how it must beat against our bodies and against every exposed surface. The molecules of our atmosphere move, on an average, nearly four (3.8) times slower than those of hydrogen under the same conditions; but then they weigh, on an average, fourteen and a half times more than hydrogen-molecules, and therefore strike with as great energy. And do not think that the effect of these blows is insignificant because the molecular projectiles are so small; they make up by their number for what they want in size.

Consider, for example, a cubic yard of air, which, if measured at the freezing-point, weighs considerably over two pounds. That cubic yard of material contains over two pounds of molecules, which are moving with an average velocity of 1,605 feet a second, and this motion is equivalent, in every respect, to that of a cannon-ball of equal weight, rushing along its path at the same tremendous rate. Of course, this is true of every cubic yard of air at the same temperature; and, if the motion of the molecules of the atmosphere around us could by any means be turned into one and the same direction, the result would be a hurricane sweeping over the earth with this velocity—that is, at the rate of 1,094 miles an hour—whose destructive violence not even the Pyramids could withstand.

Living as we do in the midst of a molecular tornado capable of such effects, our safety lies wholly in the circumstance that the storm beats equally in all directions at the same time, and the force is thus so exactly balanced that we are wholly unconscious of the tumult. Not even the aspen-leaf is stirred, nor the most delicate membrane broken; but let us remove the air from one of the surfaces of such a membrane, and then the power of the molecular storm becomes evident, as in the familiar experiments with an air-pump.

As has already been intimated, the values of the velocities both of hydrogen and of air molecules given above were measured at a definite temperature, 32° of our Fahrenheit thermometer, the freezing-point of water; and this introduces a very important point bearing on our subject, namely, that the molecular velocities vary very greatly with the temperature. Indeed, according to our theory, this very molecular motion constitutes that state or condition of matter which we call temperature. A hot body is one whose molecules are moving comparatively rapidly, and a cold body one in which they are moving comparatively slowly. Without, however, entering into further details, which would involve the whole mechanical theory of heat, let me call your attention to a single consequence of the principle I have stated.

When we heat hydrogen, air, or any mass of gas, we simply increase the velocity of its moving molecules. When we cool the gas, we simply lessen the velocity of the same molecules. Take a current of air which enters a room through a furnace. In passing it comes in contact with heated iron, and, as we say, is heated. But, as we view the process, the molecules of the air, while in contact with the hot iron, collide with the very rapidly-oscillating metallic molecules, and fly back as a billiard-ball would under similar circumstances, with a greatly-increased velocity, and it is this more rapid motion which alone constitutes the higher temperature.

Consider, next, what must be the effect on the surface. A moment's reflection will show that the normal pressure exerted by the molecular storm, always raging in the atmosphere, is due not only to the impact of the molecules, but also to the reaction caused by their rebound. When the molecules rebound they are, as it were, driven away from the surface in virtue of the inherent elasticity both of the surface and of the molecules. Now, what takes place when one mass of matter is driven away from another—when a cannon-ball is driven out of a gun, for example? Why, the gun *kicks!* And so every surface from which molecules rebound must *kick;* and, if the velocity is not changed by the collision, one-half of the pressure caused by the molecular bombardment is due to the recoil. From a heated surface, as we have said, the molecules rebound with an increased velocity, and hence the recoil must be proportionally increased, determining a greater pressure against the surface.

According to this theory, then, we should expect that the air would press unequally against surfaces at different temperatures, and that, other things being equal, the pressure exerted would be greater the higher the temperature of the surface. Such a result, of course, is wholly contrary to common experience, which tells us that a uniform mass of air presses equally in all directions and against all surfaces of the same area, whatever may be their condition. It would seem, then, at first sight, as if we had here met with a conspicuous case in which our theory fails. But further study will convince us that the result is just what we should expect in a dense atmosphere like that in which we dwell; and, in order that this may become evident, let me next call your attention to another class of molecular magnitudes.

It must seem strange indeed that we should be able to measure molecular velocities, but the next point I have to bring to your notice is stranger yet, for we are confident that we have been able to determine with approximate accuracy for each kind of gas-molecule the average number of times one of these little bodies runs against its neighbors in a second, assuming, of course, that the conditions of the gas are given. Knowing, now, the molecular velocity and the number of collisions a second, we can readily calculate the mean path of the molecule—that is, the average distance it moves, under the same conditions, between two successive collisions. Of course, for any one molecule, this path must be constantly varying; since, while at one time the molecule may find a clear coast and make a long run, the very next time it may hardly start before its course is arrested. Still, taking a mass of gas under constant conditions, the doctrine of averages shows that the mean path must have a definite value, and an illustration will give an idea of the manner in which we have been able to estimate it.

The nauseous smelling gas we call sulphide of hydrogen has a density only a little greater than that of air, and its molecules must therefore move with very nearly as great velocity as the average air-molecule—that is to say, about 1,480 feet a second; and we might therefore expect that, on opening a jar of the gas, its molecules would spread instantly through the surrounding atmosphere. But so far from this, if the air is quiet, so that the gas is not transported by currents, a very considerable time will elapse before the characteristic odor is perceived on the opposite side of an ordinary room. The reason is obvious—the molecules must elbow their way through the crowd of air-molecules which already occupy the space, and can therefore advance only slowly; and it is obvious that, the oftener they come into collision with their neighbors, the slower their progress must be. Knowing, then, the mean velocity of the molecular motion, and being able to measure by appropriate means *the rate of diffusion*, as it is called, we have the data from which we can calculate both the number of collisions in a second and also the mean path between two successive collisions. The results, as we must expect, are of the same order as the other molecular magnitudes. But inconceivably short as the free[1] path of a molecule certainly is, it is still, in the case of hydrogen gas, 136 times the diameter of the moving body, which would certainly be regarded among men as quite ample elbow-room.

Although, in this lecture, I have as yet had no occasion to mention the radiometer, I have by no means forgotten my main subject, and everything which has been said has had a direct bearing on the theory of this remarkable instrument; and still, before you can understand the great interest with which it is regarded, we must follow out another line of thought, converging on the same point.

One of the most remarkable results of modern science is the discovery that all energy at work on the surface of this planet comes from the sun. Most of you probably saw, at our Centennial Exhibition, that great artificial cascade in Machinery Hall, and were impressed with the power of the steam-pump which could keep flowing such a mass of water. But, also, when you stood before the falls at Niagara, did you realize the fact that the enormous floods of water, which you saw surging over those cliffs, were in like manner supplied by an all-powerful pump, and that pump the sun? And not only is this true, but it is equally true that every drop of water that falls, every wave that beats, every wind that blows, every creature that moves on the surface of the earth, one and all, are animated by that mysterious effluence we call the sunbeam. I say mysterious effluence; for how that power is trans-

[1] There is an obvious distinction between the free and the disturbed path of a molecule, and we cannot overlook in our calculations the perturbations which the collisions necessarily entail. Such considerations greatly complicate the problem, which is far more difficult than would appear from the superficial view of the subject that can alone be given in a popular lecture.

mitted over those 92,000,000 miles between the earth and the sun, is still one of the greatest mysteries of Nature.

In the science of optics, as is well known, the phenomena of light are explained by the assumption that the energy is transmitted in waves through a medium which fills all space, called the luminiferous ether, and there is no question that this theory of Nature, known in science as the Undulatory Theory of Light, is, as a working hypothesis, one of the most comprehensive and searching which the human mind has ever framed. It has both correlated known facts and pointed the way to remarkable discoveries. But, the moment we attempt to apply it to the problem before us, it demands conditions which tax even a philosopher's credulity.

As sad experience on the ocean only too frequently teaches, energy can be transmitted by waves as well as in any other way. But every mechanic will tell you that the transmission of energy, whatever be the means employed, implies certain well-known conditions. Let it be that the energy is to be used to turn the spindles of a cotton-mill. The engineer can tell you just how many horse-power he must supply for every working-day, and it is equally true that a definite amount of energy must come from the sun to do each day's work on the surface of the globe. Further, the engineer will also tell you that, in order to transmit the power from his turbine or his steam-engine, he must have shafts and pulleys and belts of adequate strength, and he knows in every case what is the lowest limit of safety. In like manner, the medium through which the energy which runs the world is transmitted must be strong enough to do the immense work put upon it; and, if the energy is transmitted by waves, this implies that the medium must have an enormously great elasticity, an elasticity vastly greater than that of the best-tempered steel.

But turn now to the astronomers, and learn what they have to tell us in regard to the assumed luminiferous ether through which all this energy is supposed to be transmitted. Our planet is rushing in its orbit around the sun at an average rate of over 1,000 miles a minute, and makes its annual journey of some 550,000,000 miles in 365 days 6 hours 9 seconds and $\frac{6}{10}$ of a second. Mark the tenths; for astronomical observations are so accurate that, if the length of the year varied permanently by the tenth of a second, we should know it; and you can readily understand that, if there were a medium in space which offered as much resistance to the motion of the earth as would gossamer threads to a race-horse, the planet could never come up to time, year after year, to the tenth of a second.

How, then, can we save our theory, by which we set so much, and rightly, because it has helped us so effectively in studying Nature? If we may be allowed such an extravagant solecism, let us suppose that the engineer of our previous illustration was the hero of a fairy-tale. He has built a mill, set a steam-engine in the basement, arranged his spindles above, and is connecting the pulleys by the usual belts, when some stern necessity requires him to transmit all the energy with cobwebs. Of course, a good fairy comes to his aid, and what does she do? Simply makes the cobwebs indefinitely strong. So the physicists, not to be outdone by any fairies, make their ether indefinitely elastic, and their theory lands them just here, with a medium filling all space, thousands of times more elastic than steel, and thousands on thousands of times less dense than hydrogen gas. There must be a fallacy somewhere, and I strongly suspect it is to be found in our ordinary materialistic notions of causation, which involve the old metaphysical dogma, "*nulla actio in distans*," and which in our day have culminated in the famous apothegm of the German materialist, "Kein Phosphor kein Gedanke."

But it is not my purpose to discuss the doctrines of causation, and I have dwelt on the difficulty, which this subject presents in connection with the undulatory theory, solely because I wished you to appreciate the great interest with which scientific men have looked for some direct manifestation of the mechanical action of light. It is true that the ether-waves must have dimensions similar to those of the molecules discussed above, and we must expect, therefore, that they would act primarily on the molecules and not on masses of matter. But still the well-known principles of wave-motion have led competent physicists to maintain that a more or less considerable pressure ought to be exerted by the ether-waves on the surfaces against which they beat, as a partial resultant of the molecular tremors first imparted. Already, in the last century, attempts were made to discover some evidence of such action, and in various experiments the sun's direct rays were concentrated on films, delicately suspended and carefully protected from all other extraneous influences, but without any apparent effect; and thus the question remained until about three years ago, when the scientific world were startled by the announcement of Mr. Crookes, of London, that, on suspending a small piece of blackened alder-pith in the very perfect vacuum which can now be obtained with the mercury-pump, invented by Sprengel, he had seen this light body actually repelled by the sun's rays; and they were still more startled, when, after a few further experiments, he presented us with the instrument he called a radiometer, in which the sun's rays do the no inconsiderable work of turning a small wheel. Let us examine for a moment the construction of this remarkable instrument.

The moving part of the radiometer is a small horizontal wheel, to the ends of whose arms are fastened vertical vanes, usually of mica, and blackened on one side. A glass cap forms the hub, and by the glass-blower's art the wheel is inclosed in a glass bulb, so that the cap rests on the point of a cambric needle; and the wheel is so delicately balanced on this pivot that it turns with the greatest freedom. From the interior of the bulb the air is now exhausted by means of the Sprengel pump, until less than $\frac{1}{1000}$ of the original quantity is left, and the only opening is then hermetically sealed. If, now, the sun's light or even the light from a candle shines on the vanes, the blackened surfaces—which are coated with lamp-black—are repelled, and, these being symmetrically placed around the wheel, the several forces conspire to produce the rapid motion which results. The effect has all the appearance of a direct mechanical action exerted by the light, and for some time was so regarded by Mr. Crookes and other eminent physicists, although in his published papers it should be added that Mr. Crookes carefully abstained from speculating on the subject—aiming, as he has since said, to keep himself unbiased by any theory, while he accumulated the facts upon which a satisfactory explanation might be based.

Singularly, however, the first aspect of the new phenomena proved to be wholly deceptive; and the motion, so far from being an effect of the direct mechanical action of the waves of light, is now believed to be a new and very striking manifestation of molecular motion. To this opinion Mr. Crookes himself has come, and in a recent article he writes: "Twelve months' research, however, has thrown much light on these actions; and the explanation afforded by the dynamical theory of gases makes, what was a year ago obscure and contradictory, now reasonable and intelligible."

As is frequently the case in Nature, the chief effect is here obscured by various subordinate phenomena, and it is not surprising that a great difference of opinion should have arisen in regard to the cause of the motion. This would not be an appropriate place to describe the numerous investigations occasioned by the controversy, many of which show in a most striking manner how easily experimental evidence may be honestly misinterpreted in support of a preconceived opinion. I will, however, venture to trespass further on your patience, so far as to describe the few experiments by which very early in the controversy I satisfied my own mind on the subject.

When two years ago I had for the first time an opportunity of experimenting with a radiometer, the opinion was still prevalent that the motion of the wheel was a direct mechanical effect of the waves of light, and therefore that the impulses came from the outside of the instrument, the waves passing freely through the glass envelope. At the outset this opinion did not seem to me to be reasonable, or in harmony with well-known facts; for, knowing how great must be the molecular disturbance caused by the sun's rays as shown by their heating power, I could not believe that a residual action, such as has been referred to, would first appear in these delicate phenomena observed by Mr. Crookes, and should only be manifested in the vacuum of a mercury-pump.

On examining the instrument, my attention was at once arrested by the lampblack coating on the alternate surfaces of the vanes; and from the remarkable power of lampblack to absorb radiant heat it was evident at once that, whatever other effects the rays from the sun or from a flame might cause, they must necessarily determine a constant difference of temperature between the two surfaces of the vanes; and the thought at once occurred that, after all, the motion might be a direct result of this difference of temperature—in other words, that the radiometer might be a small heat-engine, whose motions, like those of every other heat-engine, depend on the difference of temperature between its parts.

But, if this were true, the effect ought to be proportional solely to the heating power of the rays, and a very easy means of roughly testing this question was at hand. It is well known that an aqueous solution of alum, although transmitting light as freely as the purest water, powerfully absorbs those rays, of any source, which have the chief heating power. Accordingly, I interposed what we call an alum-cell in the path of the rays shining on the radiometer, when, although the light on the vanes was as bright as before, the motion was almost completely arrested.

This experiment, however, was not conclusive, as it might still be said that the *heat*-giving rays acted *mechanically;* and it must be admitted that the chief part of the energy in the rays, even from the most brilliant luminous sources, always takes the form of heat. But, if the action is mechanical, the reaction must be against the medium through which the rays are transmitted, while, if the radiometer is simply a heat-engine, the action and reaction must be, ultimately at least, between the heater and the cooler, which in this case are respectively the blackened surfaces of the vanes and the glass walls of the inclosing bulb; and here, again, a very easy method of testing the actual condition at once suggested itself.

If the motion of the radiometer-wheel is an effect of mechanical impulses transmitted in the direction of the beam of light, it was certainly to be expected that the beam would act on the lustrous as well as on the blackened mica surfaces, however large might be the difference in the resultants producing mechanical motion in consequence of the great absorbing power of the lampblack. Moreover, since the instrument is so constructed that of two vanes, on opposite sides of the wheel, one always presents a blackened and the other a lustrous surface to an incident beam, we should further expect to find in the motion of the wheel a differential phenomenon, due to the unequal action of the light on these surfaces. On the other hand, if the radiometer is a heat-engine, and the reaction takes place between the heated blackened surfaces of the vanes and the colder glass, it is evident that the total effect will be simply the sum of the effects at the several surfaces.

In order to investigate the question thus presented, I placed the radiometer before a common kerosene-lamp, and observed, with a stop-watch, the number of seconds elapsed during ten revolutions of the little wheel. Finding that this number was absolutely constant, I next screened one-half of the bulb, so that only the blackened faces were exposed to the light as the wheel turned them into the beam. Again, I several times observed the number of seconds during ten turns, which, although equally constant, was greater than before. Lastly, I screened the blackened surfaces so that, as the wheel turned, only the lustrous surfaces of mica were exposed to the light, when, to my surprise, the wheel continued to turn in the same direction as before, although much more slowly. It appeared as if the lustrous surfaces were attracted by the light. Again I observed the time of ten revolutions, and here I have collected my results, reducing them, in the last column, so as to show the corresponding number of revolutions in the same time:

CONDITIONS.	Time of Ten Revolutions.	No. of Revolutions in same Time.
Both faces exposed	8 seconds.	319
Blackened faces only	11 "	232
Mica faces only	29 "	88

It will be noticed that 88 + 232 equals very nearly 319. Evidently the effect, so far from being differential, is concurrent. Hence, the action which causes the motion must take place between the parts of the instrument, and cannot be a direct effect of impulses imparted by ether-waves; or else we are driven to the most improbable alternative, that lampblack and mica should have such a remarkable selective power that the impulses imparted by the light should exert a repulsive force at one surface and an attractive force at the other. Were there, however, such an improbable effect, it must be independent of the thickness of the mica vanes; while on the other hand, if, as seemed to us now most probable, the whole effect depended on the difference of temperature between the lampblack and the mica, and if the light produced an effect on the mica surface only because, the mica plate being diathermous to a very considerable extent, the lampblack became heated through the plate more than the plate itself, then it would follow that, if we used a thicker mica plate, which would absorb more of the heat, we ought to obtain a marked difference of effect. Accordingly, we repeated the experiment with an equally sensitive radiometer, which we made for the purpose, with comparatively thick vanes, and with this the effect of a beam of light on the mica surface was absolutely null, the wheel revolving in the same time, whether these faces were protected or not.

But one thing was now wanting to make the demonstration complete. A heat-engine is reversible, and if the motion of the radiometer depended on the circumstance that the temperature of the blackened faces of the vanes was higher than that of the glass, then by reversing the conditions we ought to reverse the motion. Accordingly, I carefully heated the glass bulb over a lamp, until it was as hot as the hand would bear, and then placed the instrument in a cold room, trusting to the great radiating power of lampblack to maintain the temperature of the blackened surfaces of the vanes below that of the glass. Immediately the wheel began to turn in the opposite direction, and continued to turn until the temperature of the glass came into equilibrium with the surrounding objects.

These early experiments have since been confirmed to the fullest extent, and no physicist at the present day can reasonably doubt that the radiometer is a very beautiful example of a heat-engine, and it is the first that has been made to work continuously by the heat of the sunbeam. But it is one thing to show that the instrument is a heat-engine, and quite another thing to explain in detail the manner in which it acts. In regard to the last point, there is still room for much difference of opinion, although physicists are generally agreed in referring the action to the residual gas that is left in the bulb. As for myself, I became strongly persuaded—after experimenting with more than one hundred of these instruments, made under my own eye, with every variation of conditions I could suggest—*that the effect was due to the same cause which determines gas-pressure*, and, according to the dynamical theory of gases, this amounts to saying that the effect is due to molecular motion. I have not time, however, to describe either my own experiments on which this opinion was first based, or the far more thorough investigations since made by others, which have served to strengthen the first impression.[1] But, after our previous discussions, a few words will suffice to show how the molecular theory explains the new phenomena.

Although the air in the bulb has been so nearly exhausted that less than the one-thousandth part remains, yet it must be borne in mind that the number of molecules left behind is by no means inconsiderable. As will be seen by referring to our table, there must still be no less than 311,000 million million in every cubic inch. Moreover, the absolute pressure which this residual gas exerts is a very appreciable quantity. It is simply the one-thousandth of the normal pressure of the atmosphere, that is, of $14\frac{7}{10}$ pounds on a square inch; which is equivalent to a little over 100 grains on the same area. Now, the area of the blackened surfaces of the vanes of an ordinary radiometer measures just about a square inch, and the wheel is mounted so delicately that a constant pressure of one-tenth of a grain would be sufficient to produce rapid motion. So that a difference of pressure on the opposite faces of the vanes, equal to one one-thousandth of the whole amount, is all that we need account for; and, as can easily be calculated, a difference of temperature of less than half a degree Fahrenheit would cause all this difference in the pressure of the rarefied air.

But you may ask, How can such a difference of pressure exist on

[1] *See* notice of these investigations by the author of this article, in *American Journal of Science and Arts*, September, 1877 (3), xiv., 231.

different surfaces exposed to one and the same medium? and your question is a perfectly legitimate one; for it is just here that the new phenomena seem to belie all our previous experience. If, however, you followed me in my very partial exposition of the mechanical theory of gases, you will easily see that on this theory it is a more difficult question to explain why such a difference of pressure does not manifest itself in every gas medium and under all conditions between any two surfaces having different temperatures.

We saw that gas-pressure is a double effect, caused both by the impact of molecules and by the recoil of the surface attending their rebound. We also saw that when molecules strike a heated surface they rebound with increased velocity, and hence produce an increased pressure against the surface, the greater the higher the temperature. According to this theory, then, we should expect to find the same atmosphere pressing unequally on equal surfaces if at different temperatures; and the difference in the pressure on the lampblack and mica surfaces of the vanes, which the motion of the radiometer-wheel necessarily implies, is therefore simply the normal effect of the mechanical condition of every gas medium. The real difficulty is, to explain why we must exhaust the air so perfectly before the effect manifests itself.

The new theory is equal to the emergency. As has been already pointed out, in the ordinary state of the air the amplitude of the molecular motion is exceedingly small, not over a few ten-millionths of an inch—a very small fraction, therefore, of the height of the inequalities on the lampblack surfaces of the vanes of a radiometer. Under such circumstances, evidently the molecules would not leave the heated surface, but simply bound back and forth between the vanes and the surrounding mass of dense air, which, being almost absolutely a non-conductor of heat, must act essentially like an elastic solid wall confining the vanes on either side. For the time being, and until replaced by convection-currents, the oscillating molecules are as much a part of the vanes as our atmosphere is a part of the earth; and on this system, as a whole, the homogeneous dense air which surrounds it must press equally from all directions. In proportion, however, as the air is exhausted, the molecules find more room and the amplitude of the molecular motion is increased, and when a very high degree of exhaustion is reached the air-particles no longer bound back and forth on the vanes without change of condition, but they either bound off entirely like a ball from a cannon, or else, having transferred a portion of their momentum, return with diminished velocity, and in either case the force of the reaction is felt.[1]

[1] The reader will, of course, distinguish between the differential action on the opposite faces of the vanes of the radiometer and the reaction between the vanes and the glass which are the heater and the cooler of the little engine. Nor will it be necessary to remind any student that a popular view of such a complex subject must be necessarily partial. In the present case we not only meet with the usual difficulties in this respect, but,

Thus it appears that we have been able to show by very definite experimental evidence that the radiometer is a heat-engine. We have also been able to show that such a difference of temperature as the radiation must produce in the air in *direct* contact with the opposite faces of the vanes of the radiometer would determine a difference of tension, which is sufficient to account for the motion of the wheel. Finally, we have shown, as fully as is possible in a popular lecture, that, according to the mechanical theory of gases, such a difference of tension would have its normal effect only in a highly-rarefied atmosphere, and thus we have brought the new phenomena into harmony with the general principles of molecular mechanics previously established.

More than this cannot be said of the steam-engine, although, of course, in the older engine the measurements on which the theory is based are vastly more accurate and complete. But the moment we attempt to go beyond the general principles of heat-engines, of which the steam-engine is such a conspicuous illustration, and explain how the heat is transformed into motion, we have to resort to the molecular theory just as in the case of the radiometer; and the motion of the steam-engine seems to us less wonderful than that of the radiometer, only because it is more familiar and more completely harmonized with the rest of our knowledge. Moreover, the very molecular theory which we call upon to explain the steam-engine involves consequences which, as we have seen, have been first realized in the radiometer; and thus it

moreover, the principles of molecular mechanics have not been so fully developed as to preclude important differences of opinion between equally competent authorities in regard to the details of the theory. To avoid misapprehension, we may here add that, in order to obtain in the radiometer a reaction between the heater and the cooler, it is not necessary that the space between them should actually be crossed by the moving molecules. It is only necessary that the momentum should be transferred across the space, and this may take place along lines consisting of many molecules each. The theory, however, shows that such a transfer can only take place in a highly-rarefied medium. In an atmosphere of ordinary density, the accession of heat which the vanes of a radiometer might receive from a radiant source would be diffused through the mass of the inclosed air. This amounts to saying that the momentum would be so diffused, and hence, under such circumstances, the molecular motion would not determine any reaction between the vanes and the glass envelope. Indeed, a dense mass of gas presents to the conduction of heat, which represents momentum, a wall far more impenetrable than the surrounding glass, and the diffusion of heat is almost wholly brought about by convection-currents which rise from the heated surfaces. It will thus be seen that the great non-conducting power of air comes into play to prevent not only the transfer of momentum from the vanes to the glass, but also, almost entirely, any direct transfer to the surrounding mass of gas. Hence, as stated above, the heated molecules bound back and forth on the vanes without change of condition, and the mass of the air retains its uniform tension in all parts of the bulb, except in so far as this is slowly altered by the convection-currents just referred to. As the atmosphere, however, becomes less dense, the diffusion of heat by convection diminishes, and that by molecular motion (conduction) increases until the last greatly predominates. When, now, the exhaustion reaches so great a degree that the heat, or momentum, is rapidly transferred from the heater to the cooler by an exaggeration, or, possibly, a modification of the mode of action we call conduction, then we have the reaction on which the motion of the radiometer-wheel depends.

is that this new instrument, although disappointing the first expectations of its discoverer, has furnished a very striking confirmation of this wonderful theory. Indeed, the confirmation is so remote and yet so close, so unexpected and yet so strong, that the new phenomena almost seem to be a direct manifestation of the molecular motion which our theory assumes ; and when a new discovery thus confirms the accuracy of a previous generalization, and gives us additional reason to believe that the glimpses we have gained into the order of Nature are trustworthy, it excites, with reason, among scientific scholars the warmest interest.

And when we consider the vast scope of the molecular theory, the order on order of existences which it opens to the imagination, how can we fail to be impressed with the position in which it places man midway between the molecular cosmos on the one side and the stellar cosmos on the other—a position in which he is able in some measure, at least, to study and interpret both ?

Since the time to which we referred at the beginning of this lecture, when man's dwelling-place was looked at as the centre of a creation which was solely subservient to *his* wants, there has been a reaction to the opposite extreme, and we have heard much of the utter insignificance of the earth in a universe among whose immensities all human belongings are but as a drop in the ocean. When now, however, we learn from Sir William Thomson that the drop of water in our comparison is itself a universe, consisting of units so small that, were the drop magnified to the size of the earth, these units would not exceed in magnitude a cricket-ball,[1] and when, on studying chemistry, we still further learn that these units are not single masses but systems of atoms, we may leave the illusions of the imagination from the one side to correct those from the other, and all will teach us the great lesson that man's place in Nature is not to be estimated by relations of magnitude, but by the intelligence which makes the whole creation his own.

But, if it is man's privilege to follow both the atoms and the stars in their courses, he finds that while thus exercising the highest attributes of his nature he is ever in the presence of an immeasurably superior intelligence, before which he must bow and adore, and thus come to him both the assurance and the pledge of a kinship in which his only real glory can be found.

[1] *Nature*, No. 22, March 31, 1870.

PERSONAL REMINISCENCES OF SOME DECEASED SAVANTS.

By CARL VOGT.

THEY die in such rapid succession! You hardly have time, after returning from a funeral, to think about who is to be the successor of the lamented dead, when you hear of the demise of another illustrious colleague. The members of the Paris Academy of Sciences can scarcely find competent successors for the dead celebrities among the few representatives of the new generation; yet the places of those celebrities must be filled, although everybody knows that the new men will but poorly fill those places. Leverrier, Becquerel, Regnault, Claude Bernard—where are the names among the younger *savants* that equal them, or that might be hoped one day to eclipse their predecessors?

I was fortunate enough to be personally acquainted with these four men, and hence I may be permitted to add to the numerous notices that have been written of their signal scientific achievements some impressions which I have retained from my personal intercourse with them.

In the years 1834 and 1835 I worked as a very young student of medicine in Liebig's laboratory at Giessen—in the summer of 1834 only now and then, but later continually—with the firm determination of turning my back upon medicine as soon as possible, and of becoming a professional chemist. The former resolution I succeeded in carrying out, but I had to leave the chemical career, originally from want of means. At that time only a few young men worked in the laboratory —among them a mercurial, gay Frenchman, who was known all over Giessen on account of a large yellow spot upon his elegantly-made blue coat. Demarçay—that was the name of our Parisian—refused to remove the spot, which had been caused by some sort of acid, nor would he cast the coat aside. In Giessen, he said, there was no tailor competent to mend or only to imitate a Paris-made garment. One day Liebig entered the laboratory with a slender little Frenchman, who wore the same kind of blue coat, but without a spot, and introduced him to us as M. Regnault, a student of the Paris School of Mines, who was to familiarize himself here with organic analysis, then the hobby of *savants*. Demarçay was of dark complexion, with raven-black hair, witty, and fond of practical jokes; Regnault was ruddy and fair, with long, light-colored hair, grave, but confiding. He spoke German very well, and, as he had a seat by my side, we were not long in becoming good friends. He was the perfect type of a rather delicate North-German or Scandinavian youth whom you might have almost taken for a boy of fifteen, so slight and fragile was his form, so amiable and pleasing his whole bearing. After a few weeks he disappeared as he had come. "I must go," he said, "but I hope to be back soon." We were surprised to discover now that Demarçay had had his yellow spot removed—it was owing to Regnault's urgent representations—and, at the same time, we learned that the time granted for scientific journeys to every engineer of the School of Mines had expired in Regnault's case, but that Liebig, who had immediately discerned the eminent talents of the young man, had interceded in Regnault's behalf in Paris, in order that another sojourn at Giessen might be allowed to him. The request was granted, and Regnault came back.

Ten years later my destiny brought me to Paris. Agassiz, with whom I had worked five years at Neufchâtel, had emigrated to America, whither I did not want to accompany him. I was indebted to him for letters of introduction to some of the prominent members of the Academy of Sciences, which was then split into two great parties: one, headed by Arago, embraced the few republicans, the mathematicians and physicists; the other, led by the elder Brongniart, embraced most of the naturalists, the chemists, and the Orleanists. I had been recommended to the latter group; with Arago I was brought into closer contact by several radical Alsacians, whose acquaintance I had made partly during my flight from the gendarmes of his royal highness the Grand-duke of Hesse, and partly afterward in Switzerland. I was to make my living in Paris by reporting the proceedings of the Academy of Sciences for the Augsburg *Universal Gazette.* Upon entering the gloomy hall for the first time, I immediately noticed Regnault; he sat with his dreamy gaze before a few papers, as before the retorts in the laboratory; and, after the lapse of ten years, looked as young and fresh as at Giessen. Thus I saw him for three years in Paris, and again after long intervals; and when, during the Franco-German War, he came to Geneva, broken-hearted because of the death of his excellent son, who, in his youth, had caused him many a pang by his mad freaks, but had afterward filled his heart with just pride and joy, the deep furrows of suffering, and the consequences of a dangerous fall several years before at the porcelain-factory of Sèvres, had been unable to obliterate his youthful appearance completely. But his last years were a long, slow agony; death had made the most cruel gaps in his family already, prior to the death of his son; the war had rudely destroyed the instruments which he had patiently collected for many years at Sèvres, and this destruction had affected him the more painfully, as the utmost precision and the most conscientious calculation formed the most essential peculiarity of his labors. Ever studious to detect the most insignificant sources of errors, to reduce miscalculations to their very minimum, to bring his apparatus and instruments to the highest degree of efficiency and technical perfection, Regnault will always be a shining model for those moving in similar paths of experimental physics.

The elder Becquerel, who died about the same time, at an advanced age, after life-long toils, was already a gray-haired man when I became acquainted with him in the Société Philomatique at Paris. His son, who had a seat beside him in the Academy, was then a zealous member of that society, whose meetings I attended regularly, because it was the favorite debating-ground of the younger *savants*, who displayed more zeal in their discussions than was witnessed in the Academy. The old gentleman frequently accompanied his son, but I never became intimate with him.

Before Haussmann had revolutionized the appearance of Paris, and prior to the Revolution of 1848, there existed a Rue Copeau, leading from the Rue Mouffetard, the headquarters of the rag-pickers, to the small entrance-gate of the Jardin des Plantes, and upon which the grand portal of the Pitié Hospital abutted. Diagonally across the street from this portal there was a house bearing the number 4, where most of the foreign naturalists, who worked for some time at the Jardin des Plantes, had rooms. A well-known anatomist, Strauss-Durkheim, author of an excellent anatomy of the cockchafer, upon which he had toiled for twenty years, presided at the table of the house, and knew how to ingratiate himself with the proprietresses, two spinster ladies, who were as gaunt and slender as Papa Strauss was broad and fat. The rooms had special names, derived from the illustrious zoölogists, anatomists, and botanists, who had inhabited them. For one hundred francs a month I had the two rooms of Johannes Müller on the first floor, overlooking the gardens, together with board. Besides the naturalist boarders, many old friends from the neighboring streets took their breakfast and dinner there. They were mostly quiet people, living on the interest of a small capital, and who attended all lectures at the Jardin des Plantes, at the Collége de France, and even at the more distant Sorbonne, solely because they there found warm rooms in the winter-time. The conversation at the dinner-table was rarely very animated. Papa Strauss, whose bald head emerged from behind a very large green lamp-shade, like the full moon from behind a dark wreath of clouds, grunted discontentedly whenever louder tones fell upon his ears.

But, at times, all Papa Strauss's grunts were fruitless, and such was especially the case when the young medical students of the Pitié Hospital came to visit us, and conversed with the naturalists of the house about the scientific questions of the day. Two of them were remarkably tall. One, a very long, slender, lively, witty, and sarcastic young man, was a nephew of Cloquet, the celebrated surgeon, and, to distinguish him from his uncle, the students called him only "Le Grand Serpent." He went afterward, as physician of the shah, to Persia, and was, during a chase, assassinated by unknown murderers, whom the shah himself had probably hired. The other, by far graver, with a melancholy expression of countenance, was Claude Bernard. Magendie's experiments, Longet's investigations of the physiology of the nervous system, were at that time most eagerly discussed. Claude Bernard said very little, but what he did say was terse and to the point. He only became excited when anybody undertook to question the experiments and achievements of his teacher Magendie, whose assistant he afterward became at the Collége de France.

While he afterward rose step by step from one dignity and distinction to another, ever steadily pursuing those memorable researches which made him the foremost physiologist of our times, I lost sight of him as a personal acquaintance. I came to Paris only in vacation-time, and then Claude Bernard was at his country-seat in the environs of his birthplace, Lyons. If after a youth of terrible privations—very often he did not know in the morning how to get his dinner—he could now feel happy, seeing that everything which the ambition of the *savant* could wish for was offered to him, the highest positions at the universities and in the learned societies, a seat in the Senate, for which he was indebted to his scientific eminence, and not to any political services, he was weighed down, on the other hand, by serious bodily ailments and by the saddest of domestic misfortunes. At first I did not recognize him when, pleasantly and kindly, as of old, but gray-haired, and with his head inclined on one side, he stepped up to me at a provincial meeting, and reminded me of the old times in the Rue Copeau and the Pitié Hospital. "I have passed through a great deal since that time," he said to me, "which may have left some traces in my appearance—for I notice that you look at me in surprise—but let us chat a little about those times and about our old friends; it does me good!"

At the same time I became acquainted with Leverrier. As I have said already in this article, I had been brought into contact with the leaders of the two great parties in the Academy of Sciences, and had been kindly received by both. In the *salons* of Brongniart and Milne-Edwards I saw most of the naturalists; at the house of Martin de Strasbourg, as the well-known deputy was called, I frequently met François Arago, who was then intent upon learning German in order to be able to distinguish the pronunciations of Encke and Hencke, whom, as official reporter of the Academy, he had often occasion to mention. But that genuine son of La Provence was eminently unsuccessful in that respect, nor did he ever learn to pronounce my own name correctly; but, as his German teacher had him to read Schiller's "William Tell," the *vogt*[1] of the tragedy became confounded in his head with the living Vogt, and to the great merriment of everybody he called me "Gessler," to which name he obstinately clung.

One day a young man entered my room. From his appearance I should have unhesitatingly taken him for the son of a Westphalian peasant; for he was fair-haired, rosy-checked, and solidly built. It was Leverrier, who delivered a sort of address to me, confounding Vogt

[1] Governor.

and Gessler all the time, and finally held out to me a quarto volume filled with figures, with the request to promote his election to the Academy. I stared at him as a cow will stare at a new stable-door, and then burst into loud laughter, which almost dumfounded the young candidate. The idea that I should be able to do anything for the promotion of his candidature seemed as ridiculous as he looked upon it as a matter of course. But, when I told him that I deemed my assistance utterly superfluous, and that I had heard all my friends of the Brongniart party talk about his election as a foregone conclusion, he almost embraced me for joy, and said that his visit to me was the most agreeable he had paid for a long time. He urged me to visit him, to see his wife and his little son, and so on. Thus he left me, flushed with excitement, and, when I told a friend at the Jardin des Plantes that the whole affair seemed utterly incomprehensible to me, he said: "You are a novice in such things. Do you know what a candidate for the Academy is? The unhappiest man in the world. He has to hire a carriage for a month; he rides out early in the morning to pay visits, and comes home late in the evening, fearfully tired. He has no time for eating and sleeping; for of nights he dreams of fresh essays, and finally sinks half dead into his easy-chair. He visits everybody, even the cousin of the dress-maker who sews for the aunt of the wife of an academician; and you are surprised that Leverrier should come to see you? After a while, when I am a candidate, I shall also pay you a visit, although I see you every day at the Jardin des Plantes. Otherwise you might take offense."

Leverrier had, at that time, a very pleasant home. His wife was a handsome, amiable woman, his son was a fat, rosy-cheeked boy, and his daily visitor was Arago, who knew how to interest the smallest as well as the largest circles by his lively and witty conversation. He was a republican, like Arago, to whom he was indebted for everything, and whom he afterward treated in a manner which was justly and harshly criticised. For he became a rabid reactionist, and he whom everybody had taken for a frank, noble character was soon looked upon as the most rancorous man in Paris. People admired the astronomical calculator and the indefatigable student; but they hated and even despised the colleague and the superior. I am inclined to think that all the members of the Academy together were not so cordially execrated during their lifetime as Leverrier alone. I was averse to renew my intimacy with the man who had become repugnant to me.

I do not propose to analyze here the scientific merits of the men whom France has recently lost. If Becquerel and Regnault were known only in professional circles, the name of Leverrier is familiar to all who have heard of the planet Neptune, which he so ingeniously discovered; and Claude Bernard is not unknown to cultivated people, as his fertile pen has popularized physiological knowledge and investigations. Only one of the four, Becquerel, was popular as a lecturer; Claude Bernard was the only one among them whose views reached far beyond his special field of knowledge, and, for this reason, he knew how to adapt the style of his writings to the requirements of cultivated society.

In conclusion, I should like to draw attention to one thing. None of these four men, who achieved lasting fame in so many different branches of science, had been originally destined for scientific pursuit. What they were and what they achieved were due to themselves and to their iron will. Becquerel had left the Polytechnic School in 1808, in his twentieth year, had become a lieutenant of engineers, had been promoted to the command of a battalion in the Spanish campaigns, and left the service after the battle of Waterloo in order to devote himself to the study of physics; Leverrier and Regnault had originally been clerks in stores, and had studied in their leisure hours until they were able to gain admittance to the Polytechnic School; Claude Bernard had come to Paris with hardly anything in his pocket but a tragedy, and he had first dabbled in literature. Hard, indescribably hard work, untold privations, and struggles of all kinds, enabled these men to attain the high position which they will always hold in the history of science. To them may be applied what one of my friends once said in regard to an eminent *savant:* "Dans sa jeunesse il a tiré le diable par la queue et mangé de la vache enragée; mais il a réussi, parce qu'il avait le feu sacré!"

EVOLUTION OF CEREMONIAL GOVERNMENT.

By HERBERT SPENCER.

IV. PRESENTS.

When we read that Cook "presented the king [of Otaheite] with two large hatchets, some showy beads, a looking-glass, a knife, and some nails;" or when Speke, describing his reception by the King of Uganda, narrates—"I then said I had brought the best shooting-gun in the world—Whitworth's rifle—which I begged he would accept, with a few other trifles"—we are reminded how travelers in general, coming in contact with strange peoples, propitiate them by gifts. Two concomitant results are achieved. There is the immediate gratification caused by the worth of the thing given, which tends to beget a friendly mood in those approached; and there is the tacit expression of a desire to please, which has a like effect. It is from the last of these that the development of gift-making as a ceremony proceeds.

The alliance between mutilations and presents—between offering a part of the body and offering something else—is well shown by a statement of Garcilasso, respecting the ancient Peruvians; which, at the same time, shows how present-making becomes a propitiatory act apart from the value of the thing presented. Describing people who carry burdens over the high passes, he speaks of them as unloading themselves on the top, and then severally saying to the god Pachacamac:

"'I give thanks that this has been carried,' and in making an offering they pulled a hair out of their eyebrows, or took the herb called *cuca* from their mouths, as a gift of the most precious things they had. Or, if there was nothing better, they offered a small stick or piece of straw, or even a piece of stone or earth. There were great heaps of these offerings at the summits of passes over the mountains."

Though, coming to us in this unfamiliar form, these offerings of parts of themselves, or of things they prized, or else of worthless things, seem strange, they will seem less strange on remembering that at the foot of a way-side crucifix in France may any day be seen a heap of small crosses severally made of two bits of lath nailed together. Intrinsically of no more value than these straws, sticks, and stones, the Peruvians offered, they similarly force on our attention the truth that the act of presentation passes into a ceremony expressing the wish to conciliate. How natural is this substitution of a nominal giving for a real giving, where real giving is impracticable, we are shown even by intelligent animals. A retriever, accustomed to please his master by fetching killed birds, etc., will fall into the habit at other times of fetching something to show his desire to please. On first seeing in the morning, or after an absence, one he is friendly with, he will join, with the usual demonstrations of joy, the seeking and bringing in his mouth a dead leaf, a twig, or any small available object lying near. And this example, while serving to show the natural genesis of this propitiatory ceremony, serves also to show how deep down there begins the process of symbolization; and how, at the outset, the symbolic act is as near a repetition of the act symbolized as the circumstances allow.

Prepared, as we thus are, to trace the development of gift-making into a ceremony, let us now observe its several varieties, and the social arrangements eventually derived from them.

In headless tribes, and in tribes of which the headship is unsettled, and in tribes of which the headship though settled is feeble, the making of presents does not become an established usage. Australians, Tasmanians, Fuegians, are instances; and on reading through accounts of wild American races that are little organized, like the Esquimaux, Chinooks, Snakes, Comanches, Chippewas, etc., or organized in a democratic manner, like the Iroquois and the Creeks, we find, along with absence of strong personal rule, scarcely any mention of gift-making as a political observance.

In apt contrast come the descriptions of usages among those American races which in past times reached, under despotic governments, considerable degrees of civilization. Torquemada tells us that in Mexico, "when any one goes to salute the lord or king, he takes with him flowers and gifts." So too of the Chibchas we read that, "when they brought a present in order to negotiate or speak with the cazique (for no one went to visit him without bringing a gift), they entered with the head and body bent downward;" and among the ancient Yucatanese, "when there was hunting or fishing or salt-carrying, they always gave a part to the lord." People of other types, as the Malayo-Polynesians, living in kindred stages of social progress under the undisputed sway of chiefs, exemplify this same custom. Speaking of the things they bartered to the Tahitian populace for food, native cloth, etc., Forster says: "However, we found that after some time all this acquired wealth flowed as presents, or voluntary acknowledgments, into the treasure of the various chiefs; who, it seems, were the only possessors of all the hatchets and broad-axes." In Feejee, again, "whoever asks a favor of a chief, or seeks civil intercourse with him, is expected to bring a present."

In these last cases we may see how this making of presents to the chief passes from a voluntary propitiation into a compulsory propitiation; for, on reading that "the Tahitian chiefs plundered the plantations of their subjects at will," and that in Feejee "chiefs take the property and persons of others by force," it becomes manifest that present-making has come to be the giving of a part to prevent loss of the whole. It is the policy at once to satisfy cupidity and to express submission. "The Malagasy, slaves as well as others, occasionally make presents of provisions to their chiefs, as an acknowledgment of homage." And it is inferable that, in proportion to the power of chiefs, will be the anxiety to please them, both by forestalling their greedy desires and by displaying loyalty.

In few if any cases, however, does the carrying of gifts to a chief become so developed a usage in a simple tribe. At first, the head-man, not much differentiated from the rest, and not surrounded by men ready to enforce his will, fails to impress other members of the tribe with a fear great enough to make present-giving an habitual ceremony. It is only in compound societies, formed by the overrunning of many tribes by a conquering tribe, of the same race or another race, that there comes a governing class, formed of head-chiefs and sub-chiefs, sufficiently distinguished from the rest, and sufficiently powerful to inspire the required awe. The above examples are all taken from societies in which kingship has been reached.

A more extended form is, of course, simultaneously assumed by this ceremony. For, where along with subordinate rulers there exists a chief ruler, he has to be propitiated both by the people at large and by the subordinate rulers. Hence two kinds of gift-making.

A case in which the usage has retained its primitive character is furnished by Timbuctoo. Here "the king does not levy any tribute on his subjects or on foreign merchants, but he receives presents." But Caillié adds: "There is no regular government. The king is like a father ruling his children." When disputes arise, he "assembles a council of the elders." That is to say, present-giving remains voluntary where the kingly power is not great. Among another African people, the Caffres, we see gifts losing their voluntary character. "The revenue of the king consists of an annual contribution of cattle, first-fruits, etc.;" and "when a Koossa [Caffre] opens his granary he must send a little of the grain to his neighbors, and a larger portion to the king." In Abyssinia, too, there is a like mixture of exactions and voluntary gifts: besides settled contributions taking the form of pieces of cloth and corn, the prince of Tigré receives annual presents. And a kindred system of partially-settled and partially-unsettled donations from people to kings is general throughout East Africa. How, in addition to presents which, having become customary, cease in so far to be propitiatory, there is a tendency to make presents that are propitiatory because unexpected, will be understood on remembering that, where the kingly power has become great, subjects hold their property only on sufferance. When Burton tell us that, in Dahomey, "there is scant inducement to amass riches, of which the owner would assuredly be 'squeezed' as often as he could support the operation;" and when we read of the ancient kings of Bogotá that, "besides the ordinary tributes paid several times a year and other numberless donations, they were absolute . . . lords of the property and life of their subjects"—we may see why, beyond donations which at first voluntary and irregular have become compulsory and regular, there tend ever to grow up new voluntary donations.

If, when a private person brings an offering to his chief or king, the act implies submission, still more does the bringing of an offering by a subordinate ruler to a supreme ruler; here, where disloyalty is more to be feared, the significance of the ceremony as proving loyalty becomes greater. Hence the making of presents grows into a formal recognition of supremacy. In ancient Vera Paz, "as soon as some one was elected king . . . all the lords of the tribes appeared or sent relations of theirs . . . with presents. . . . They declared [at the proclamation] that they agreed to his election and accepted him as king." Among the Chibchas, when a new king came to the throne, "the chief men then took an oath that they would be obedient and loyal vassals, and as a proof of their loyalty each one gave him a jewel and a number of rabbits, etc." Of the Mexicans, Toribio says: "Each year, at certain festivals, those Indians who did not pay taxes, even the chiefs . . . made gifts to the sovereigns . . . in token of their submission." And so in Peru. "No one approached Atahuallpa without bringing a present in token of submission; and, though those who came were great nobles, they entered with the presents on their own backs, and without shoes." The significance of gift-making as implying allegiance is well shown by two contrasted statements in the records of the Hebrews. Of Solomon it is said that "he reigned over all the kings from the river even unto the land of the Philistines and to the border of Egypt;" and also that "all the kings of the earth sought the presence of Solomon . . . and they brought every man his present . . . a rate year by year." Conversely, it is written that, when Saul was chosen king, "the children of Belial said, How shall this man save us? And they despised him, and brought him no presents." Throughout the remote East, the bringing of presents to the chief ruler has still the same meaning. In Japan it was "a duty of each lord to visit and pay his respects at the imperial court once a year, when they offered presents;" and, further, "the secular monarch pays his respect and duty once a year to the mikado . . . by a solemn embassy and rich presents." In China the meaning of the act as expressing subordination is extremely marked. Along with the statement that "at the installation of the great khan four thousand messengers and embassadors who came loaded with presents assisted at the ceremony," we read that the Mongol officers asked the Franciscan friars dispatched by Innocent IV. "whether the pope knew that the grand-khan was Heaven's son, and that the dominion of the earth belonged of right to him . . . what present they had brought from the pope to the great khan." And equally pronounced is the interpretation put upon gift-making to the monarch in Burmah, where, according to Yule, strenuous efforts were made "on former occasions to introduce foreign envoys as suppliants on 'beg-pardon days' among the vassals and dependents of the empire: their presents being represented as deprecatory offerings to avert deserved punishment for offenses against their liege lord."

Nor does early European history fail to exemplify the meanings of present-giving, alike for general propitiation, for special propitiation, and as signifying loyalty. We learn that during the Merovingian period "on a fixed day, once a year, in the field of March, according to ancient custom, gifts were offered to the kings by the people;" and that this custom continued into the Carolingian period: the presents being of all kinds—food and liquor, horses, gold, silver, jewels, garments. We have the fact that they were made alike by individuals and communities: towns thus expressing their loyalty. And we have the fact that from the time of Gontram, who was overwhelmed with gifts by the inhabitants of Orleans on entering it, onward, it long continued the habit with towns thus to seek the good-will of monarchs who visited them, until eventually such presents became imperative. In ancient England too, when the monarch visited a town, present-making, at first by free-will but at length of necessity, entailed so heavy a loss that in some cases "the passing of the royal family and court was viewed as a great misfortune."

Grouped as above, the evidence will suggest to every reader the inference that from propitiatory presents, voluntary and exceptional to begin with, but becoming as political power strengthens less voluntary and more general, there eventually grow up universal and involuntary contributions—established tribute; and that with the rise of a currency this passes into taxation. How this transformation tends ever to take place, and what are the motives which continually press it on, and change extra voluntary gifts into extra involuntary ones, is well shown by Malcolm's account of the usages in Persia. Speaking of the "irregular and oppressive taxes to which they [the Persians] are continually exposed," he says: "The first of these extra taxes may be termed usual and extraordinary presents. The usual presents to the king are those made annually by all governors of provinces and districts, chiefs of tribes, ministers, and all other officers in high charge, at the feast of Nourouze, or vernal equinox. . . . The amount presented on this occasion is generally regulated by usage; to fall short is loss of office, and to exceed is increase of favor."

That under such kind of pressure regular tribute originated from irregular presents, is in various cases implied both by the nature of the things given and by the growing periodicity of the giving. Supposing them to be acceptable, gifts will naturally be made from among those things which people have that are at once the best and the most abundant. Hence it will happen that when they become regular in an extensive kingdom, they will represent the products of the respective districts; as in ancient Peru, where from one province the people sent fragrant woods, from another cotton, from another emeralds and gold, from another parrots, honey, and wax; or as in ancient Mexico, where the towns paid "what the country afforded, as fish, flesh, corn, cotton, gold, etc.; for they had no money." In other cases where the arrangements are less settled, the gifts from the same place are miscellaneous; as, for instance, those made by towns to early French kings—"oxen, sheep, wine, oats, game, wax-torches, confections, horses, arms, vessels of gold and silver, etc." Clearly, if the making of presents passes into tribute in kind, there will result these varieties of articles; determined sometimes by the character of the locality and sometimes by the abilities of individuals.

The passing of present-making into payment of tribute as it becomes periodic, is well exemplified in some comparatively small societies where governmental power is well established. In Tonga "the higher class of chiefs generally make a present to the king, of hogs or yams, about once a fortnight: these chiefs at the same time receive presents from those below them, and these last from others, and so on, down to the common people." Ancient Mexico, formed of provinces subjugated at various times and dependent in various degrees, exhibited several stages of the transition from presents to tribute. Speaking of the time of Montezuma I., Duran says: "The list of tributes included everything. . . . The provinces . . . made these contributions . . . since they were conquered, that the gallant Mexicans might . . . cease to destroy them:" clearly showing that they were at first propitiatory presents. Further we read that "in Meztitlan the tribute was not paid at fixed times . . . but when the lord wanted it. . . . They did not think of heaping up the tribute, but they asked what was wanted at the moment for the temples, the festivals, or the lords." Of the tributes throughout the country of Montezuma, consisting of "provisions, clothing, and a great variety of miscellaneous articles," we are told that "some of these were paid annually, others every six months, and others every eighty days." And then of the gifts made at festivals by some "in tokens of their submission," Toribio says: "In this way it seems manifest that the chiefs, the merchants, and the landed proprietors, were not obliged to pay taxes, but did so voluntarily."

The transition from voluntary gifts to compulsory tribute is traceable in early European history. Among the sources of revenue of the Merovingian kings, Waitz enumerates the free-will gifts of the people on various occasions (especially marriage), besides the yearly presents made originally at the March gatherings, but afterward at other periods about the beginning of the year—voluntary when they began, but increasingly becoming a fixed tax. And then, speaking of these same yearly presents of the people in the Carolingian period, the same writer says they had long lost their voluntary character, and are even described as a tax by Hinckmar. They included horses, gold, silver, and jewels, and (from nunneries) garments, and requisitions for the royal palaces; and he adds that these dues, or *tributa*, were all of a more or less private character; though compulsory, they had not yet become taxes in the literal sense. There is evidence that the voluntary presents, made by towns to potentates on their entry, similarly passed from the voluntary to the compulsory. According to Leber, the express orders of the king were needed to make Paris give presents to the Duke of Anjou in 1584, as also on other occasions to embassadors and foreign monarchs.

In proportion as money-values became more definite, and payments in money became easier, commutation resulted: instance in the Carolingian period, "the so-called *inferenda*—a due originally paid in cattle, now in money;" instance in our own history, the giving of money instead of goods by towns to a king and his suite making a progress through them. The evidence may fitly be closed with the following passage from Stubbs:

> "The ordinary revenue of the English king had been derived solely from the royal estates and the produce of what had been the Folkland, with such commuted payments of feormfultum, or provision in kind, as represented either the reserved rents fron ancient possessions of the crown, or the quasi-voluntary tribute paid by the nation to its chosen head."

In which passage are simultaneously implied the passage from voluntary gifts to involuntary tribute and the commutation of tribute into taxes.

If voluntary gifts, made to propitiate the man who is supreme, by-and-by become tribute and eventually form a settled revenue, may we not expect that gifts made to subordinate men in power, when their aid is wished, will similarly become customary, and at length yield them maintenance? Will not the process above indicated in relation to the major state-functionary repeat itself with the minor state-functionaries? We find that it does so.

First, it is to be noted that, besides the periodic and ordinary presents made in propitiation and acknowledgment of his supremacy, the ruling man in early stages commonly has special presents made to him when called on to use his power in defense or aid of an aggrieved subject. Among the Chibchas, "no one could appear in the presence of a king, cazique, or superior, without bringing a gift, which was to be delivered before the petition was made." In Sumatra, a chief "levies no taxes, nor has any revenue, . . . or other emolument from his subjects, than what accrues to him from the determination of causes." There is a kindred usage in Northwestern India. Of Gulab Singh, a late ruler of Jummoo, Mr. Drew says: "With the customary offering of a rupee as *nazar* [present] any one could get his ear; even in a crowd one could catch his eye by holding up a rupee and crying out, . . . 'Maharajah, a petition!' He would pounce down like a hawk on the money, and, having appropriated it, would patiently hear out the petitioner." There is evidence that among ourselves in ancient days a like state of things existed. "We may readily believe," says Broom, referring to a statement of Lingard, "that few princes in those [Anglo-Saxon] days declined to exercise judicial functions when solicited by favorites, tempted by bribery, or stimulated by cupidity and avarice." And, on reading that in early Norman times "the first step in the process of obtaining redress was to sue out, or purchase, by paying the stated fees," the king's original writ, requiring the defendant to appear before him, we may suspect that the stated amount paid for this document represented what had originally been the present to the king for giving his judicial aid. There is support for this inference. Blackstone says, "Now indeed even the royal writs are held to be demandable of common right, on paying the usual fees:" implying a preceding time in which the granting of them was a matter of royal favor to be obtained by propitiation.

Naturally, then, when judicial and other functions come to be deputed, gifts will similarly be made to obtain the services of the functionaries; and these, originally voluntary, will become compulsory. Ancient records from the East yield evidence. Thus, in Amos ii. 6, it is implied that judges received presents; as are said to do the Turkish magistrates in the same regions down to our day: the assumption of the prophet, and of the modern observer, that this usage arose by a corruption, being one of those many cases in which the survival of a lower state is mistaken for the degradation of a higher state. Thus, again, in early times in France judges received "spices" as a mark of gratitude from those who had won a cause. By 1369, if not before, these were converted into money; and in 1402 they were recognized as a due. The usage continued till the Revolution. In our own history the case of Bacon exemplifies not a special and late practice, but the survival of an old and usual one; local records show the habitual making of gifts to officers of justice and their attendants; and the facts are summed up in the statement that "no approach to a great man, a magistrate, or courtier, was ever made without the Oriental accompaniment—a gift." That in past times the propitiatory presents made to state-functionaries formed, in some cases, their entire revenues, is inferable from the fact that in the twelfth century the great offices of the royal household were sold; the implication being that the value of the presents received was great enough to make the places worth buying. Russia in early days seems to have exemplified the state in which the dependents and deputies of the ruler subsisted chiefly, if not wholly, on presents. Karamsin "repeats the observations of the travelers who visited Muscovy in the sixteenth century. 'Is it surprising,' say these strangers, 'that the grand-prince is rich? He neither gives money to his troops nor his embassadors; he even takes from these last all the costly things they bring back from foreign lands. . . . Nevertheless these men do not complain.'" Whence we must infer that, lacking wages and salaries from above, they lived on gifts from below. Moreover, we are at once enlightened respecting the existing state of things in Russia; for it becomes manifest that what we now call the bribes, which the miserably salaried officials require before performing their duties, are the representatives of the presents which formed their sole maintenance in times when they had no salaries. And the like may be inferred respecting Spain, of which Rose says: "From judge down to constable, bribery and corruption prevail. . . . There is this excuse, however, for the poor Spanish official. His government gives him no remuneration, and expects everything of him."

So natural has habit now made to us the payment of fixed sums for specified services, that, as usual, we assume this relation to have existed from the beginning. But when we read how, in little organized societies, such as that of the Bechuanas, the chiefs allow their attendants "a scanty portion of food or milk, and leave them to make up the deficiency by hunting or by digging up wild roots;" and how, in societies considerably more advanced, as Dahomey, "no officer under government is paid"—we are shown that originally the subordinates of the chief man, not officially supported, have to support themselves. And since their positions give them powers of injuring and benefiting subject persons—since, indeed, it is often only by their aid that the chief man can be invoked—there arises the same motive to propitiate them by presents that there does to propitiate by presents the chief man himself; whence the parallel growth of an income. The inference that the sustentation of political officials begins in this way will presently find verification from its harmony with the inference more clearly to be established, that the sustentation of ecclesiastical officials thus originates.

Since at first the double of the dead man is conceived as being equally visible and tangible with the original, and as being no less liable to pain, cold, hunger, thirst; he is supposed similarly to want food, drink, clothing, etc., and to be similarly propitiated by providing them for him. So that, at the outset, presents to the dead differ from presents to the living neither in meaning nor motive.

All over the world, in lower forms of society, past and present, we find gifts to the dead paralleling gifts to the living. Food and drink are left with the unburied corpse by Papuans, Tahitians, Sandwich-Islanders, Malayans, Badagas, Karens, ancient Peruvians, Brazilians, etc. Food and drink are afterward carried to the grave in Africa, by the Sherbro people, the Loango people, the inland negroes, the Dahomans, etc.; throughout the Indian hills by Bhils, Santals, Kukis, etc.; in America, by Caribs, Chibchas, Mexicans; and the like usage was general among ancient races in the East. Clothes are periodically taken as presents to the dead by the Esquimaux. In Patagonia they annually open the sepulchral chambers and reclothe the dead; as did too the ancient Peruvians. When a potentate dies among the Congo people, the quantity of clothes given from time to time is so great "that, the first hut in which the body is deposited becoming too small, a second, a third, even to a sixth, increasing in dimensions, is placed over it." The motive for thus trying to please the dead man is the same as would have been the motive for trying to please the man while alive. When we read that a chief among the New Caledonians says to the ghost of his ancestor: "Compassionate father, here is some food for you; eat it; be kind to us on account of it;" or when the Veddah, calling by name a deceased relative, says: "Come and partake of this! Give us maintenance, as you did when living!" we see it to be undeniable that present-giving to the dead is the same as present-giving to the living, with the sole exception that the receiver is invisible.

Noting only that there is a like motive for a like propitiation of the undistinguished supernatural beings which primitive men suppose to be all around them—noting that whether it be in the fragments of bread and cake left for the elves, etc., by our Scandinavian ancestors, or in the eatables and drinkables which at their feasts the Dyaks place on the tops of the houses to feed the spirits, or in the small portions of food cast aside and of drink poured out for the ghosts before beginning their meals by various races throughout the world—let us go on to observe the developed present-making to the developed supernatural being. The things given and the motives for giving them remain the same; though the sameness is slightly disguised by the use of different words

—oblations to a deity and presents to a person. The original identity is well shown by the words of Guhl concerning the Greeks: "Gifts, as an old proverb says, determine the acts of gods and kings;" and it is equally well shown by a verse in the Psalms (lxxvi. 11): "Vow and pay unto the Lord your God: let all that be round about him bring presents unto him that ought to be feared." Moreover, we shall find a parallelism in the details that is extremely significant.

Food and drink, which constitute the earliest kind of propitiatory gift to a living person, and also the earliest kind of propitiatory gift to a ghost, remain everywhere the essential components of an oblation to a deity. As, where political power is evolving, the presents irregularly and then regularly sent to the chief, at first consist mainly of sustenance; so, where ancestor-worship, developing, has expanded the ghost into a god, the offerings, becoming habitual, have as elements common to them in all places and times, things to eat and drink. That this is so in low societies at large, no proof is needed; and that it is so in higher societies is also a familiar fact, though a fact ignored where its significance is most worthy to be marked. If a Zulu slays an ox to secure the good-will of his dead relative's ghost, who complains to him in a dream that he has not been fed —if among the Zulus this private act develops into a public act when a bullock is periodically killed as "a propitiatory offering to the spirit of the king's immediate ancestor"—we may, without impropriety, ask whether there do not thus arise such acts as those of an Egyptian king who by hecatombs of oxen hopes to please the ghost of his deified father; but it is not supposable that there was any kindred origin for the sacrifices of cattle to Jahveh, concerning which such elaborate directions are given in Leviticus. When we read that among the Greeks "it was customary to pay the same offices to the gods which men stand in need of—the temples were their houses, sacrifices their food, altars their tables"—it is permissible to observe the analogy between these presents of eatables made to gods and the presents of eatables made at graves to the dead, as being both derived from like presents made to the living; but that the presentation of meat, bread, fruits, and liquors, to Jahveh had a kindred derivation, is a thought not to be entertained—not even though we have a complete parallel between the cakes which Abraham bakes for the refreshment of the Lord when he comes to visit him in his tent on the plains of Mamre and the showbread kept on the altar and from time to time replaced by other bread fresh and hot. Here, however, recognizing these parallelisms, it may be added that though in later Hebrew times the original and gross interpretation of sacrifices became obscured, and though the primitive theory has since undergone gradual dissipation, yet the form survives. The offertory of our Church still retains the words, "accept our alms and oblations;" and at her coronation Queen Victoria offered on the altar, by the hands of the archbishop, "an altar-cloth of gold and an ingot of gold," a sword, then bread and wine for the communion, then a purse of gold, followed by a prayer "to receive these oblations."

Looked at without bias, the evidence coming from all parts of the world thus proves that oblations are at first literally presents. Animals are given to kings, slain on graves, sacrificed in temples; cooked food is furnished to chiefs, laid on tombs, placed on altars; first-fruits are presented alike to living rulers, to dead rulers, to gods; here beer, here wine, here *chica*, is sent to a visible potentate and poured out as libation to an invisible deity; incense, in some places burned before distinguished persons, is burned before gods in various places; and, besides such consumable things, valuables of every kind, given to secure good-will, are accumulated in the treasures of kings and in the temples of gods.

There is one further remark of moment. We saw that the present to the visible ruler was at first propitiatory because of its intrinsic worth, but came afterward to have an extrinsic propitiatory effect as implying loyalty. Similarly, the presents to the invisible ruler, primarily considered as directly useful, secondarily come to signify obedience; and their secondary meaning gives that ceremonial character to sacrifice which still survives.

And now we come upon a remakable sequence. As the present to the ruler eventually develops into political revenue, so the present to the god eventually develops into ecclesiastical revenue.

Let us set out with that earliest stage in which no definite organization, either political or ecclesiastical, exists, and in which the last is represented by the medicine-man, whose function is more that of expelling malicious ghosts than propitiating ghosts regarded as placable. At this stage the present to the supernatural being is often shared between him and those who propitiate him: the supposition, commonly vague and unsettled, being either that the supernatural being takes a substantial part of the food offered, or else that he feeds on its supposed spiritual essence while the votaries consume the material shell. The meaning of this, already indicated in the case of some other early usages, is that while the supernatural being is propitiated by the present of food, there is, by eating together, established between him and his propitiators a bond of union: implying protection on the one side and allegiance on the other. The primitive notion that the nature of a thing, inhering in all its parts, is acquired by those who consume it, and that therefore those who consume two parts of one thing acquire from it some nature in common which binds them together—that same notion which initiates the practice of forming a brotherhood by partaking of one another's blood, which instigates the funeral rite of blood-offering, which suggests the practices of the sorcerer, and which gives strength to the claims established by joining in the same meal, originates this prevalent usage of consuming part of the present of food made to the ghost or the god. In some places the people at large participate in the offering; in some places the medicine-men or priests only; and in some places the last practice is habitual while the first is occasional, as in ancient Mexico, where communicants "who had partaken of the sacred food were engaged to serve the god during the subsequent year."

Here the fact which concerns us is that, from the presents thus used, there arises a maintenance for priests. When we read that the Chippewayan priests "are supported by voluntary contributions of provision," and that the priests of the Khonds have certain perquisites, and receive gifts, we vaguely see how in these rude societies there begins the support of a priesthood out of sacrifices; and in other cases we see this distinctly. Among the Kukis the priest, to pacify the angry deity who has made some one ill, takes, it may be a fowl, which he says the god requires, and, pouring its blood as an offering on the ground while muttering praises, "then deliberately sits down, roasts and eats the fowl, throws the refuse into the jungle, and returns home." In like manner the Battas of Sumatra sacrifice to the gods, horses, buffaloes, goats, dogs, fowls, "or whatever animal the wizard happens on that day to be most inclined to eat." And again we read that, by the Bustar tribes in the Mahadeva hills, Kodo Pen "is worshiped at a small heap of stones by every new-comer, through the oldest resident, with fowls, eggs, grain, and a few copper coins, which become the property of the officiating priest." More developed societies in Africa show us a kindred arrangement. Burton says that, in Dahomey, "those who have the 'cure of souls' receive no regular pay, but live well upon the benevolences of votaries;" and Forbes more specifically states that in their temples "small offerings are daily given by devotees, and removed by the priests." Similarly in the adjoining kingdom of Ashantee, "the revenue of the fetichmen is derived from the liberality of the people. A moiety of the offerings which are presented to the fetich belongs to the priests." It is the same in Polynesia. Ellis, describing the Tahitian doctor as almost invariably a priest, states that he received a fee, part of which was supposed to belong to the gods, before commencing operations. So, too, was it in the ancient states of America. A cross-examination, narrated by Oviedo, contains the passage:

"*Fr.* Do you offer anything else in your temples?

"*Ind.* Every one brings from his house what he wishes to offer—as fowls, fish, or maize, or other things—and the boys take it and put it inside the temple.

"*Fr.* Who eats the things thus offered?

"*Ind.* The father of the temple eats them, and what remains is eaten by the boys."

And then in Peru, where worship of the dead was a main occupation of the living, and where the ecclesiastical system was elaborately developed, the accumulated gifts to ghosts and gods had resulted in sacred estates, numerous and rich, out of which the priests of all kinds were maintained. A parallel genesis is shown us by ancient historic peoples. Among the Greeks "the remains of the sacrifice are the priests' fees," and "all that served the gods were maintained by the sacrifices and other holy offerings." Nor was it otherwise with the Hebrews. In Leviticus ii. 10 we read, "And that which is left of the meat-offering shall be Aaron's and his sons'" (the appointed priests); and other passages entitle the priest to the skin of the offering, and to the whole of the baked and fried offering. Neither does the history of early Christianity fail to exhibit the like development. "In the first ages of the Church, those *deposita pietatis* which are mentioned by Tertullian were all voluntary oblations." Afterward "a more fixed maintenance was necessary for the clergy; but still oblations were made by the people. . . . These oblations [defined as 'whatever religious Christians offered to God and the Church'], which were at first voluntary, became afterward, by continual payment, due by custom." In mediæval times a further stage in the transition is shown us: "Besides what was necessary for the communion of priests and laymen, and that which was intended for eulogies, it was at first the usage to offer all sorts of presents, which at a later date were taken to the bishop's house and ceased to be brought to the church." And then by continuation and enlargement of such donations, growing into bequests, nominally to God and practically to the Church, there grew up ecclesiastical revenues.

Doubtless sundry readers have made on the foregoing statements the running criticism that they represent all presents as made by inferiors to propitiate superiors; and that they ignore the presents having no such purpose, which are made by superiors to inferiors. These, though they do not enter into what can be called ceremonial government, must be noticed. The contrast between the two kinds of presents, in meaning, is well recognized where present-making is much elaborated, as in China. "At or after the customary visits between superiors and inferiors, an interchange of presents takes place: but those from the former are bestowed as *donations*, while the latter are received as *offerings;* these being the Chinese terms for such presents as pass between the emperor and foreign princes."

Naturally it happens that as the power of the political head develops, until at length, with little or no check, he assumes universal ownership, there results a state in which he finds it needful to give back to his dependents and subjects part of that which he has monopolized. And having been originally subordinated by giving, these are now, to a certain extent, further subordinated by receiving. People of whom it can be said, as of the Kukis, that "all the property they possess is by simple sufferance of the rajah," or people who, like the Dahomans, are owned in body and estate by their king, are obviously so conditioned that property having flowed in excess to the political centre must flow down again from lack of other use; and hence in Dahomey, though no state-functionary is paid, the king gives his ministers and officers royal bounty. Without traveling further a-field for illustrations, it will suffice if we note these relations of causes and effects from early European times downward. Of the ancient Germans, Tacitus says: "The chief must show his liberality, and the follower expects it. He demands at one time this war-horse; at another, that victorious lance imbrued with the enemy's blood. The prince's table, however inelegant, must always be plentiful; it is the only pay of his followers." That is, a monopolizing supremacy had, as its sequence, gratuities to dependents. Mediæval times were characterized by modified forms of the same system. In the thirteenth century, "in order that the princes of the blood, the whole royal house, the great officers of the crown, and those . . . of the king's household, should appear with distinction, the kings gave them dresses according to the rank they held and suitably to the season at which these solemn courts were celebrated. These dresses were called liveries because they were delivered," as the king's free gifts; a statement showing clearly how the reception of such presents signified subordination. Down to the fifteenth century on a feast-day, the Duke of Burgundy gave to the knights and nobles of his household "presents of jewels and rich gifts . . . according to the custom of that day;" such presents, in addition to maintenance, house-room, and official dresses for themselves and their servants, probably constituting the sole acknowledgment for their attendance. It need scarcely be added that, throughout the same stages of progress in Europe, the scattering of *largesse* to the people by kings, dukes, and nobles, was similarly a concomitant of that servile position in which such return as they got for their labor in addition to daily sustenance was in the shape of gratuities rather than in the shape of wages. Moreover, we still have, down to our own day, in vails and Christmas-boxes to servants, etc., the remnants of a system under which fixed remuneration was eked out by gifts—a system itself sequent upon the earlier system under which gifts formed the only remuneration.

Thus it becomes tolerably clear that, while from presents offered by subject persons there eventually develop tribute, taxes, and fees, from donations made by ruling persons there eventually develop salaries.

Something must be added concerning presents passing between those who do not stand in acknowledged relations of superior and inferior. Consideration of these carries us back to the primitive form of present-making, as it occurs between strangers or members of alien societies; and, on looking at some of the facts, there is suggested a question of much interest: whether from the propitiatory gift made under these circumstances there does not originate another important kind of social action? Barter is not, as we are apt to suppose, universally understood. Cook, speaking of his failure to make any exchange of articles with the Australians of his day, says, "They had, indeed, no idea of traffic." And other statements suggest that, when exchange begins, there is little idea of equivalence between the things given and received. Speaking of the Ostiaks, who supplied them "with plenty of fish and wild-fowl," Bell says, "Give them only a little tobacco and a dram of brandy, and they ask no more, not knowing the use of money." Remembering that at first no means of measuring values exists, and that the conception of equality of value has to grow by use, it seems not impossible that mutual propitiation by gifts was the act from which barter arose; the expectation that the present received would be of like worth with that given being gradually established, and the exchanged articles simultaneously losing the character of presents. One may, indeed, see the intimate connection between the two in the familiar cases, instanced at the outset, of presents from European travelers to native chiefs; as where Mungo Park writes, "Presented Mansa Kussan [the chief man of Julifunda] with some amber, coral, and scarlet, with which he appeared to be perfectly satisfied, and sent a bullock in return." Such transactions show us both the original meaning of the initial present as propitiatory, and the idea that the responsive present should have an approximately-like value, implying informal barter.

Leaving this speculation, however, we have here to note the way in which the propitiatory present becomes a social observance. Like every other kind of ceremony which begins as an effort to gain the good-will of some feared being, visible or invisible, gift-making descends through successive stages, until it becomes an act of civility between those who, while not actually subordinate one to the other, please one another by simulating subordination. That along with the original form of it, signifying allegiance to a chief or king, there goes the spread of it as a means of insuring the friendship of powerful persons in general, we see in ancient Peru, where, as already said, "no one approached Atahuallpa without bringing a present in token of submission," and where also "the Indians . . . never thought of approaching a superior without bringing a present." And then in Yucatan the usage extended to equals. "At their visits the Indians always carry with them presents to be given away, according to their position; those visited respond by another gift." In Japan, so rigorously ceremonious, the stages of the descent are well shown: there are the periodic presents to the mikado, expressive of loyalty; there is the fact named by Mitford that "the giving of presents from inferiors to superiors is a common custom;" and there is the further fact he names that "it is customary on the occasion of a first visit to a house to carry a present to the owner, who gives something of equal value on returning the visit." Among other peoples we see this mutual propitiation between equals taking other forms. Markham, writing of Himalayan people, states that exchanging caps is "as certain a mark of friendship in the hills as two chiefs in the plains exchanging turbans." And, referring more especially to the Iroquois, Morgan says, "Indian nations, after treating, always exchanged belts, which were not only the ratification, but the memorandum of the compact."

How gift-making, first developed into a ceremony by fear of the ruler, and made to take a wider range by fear of the strong or the influential, is eventually rendered general by fear of equals who may prove enemies if they are passed over when others are propitiated, we may gather from European history. Thus, in Rome, "all the world gave or received New-Year's gifts." Clients gave them to their patrons; all the Romans gave them to Augustus. "He was seated in the entrance-hall of his house; they defiled before him, and every citizen, holding his offering in his hand, laid it, when passing, at the feet of that terrestrial god. These gifts consisted in silver money, and the sovereign gave back a sum equal or superior to their presents." Because of its association with pagan institutions, this custom, surviving into Christian times, was condemned by the Church. In 578 the Council of Auxerre forbade New-Year's gifts, which it characterized in strong words. Ives, of Chartres, says, "There are some who accept from others, and themselves give, devilish New-Year's gifts." In the twelfth century, Maurice, Bishop of Paris, preached against bad people who "put their faith in presents, and say that none will remain rich during the year if he has not had a gift on New-Year's-day." Notwithstanding ecclesiastical interdicts, however, the custom survived through the middle ages down to modern times; until now priests themselves, as well as others, participate in this usage of mutual propitiation. Moreover, there have simultaneously developed kindred periodic ceremonies; such as, in France, the giving of Easter-eggs. And present-makings of these kinds have undergone changes like those which we traced in other kinds of present-makings: beginning as moderate and voluntary, the presents have become extravagant and in a measure compulsory.

It thus appears that, spontaneously made among primitive men by one member of a tribe to another, or to an alien whose good-will is desired, the gift becomes, as society evolves, the originator of many things.

To the political head, as his power grows, the making of presents is prompted partly by fear of him and partly by the wish for his aid; and the presents made, at first propitiatory only from their intrinsic worth, come presently to be propitiatory as expressions of loyalty; from the last of which there results present-giving as a ceremonial, and from the first of which there results present-giving as tribute, eventually developing into taxes. Simultaneously, the supplies of food, etc., placed on the grave of the dead man to propitiate his ghost, developing into larger and repeated offerings at the grave of the distinguished dead man, and becoming at length sacrifices on the altar of the god, differentiate in an analogous way. The present of meat, drink, or clothes, at first supposed to propitiate because actually useful to the ghost or the god, becomes, by implication, significant of allegiance. Hence, making the gift grows into an act of worship irrespective of the value of the thing given; while in virtue of its substantial worth, the gift, affording sustenance to the priest, makes possible the agency by which the worship is conducted; from the oblation originate church revenues.

Thus we unexpectedly come upon further proof that the control of ceremony precedes the political and ecclesiastical controls; since it appears that from actions which the first initiates eventually result the funds by which the others are maintained.

When we ask what relations present-giving has to different social types, we note, in the first place, that there is little of it in simple societies, where chieftainship does not exist, or is unstable. In wandering, headless tribes it manifestly cannot become established and systematized; nor in simple settled tribes of which the headships are nominal. But we find it to prevail in compound and doubly-compound societies, as throughout the semi-civilized states of Africa, those of Polynesia, those of ancient America, etc., where the presence of stable headships, primary and secondary, gives both the opportunity and the motive; and, recognizing this truth, we are led to recognize the deeper truth that present-making, while but indirectly related to the social type as simple or compound, is directly related to it as more or less militant in organization. The desire to propitiate must be great in proportion as the person to be propitiated is feared; and therefore the conquering chief, and still more the king who has made himself, by force of arms, ruler over many chiefs, is one whose good-will is most anxiously sought by acts which simultaneously gratify his avarice and express submission. Hence, then, the fact that the ceremony of making gifts to the ruler prevails most in societies that are either actually militant, or in which chronic militancy during past times has evolved the despotic government appropriate to it. Hence the fact that throughout the East, where this social type exists everywhere, the making of presents to those in authority is everywhere imperative. Hence the fact that in early European ages, while the social activities were militant and the structures corresponded, loyal presents to kings from individuals and corporate bodies were universal; while *largesse* from superiors to inferiors, also growing out of that state of complete dependence which accompanied militancy, was common.

The like connection holds with the custom of making presents to deities. In the extinct militant states of the New World, sacrifices to gods were perpetual, and their shrines were being ever enriched by deposited valuables. Papyri, wall-paintings, and sculptures, show us that among ancient Eastern nations, highly militant in their activities and types of structure, the oblations to deities were large and continual; and that vast amounts of property were devoted to making glorious the places where they were worshiped. So, too, in early militant times throughout Europe, gifts to God and the Church were more general and extensive than they have become in later industrial times. It is observable, too, how, even now, that representative of the primitive oblation which we still have in the bread and wine of the mass and the sacrament (offered to God before being consumed by communicants) recurs less frequently here than in Catholic societies, which are relatively more militant in type of organization; while the offering of incense, which is one of the primitive forms of sacrifice among various peoples, and survives in the Catholic service, has disappeared from the authorized service in England. Nor in our own society do we fail to trace a kindred contrast; for, while within the Established Church, which forms part of that regulative structure developed by militancy, sacrificial observances still continue, they have ceased among those most unecclesiastical of dissenters, the Quakers; who, absolutely unmilitant, show us also by the absence of an established priesthood, and by the democratic form of their government, the type of organization most remote from militancy and most characteristic of industrialism.

The like holds even with the custom of present-giving for purposes of social propitiation. We see this on comparing European nations, which, otherwise much upon a par in their stages of progress, differ in the degrees to which industrialism has qualified militancy. In Germany, where periodic making of gifts among relatives and friends is a universal obligation, and in France, where the burden similarly entailed is so onerous that at Christmas and Easter people not unfrequently leave home to escape it, this social usage survives in greater strength than in England, less militant in organization.

Of this kind of ceremony, then, as of the kinds already dealt with, we may say that, taking shape with the establishment of that political headship which militancy produces, it develops with the development of the militant type of social structure, and declines with the development of the industrial type.

HOW SOUND AND WORDS ARE PRODUCED.

By GEORGE M. SHAW.

THE recent appearance of those remarkable devices the telephone and the phonograph has given such a new interest to the general subject of voice, music, and sound, and the conditions and mechanisms by which they are produced, that a familiar explanation of some of the points involved may be useful at the present time.

Prof. Tyndall, in his work "On Sound," speaking of a tremendous powder-explosion which occurred at Erith, England, in 1864, shattering the windows on every side, though the village was some miles from the magazine, says: "Lead sashes were employed in Erith church, and these being in some degree flexible, enabled the windows to yield to pressure without much fracture of the glass. Every window in the church, front and back, was bent *inward.* In fact, as the sound-wave reached the church, it separated right and left, and for a moment the edifice was clasped by a girdle of intensely-compressed air, which forced all its windows inward."

Now, was this "sound-wave" of compressed air, that struck the church, a wind-storm from the place of explosion? If not, whence all this force? That there was no wind is plain from the fact no dust was raised, nor a leaf stirred from its place. We must look for another explanation.

Suppose that, in the middle of a closely-packed crowd, "room" were suddenly made by pushing back the by-standers. These, thus suddenly losing their balance, would fall back on those behind them, and these in turn on others, and so on to the outsiders. It is easy to see that each one would recover his own balance by pushing against the one behind him, and so the fall-back movement would be seen to pass like a wave through the crowd, each one passing it on as it reached him. In like manner, the push of the expanding gases, at the explosion, was transmitted to the church, the intervening air only passing the push along. If the windows of the church had been elastic, they would have swayed with the air; as it was, they were pushed in, but had no back-spring.

The impulse which struck the church struck many ears in the same way, but their drums taking up the air-push and its back-snap, sent it to the brain, where it was put down as a tremendous sound. Sound, then, is only the beating of air-waves in the ear.

Now, a sound is either a noise or a musical tone. We take a noise to be the blow of a single wave, or an irregular succession of waves striking the ear, while a tone is the sound made by the beating of the same kind of a wave, at regular intervals, in such rapid succession as to form a sound-blend in the ear akin to the spoke-blend presented to the eye by the spokes of a fast-turning wheel.

We have divided sound into *noise* and *musical tones*, and have spoken of a tone, distinguished from noise, as being a sound-blend

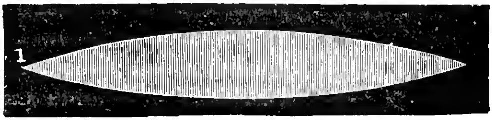


FIG. 1.

made in the ear by the beating of the same kind of a wave, at regular intervals, in rapid succession. Let us prove this. We will strike middle C on a piano. We get a musical tone from its string, which is set a-vibrating, as shown in Fig. 1. But how shall we determine the number of vibrations, for we cannot begin to count them? We will take a tuning-fork, *D*, Fig. 2, that gives the same tone as middle C, thus having the same number of vibrations, and attach with a bristle fastened to one prong by a little wax. This will trace the vibrations, *P*, on the smoked paper *L*. The wave-forms of the marking, counted along either one side, indicate the number of vibrations. We count these wave-forms, and divide by the number of seconds the vibration lasted, and we have the number of vibrations per second corresponding to the tone of the fork. In this case we find "middle C" to vibrate 264 times in a second. In

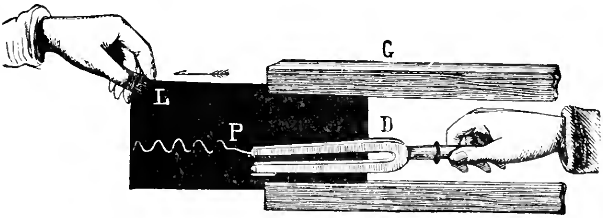


FIG. 2

the same way, we find D to vibrate 297; E, 330; F, 352; G, 396; A, 440; B, 495; and C, again, 528 times per second, just double of "middle C" below. In the same way each of the other tones doubles its vibrations going up, and halves them going down. Thus, from the first A of the bass of a seven-octave piano, to the last A of the treble, we have a range of from 27 vibrations, or pulses, per second to as many as 3,520. The number of vibrations is the same for the same note on any instrument.

We have thus proved, in a simple way, that a musical tone is produced by rapid, *regular* vibration, as shown by the marking—the air-waves, set up by the vibration, seeming to blend in the ear in a manner similar to that in which the vibrations of the string blend to the eye, which makes the tone seem continuous. In this experiment we notice that tones are high or low, according to the number of their vibrations—the higher the tone the greater the number of its vibrations per second. Again, we observe that we can make the same tone loud or soft, without making it higher or lower. We notice that loudness is obtained by striking with greater force, making the string or fork swing farther from side to side, but still swing the same number of times in a second. This force of the swing is given to the air, and carried to the ear, beating it with greater violence than before, but still only the same number of times a second. This width of swing, which makes the loudness of a sound, by a greater compression in the air-wave, is called the *amplitude of vibration*, and corresponds to the height of water-waves, where the amplitude is up and down. In water, the greater the force the higher are the waves. Now, let us turn to the sound-wave in the air, which we will study by the aid of Fig. 3. Here we take an ordinary A tuning-fork, having an elasticity of 440 vibrations per second, and set it a-vibrating. The prong of the fork, in moving from a to a', pushes the layer of air in front of it, which, in its endeavor to recover from this huddling, pushes against the next layer, which is thus in its turn compressed, the compression or push passing in this way, from layer to layer, through the air—the wider the swing of the prong the greater the compression in the air, and the louder the sound; meanwhile the prong moves back from a'

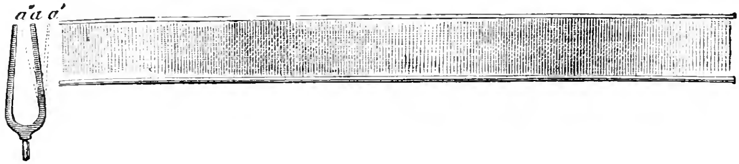


Fig. 3.

to a, causing a vacuum, which is instantly filled up by the return of the air which it had just pushed away. But the fork now swings back to a'', causing the layer of air not only to return to its ordinary density at a, but causing it to expand, in order to fill up the vacuum from a a'', thus producing a rarefaction, or stretch, in the air, which draws back on every other layer, causing a pulse of rarefaction to follow every pulse of compression; in other words, causing a stretch-gap to follow every push. A clear idea of this may be had by again using our illustration of a crowd: the place where some are just falling back on those behind them illustrates the wave of compression, while the gap between those falling back and those who have just recovered their balance illustrates the wave of rarefaction which follows it. An air-wave is made up of a compression and a rarefaction—a push and a stretch—the two being produced in one vibration of the prong, the compression by the motion from a to a', and the rarefaction by the reactive motion from a to a''. On its way back to a, the prong lets up on the stretch, and goes on to a' with another push, and so on as long as it vibrates. These compressions and rarefactions, represented in the figure by its shadows and lights, correspond to the crests and hollows of water-waves.

In water we measure the length of waves (that is, the distance between them) from swell to swell. Sound-waves are measured from huddle to huddle. Now, how are we going to measure this? Let us take the case of water. If we knew that in 100 yards of water there were 100 equal waves, we would know that each wave was one yard in length—that is, that the wave-swells were thus far apart; or, if there were 50, each wave would stretch two yards. We would find the length of wave by dividing the distance covered by the number of waves stretched over it. The length of sound-waves is measured in the same way. We will measure the length, or distance apart, of the waves of our A-fork experiment. Sound travels, in round numbers, 1,100 feet in a second. Now, our A-fork, vibrating 440 times a second, sets 440 sound-waves in motion in a second, so that, at the end of a second, there would be 440 air-waves afloat, and the first one would have reached a distance of 1,100 feet away. Now, there being 440 equal air-waves in 1,100 feet, how far apart are they—in other words, how long is each wave? Dividing the 1,100 feet by the 440 waves, we get two and a half feet, or 30 inches, as the length of the air-waves of the first A-tone above "middle C"—the A-string of a violin. In the same way we find that the *first* A of the bass of our piano produces air-waves about *forty feet* in length, while the waves of the last A of the treble are not quite *four inches* long. We find the length of the air-waves of any musical note—that is, the distance apart of the *pushes* in the air—by dividing 1,100 feet, the distance which the waves would cover in a second, by the number of the note-vibrations per second, which represents the number of air-waves it would make in that time.

One thing we notice in all sounds, and that is their character, or peculiarity. They may be as near alike as they can be made, but each different kind will have something about it which distinguishes it from every other, and it is by this means that we distinguish different instruments or voices. The cause of this is the peculiar shape in which the wave comes from different sources, a sort of individual stamp by which a sound carries the telltale mark of its maker. These different stamps or trimmings of air-waves may be illustrated in Fig. 4, and will

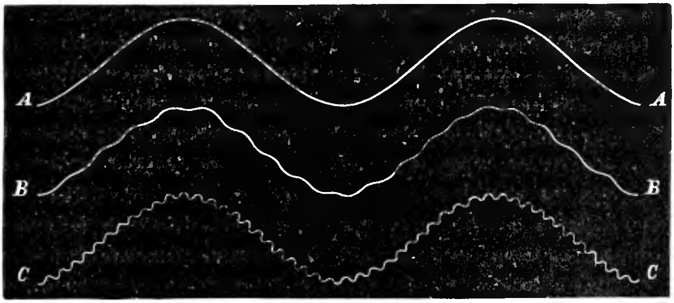


FIG. 4.

be *explained* presently. The heavings represent the compressions, and the hollows the rarefactions, in the air. Let *A* represent the wave-form of the purely ideal tone of the note A with no stamp or quality given to it. *B* might represent the wave-form given it by a piano; and *C*, that given to it by a violin. In each case the wave-length, or distance between swells, and therefore *pitch* of tone, and the amplitude, or size of swells, and therefore *loudness* of tone, are the same; the only difference is, that the last two tone-waves seem to be trimmed with feather-waves, so to speak, the trimming varying with the source of the wave.

A simple noise being a sound-wave, has its wave-form or make-mark. The blending of many such would produce a tone in that likeness; hence, a musical note is a blending of like noises, and every noise is really the first wave, the key-note of a musical tone. Take the ringing of a door-bell. Here the ear hears not only a musical tone, a sound-blend, in the *ring* of the bell, but also the noise of the clapper's clang, clang, clang. The vibrations of the bell throw the air into musical waves, shown in Fig. 5, while a huge clang-wave will sweep

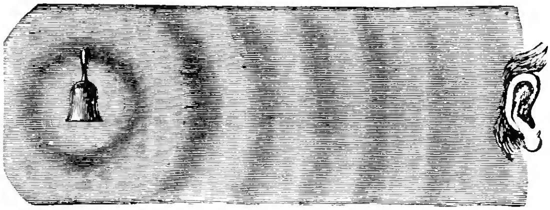


Fig. 5.

along among the *ring*-waves every time the clapper strikes. If these clang-waves were to come along fast enough to blend, and at regular intervals, they would produce a tone of their own. The clanging of the clapper would not be a noise, but a deep tone, perhaps making a chord with the *ring*-tone. But, as it is, the clang-waves come irregularly and slowly, and only a noise is the result. The clang-wave is not represented in the figure, but may be easily imagined. From this we see that different sets of air-waves can move along together, and, though they should conglomerate, the ear can single them out. And now we can explain the peculiar character of different sounds, represented by the different forms of waves in Fig. 4. If the string in Fig. 1 would really vibrate in a clean sweep as it appears to, it would make

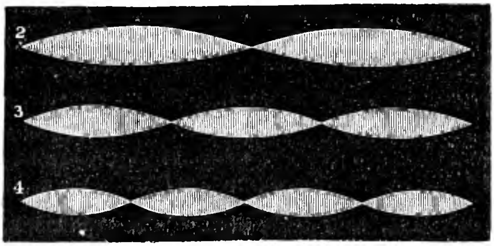


Fig. 6.

a smooth wave-form, like *A* in Fig. 4; but, while it vibrates as a whole, in starting the vibration of the string the sudden jerk on it will run along the string in a sort of wabble-wave to its ends and back again, as long as the string vibrates.

These wabble-waves, in passing each other as they run back and forth on the string in opposite ways, will form stand-still crossing points at distances apart corresponding to the length of the wabble-waves; thus dividing the string into vibrating parts, as in Fig. 6.

These make their own little swift air-waves, while the whole string is making its large and comparatively slow ones, and thus produce what are called overtones—waves within waves. These form the feather-wave trimming spoken of, and shown in Fig. 4. These over-vibrations chord

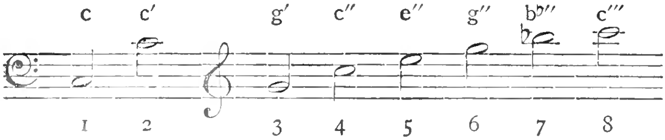


Fig. 7.

or harmonize with the vibrations of the whole string, and are drowned in it, forming a conglomerate air-wave. They are two, three, four, five, six, seven, eight, etc., times the vibration of the whole string, and it is according to which of these over-vibrations is the fullest, that the sound takes its peculiar quality. Sounds without overtones are dull; with too many, harsh and grating; and, with the first six in fair proportion, are rich and sweet. Fig. 7 represents in musical language the overtones of the note C of 132 vibrations; number 1 being the whole string, the other numbers denoting the overtones up to the eighth, the first six being those that give richness to the tone, and of these, one or another being the most prominent according to the source from which the note comes.

We have said that the overtones are drowned in the tone—only stamping or trimming it, but they can be picked out. Let us see now how we can pick these overtones out of the conglomerate.

It is found that a column of air one-fourth the wave-length, of any note's air-waves, will resound to that note and to no other. Let us take our A-fork again with 440 vibrations per second, making a wave-length of 30 inches, and when vibrating hold it over a tall jar as in Fig. 8. The column of air may not be the right length. By pouring in water a point will be reached at which the jar will burst into the tone A with the fork. By pouring in more water it stops. A certain length only will resound A. Measur-

Fig. 8.

ing the resounding column of air, from the water to the top of the jar, we find it to be $7\frac{1}{2}$ inches, one-fourth the length of the A-wave. Now, by making a resounder of this size, with an ear-opening in the bottom, we shall have an instrument that will pick out A every time from a sea of sound. This resonator is shown in Fig. 9; and Fig. 10 shows another form of the same instrument. Resonators tuned to the different

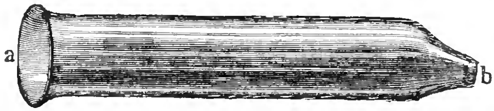


Fig. 9.

notes are made, and by their aid any sound can be analyzed, and each overtone brought out like the throbbing of a single string.

In this way it has been found that the peculiar character, or stamp, of any sound depends on its overtones, and furthermore on exactly what ones, so that by reproducing them any sound can be imitated. Of all sounds those of the human voice are the sweetest. None others are so rich in harmonic overtones, and this brings us to Words.

The vocal mechanism is made in two pieces. One, a wonderful musical instrument with only *one vibrator*—the vocal chords, Fig. 11—which can tune itself at once to any note. The other, the mouth, as an echo-cave or resonator, no less wonderful in its power of forming itself to resound the harmonics of the vocal tones. This gives the

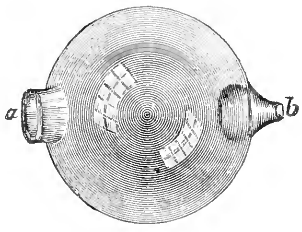


Fig 10.

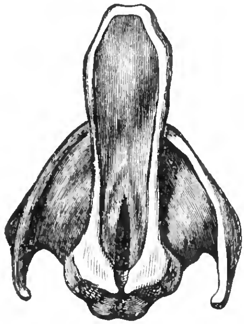


Fig. 11.

voice its power of imitating any sound within its reach. We will analyze the voice.

Let the vocal chords sing or vibrate any note, and by merely changing the hollow of the mouth the purely musical sound will turn into what are called the *vowel*-sounds of speech, the closest position of the mouth making it *ee*, the deepest *oo*. Why is this, since the musical note is the same in each? It is because the different positions of the mouth resound to different overtones. While some vowel is sung we hold different resonators to the ear until we find the overtones. They must be the cause of the *vowelizing* of the tone sung. To prove it we take a tuning-fork vibrating the note of that vowel's overtone as found by the resonator, and, holding it in front of the mouth, we shape the mouth until it resounds to the tuning-fork. Keeping the mouth in this position, we sound the vocal chords, and the result is the vowel, thus proving that that particular overtone is its stamp. And so each vowel-sound is found to be due only to different overtones of the tone sung, brought out by the resonance of the mouth. Mixing in some of the other overtones forms the distinguishing peculiarity of individual voices.

Vowel-sounds, then, are really an exquisite musical harmony, being nothing but "chords" of the tone with its different overtones, different "chords" making different vowels. The common musical scale is derived from a tone and its overtones, by making, on separate strings, full tones corresponding to the overtones of some fundamental string-tone. That which produces a "chord" in music, where the harmony is made by full tones, would produce a vowel if the main tone only were full, and the "chording" tones overtones. When, then, a vowel is sung, high or low, it is still the same vowel at a different pitch—that is, the same "chord" in another key. But "chords" are music, and music means air-waves, so that vowels are musical air-waves. But vowels alone, which are only musical tones, will not make speech. Yet, by breaking into the vowel-tone with certain expressive noises called consonants, we can give the vowel-tone such a turn as to make its motion a copy of a motion of sensation, which, reaching the mysterious mechanism of an ear, will be changed back into a sensation.

It seems strange that words should be nothing but music broken up by different expressive noises, but we all know how differently we are affected by different noises. And in music it is recognized that different keys produce different effects ; certain keys better than others, exciting certain emotions. But what are certain keys but certain vibrations, and these vibrations but certain motions? And, again, what are emotions but *derived motions*, which again are but vibrations?

To illustrate, let us follow the transmutations of a sensation. Let a "consciousness" be excited. That means motion, and from that tense focus the emotion rushes through the nerves, losing in intensity as it gains more room—that is, the more nerves there are that are set in vibration the slower the vibration becomes—music still and in the same key, but lower down the scale. Suppose the key of the emotion or sensation to be the one that moves the hand, then the hand will act. Suppose the key to be the one whose "chords" the vocal mechanism plays in, then that will take up the nerve-waves, which will thus be transformed into air-waves, but who can tell how many octaves below the pitch of the sensation-waves in the nerves? The waves have passed as through a lens, and been magnified like mites in a magic-lantern. Suppose the sensation to have made one speak the word "hope." We cannot explore the nerve-waves, but, projected in the air, they become a picture that we can study. First there is the rough breathing or tremor *h*, then the mouth tunes itself for the musical tone *o*. Suppose the *o* to be made in a man's voice at a pitch A, below middle C. The *o*-making overtone is its octave overtone or second, which in this case will be A above middle C, the pitch to which the mouth will resound. Besides this prominent overtone, *o* has some feeble *third* and *fourth* overtones, and for the *personal* peculiarity say a little *fifth*. What is

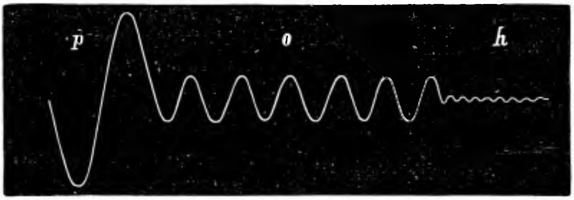


FIG. 12.

this *o*, then? A tone-vibration of 220 per second, frilled with overtone vibrations of 440, 660, 880, and 1,100 *per second*. In the air, on its way to an ear, this *o* is a matter of air-waves 5 feet in length, filled in with waves of 30, 20, 15, and 10 inches in length, and—let us be thankful that we do not have to understand *o* before we can exclaim it. Following this, the mouth suddenly shuts up and pushes off the vowel-ripples with a noisy billow *p*. Fig. 12 will give an idea of the "hope" waves going through the air, end-foremost, of course, as they were spoken. And so words follow each other in sets of waves like the above, with rests between the sets made by the pauses between words.

Now, how far will these waves be loud enough to be heard—that is, how long will they keep strong enough to beat the drum-head of an ear? The farther they go the more they spread, and the weaker they become. A strong voice may be heard at an eighth of a mile, or about 700 feet. As sound travels 1,100 feet per second, it follows that, in less than a second after being spoken, the waves become too weak to make words. Let us be quick, then, to find what they are saying. Sun-waves, spreading from a focus, may be brought again to a focus by condensing them with a lens. So the

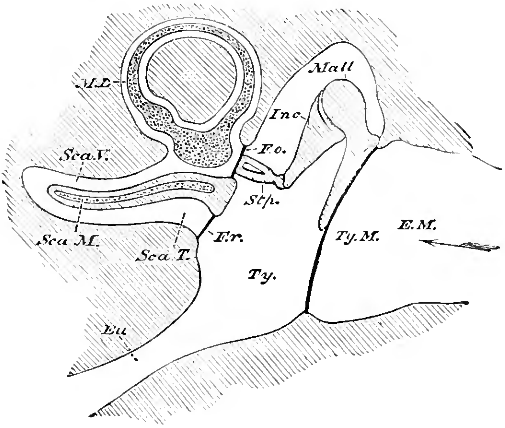


FIG. 13.

sensation-waves, which spread from a focus, may be brought again to a focus by condensing them with an *ear* (Fig. 12). Here, across a little echo-cave, is hung a curtain, *Ty. M.*, which is blown in and out as each air-wave beats against it; and, though the air-waves vary from 40 feet to 4 inches apart, they jump the distance quickly, and this curtain, taking an exact copy of each, in vibrations less than the thousandth part of an inch, sends them, through the tapping bones, *Mall.*, *Stp.*, to an inside curtain, *F.o.*, where they are condensed again, and thrown through a liquid which fills the hollow inside of it. Here three thousand tuned nerves take up, each, its own accchording waves, and bear them to the brain; and thus the wild waves of an emotion passed from one "consciousness" to another in less than a second, proving that the "quickness of thought" is no metaphor. Through pipes, the *sound* of the voice may be heard nearly four miles, and conversation carried on at nearly a mile. Through the wire of the *telephone*, which has become literally the "thread of a conversation," sound, with all its qualities, is conveyed hundreds of miles, as we have already shown in a former article.

THE SCIENTIFIC STUDY OF HUMAN TESTIMONY.

By GEORGE M. BEARD, M. D.

I.

"Of what account are the most venerated opinions, if they be untrue? At best they are only venerable delusions."—Sir William Hamilton.

ABOUT two years ago I chanced to call on an educated professional man, who was much interested in the subject of delusions. He said, "I have been long wishing to see you, in order to get an explanation of some strange things that have happened under my observation." I inquired what these strange things were. He replied, as usual in such cases, by giving a detailed account of certain performances of a well-known trickster, to which I listened as politely as I could, and he concluded with this conundrum: "Now, how do you explain that?" I replied: "I do not know what happened, for there was no expert there to report. If I knew what happened, I could very likely explain it, for a knowledge of what happened would itself be the explanation." "But I have just told you what happened," he interposed, somewhat excitedly. "My wife and I both were there, and we saw it all, with our own eyes. Can't we trust our senses?" "Trust our senses?" I replied; "not at all. In science we never trust our senses." My friend was as much astonished and indignant as though he had been personally insulted, and I felt it to be prudent to withdraw from the house.

Quite recently, while conversing with a scholar and logician of far more than usual powers, we chanced to talk of the alleged feats of levitation, and he asked me how they were to be explained. I told him that there was no evidence that they had ever occurred; and that it was known deductively, by the established laws of physiology, that they had not and could not occur. I furthermore stated that claims of this sort could be and should be only studied by experts; that experiments with living human beings could only be conducted by experts in cerebro-physiology, and that probably there were not half a dozen persons in the world capable of making experiments of that kind. My friend failed to see the justness of this view, and confessed himself unable to understand how so simple a matter as the rising of a body in a room could not be settled by the eyes of any honest, well-balanced man. "Why," said he, "if a dozen George Washingtons should testify that they had all seen a man rise in the air, I should be compelled, by the rules of evidence, to believe them. What is the need of an expert in a matter of simple eyesight and common honesty?"

I refer to these conversational experiences, because they represent, in a concrete form, the present attitude of scholars and logicians toward the principles of evidence.

That these instances are not exceptional is proved by the literature of science, of religion, of logic, and of law, in all of which departments the subject of human testimony is more or less discussed. Neither in Whewell's "History of the Inductive Sciences" nor in Jevons's "Principles of Science" do we find a correct or thorough analysis of human testimony, on which all science depends; by these authors, as much as by religious, apologetic writers, it is assumed that the senses are to be trusted. In the department of logic we do not find, either in Mill or Hamilton, any attempt even to build up a science of human testimony which must everywhere constitute the premises of reasoning, and by which the results of reasoning are to be determined. Constantly Sir William Hamilton reiterates that logic deals only with the forms of reasoning, and is not at all responsible for the premises; but nowhere does he point out, in a satisfactory manner, the principles on which premises are to be obtained. It is true that Bacon, under the fantastic titles, "Idols of the Tribe," "Idols of the Den," "Idols of the Forum," and "Idols of the Theatre," first pointed out some of the more obvious sources of error, and writers on logic repeat his views; but other sources of error, equally important but far more subtile, are not referred to even in the most recent treatises on reasoning. Students of science, particularly of physiological science, and, above all, experimenters with living human beings, must either trust to their instincts, as many do, or find out for themselves, by study and experience, the special sources of error in researches of this character, and guard against them.

Coming to law, we find that Prof. Greenleaf, one of the most valued writers on the principles of evidence, says that "the credit due to the testimony of witnesses depends upon, firstly, their honesty; secondly, their ability; thirdly, their number and the consistency of their testimony; fourthly, the conformity of their testimony with experience; and, fifthly, the coincidence of their testimony with collateral circumstances." Here we observe that honesty is placed before ability, while under ability no distinction is drawn between general and special ability—in other words, between the non-expert and the expert. In the formulated statement of the principles of evidence from which this extract is taken, not only is there no distinction made between expert and non-expert, but no recognition of the fact that the senses of honest and unbiased witnesses may be, through a variety of causes, untrustworthy.

The mistakes in the administration of justice are already numerous, but they would have been more so if judges and juries had not instinctively rejected the principles of evidence thus taught by the highest authorities in jurisprudence.

All modern science is the product of exclusively expert evidence: until an expert develops, there can indeed be no science; and yet, one may look in vain through all the authors on logic for a satisfactory definition of an expert, or for any detailed arrangement of tests by which expertness is to be estimated.

The subject of human testimony has, in short, never been scientifically studied; practical rules for the guidance of those who employ it are all that either logic or law has yet given to the world. As some of these practical rules are based on incorrect assumptions in regard to the value of human testimony, they frequently lead to serious error, and, as they fail to draw just distinctions between the good and bad in evidence, or to give special suggestions for special cases, they are oftentimes of no assistance whatever. This criticism is not made in the way of complaint, for only within the past few years has it been possible to even begin the scientific study of human testimony, while nearly all of our writers on this subject belong to the past generations,[1] and the few later authors mostly copy the errors and imperfections of their predecessors.

Human testimony comes from the human brain: the scientific study of human testimony is only possible through a knowledge of the human brain in health and disease, and is therefore a department of cerebro-physiology and pathology. Only recently have the laws of cerebro-physiology and pathology been sufficiently understood, even by

[1] It may perhaps be objected to this statement that many so-called apologetic and skeptical writings are of recent date; but writers of this class, on both sides, as well as the controversialists on the spiritualism question, assume, without discussion, the principles of evidence as taught in logical and legal text-books. On every page of the writings of the Tübingen school, as De Wette, Bauer, Paulus, Straus, as well as of their opponents in Germany and in the Bampton Lectures, we find evidences of the imperative need of a reconstruction of the principles of evidence. This need is fully admitted by the late Mr. Mozley, in the preface to the third edition of his "Lectures on Miracles."

the very few who cultivate that specialty, to enable them to formulate principles for the scientific study of that most important product of the human brain—human testimony. If, then, Bacon and Descartes, Hume and Hamilton, Whewell and Jevons, Greenleaf and Wharton, have failed to adapt their analyses of the principles of evidence to the needs of our time, their failure is due to the backwardness of physiology and pathology that must constitute the basis of the study of evidence, and on which the foundations for a reconstruction must be laid.

We do not yet know all of the human brain, either in health or disease; but our knowledge of it is sufficiently advanced to make it possible to see, with considerable clearness, its relation to testimony. If we do not know just how the cerebral cells evolve thought, we do know that thought is evolved by them or through them, and that various diseases of the brain and nervous system—now pretty well understood, but of which, twenty years ago, little or nothing was known—may utterly destroy the objective worth of thought, and render it, scientifically speaking, valueless.

The progress of cerebro-physiology and pathology, in recent times, has been mostly along the line of the Involuntary Life—a phrase which I have elsewhere and often used to designate those phenomena of mind or body, or of both, in their reciprocal relations, that are independent of will or consciousness, or of both. This Involuntary Life is the branch of physiology that has been least studied and least understood; its importance, however, is supreme, not only in itself, but on account of its relations to all other sciences. It is the one strategic point of modern thought, around which all the leaders in controversy are unconsciously gathering, and for the possession of which opposing hosts will soon contend. Here, as I have previously shown, is the last stand of modern delusions, of every name and form.[1]

The scientific study of human testimony requires a recognition of these three facts, in the physiology and pathology of the brain:

1. *The Limitations of the Human Brain in Health.*—Literature is so crowded with laudations of the human intellect, from the classic apostrophe of Hamlet—"What a piece of work is man! how noble in reason! how infinite in faculty! in form and moving, how express and admirable! in action, how like an angel! in apprehension, how like a god!"—down to the motto of Sir William Hamilton: "On earth there is nothing great but man; in man is nothing great but mind;" and so strong is the tendency in man to view himself from one side only, and to compare himself with the lower animals, or even with inorganic matter, that we are scarcely prepared for the conclusion to which a scientific study of the subject compels us, that, considered from all points of view—from what is above and beyond it, as well as from what is below and near it, from the aspirations that can never be realized, the vast but simple problems of the universe that it hopelessly strives to

[1] "The Scientific Basis of Delusions; or, a New Theory of Trance," etc., 1877.

solve, as well as from the narrow strip of territory it has subjected to science—the human brain is an organ of very limited capacity.

If some superior being endowed with superhuman, though not necessarily divine powers, should attempt to analyze the mind of man—to assign its relative position in creation, and to place it, properly ticketed and labeled, in some supra-terrestrial museum—it would be found to be a far less imposing object than man's own imagination has pictured it. If it be claimed, as it may be by some, that although this brain has thus far achieved but little, although, whether considered in the aggregate, the average capacity in many nations and through many generations, or, concretely in cases of individual and exceptional genius—as Socrates, Napoleon, Goethe, Newton, Shakespeare—it has fallen so far short of its desires and aims and apparent needs as not to merit the encomiums that poets and philosophers have lavished upon it, yet it has before it in this world, and in our present mode of being, a future of possibly infinite development, I may reply that the study of human testimony is in no way affected by such possibility, since it has to do only with the brain in the past, the present, or the near future.

The whole subject of the limitations of the human brain[1] is of high import, is very wide in extent, and suggestive practically as well scientifically and in ways almost innumerable, some of which I hope to point out at a future time; but, for the present purpose, the reconstruction of the principles of evidence, it is necessary to refer only to the following illustrations:

[1] The number of distinct thoughts of which the mind is capable in a given time is very limited, and can be estimated by experiment with considerable precision. Says Sir Henry Holland:

"Within a minute I have been able to coerce mind, so to speak, into more than a dozen acts or states of thought so incongruous that no natural association could possibly bring them into succession. In illustration I note here certain objects which, with a watch before me, I have just succeeded in compressing, distinctly and successively, within thirty seconds of time—the Pyramids of Gizeh, the ornithorhynchus, Julius Cæsar, the Ottawa Falls, the rings of Saturn, the Apollo Belvedere. This is an experiment I have often made on myself, and with the same general result. It would be hard to name or describe the operation of mind by which these successive objects have been thus suddenly evoked and dismissed. There is the volition to change; but how must we define that effort by which the mind, without any principle of selection or association, can grasp so rapidly a succession of images thus incongruous, drawn seemingly at random from past thought and memories? I call it an effort because it is felt as such, and cannot be long continued without fatigue.

"In commenting upon this a writer in *Nature* says: 'This is a curious subject which easily admits of experiment, but it will be found that the velocity with which thoughts can be made to succeed each other depends entirely upon the degree of similarity or connection between them. Judging from my own experience and that of three students well qualified to test the matter, I find that, where the objects thought of are as incongruous as possible, the number which the mind can suggest to itself in a minute varies from twelve, the result of Sir Henry Holland, up to about twenty. Any one who tries the experiment, however, will find that there is an almost insuperable temptation to go off on lines of association. To avoid these, and yet to think rapidly, requires a very disagreeable effort, becoming more and more painful by repetition. When the thoughts are restricted with-

1. The fact that success, even with the most richly-endowed natures, is only possible through specialism.

2. The imperfections and uncertainties of memory.

3. The exceedingly narrow limitations of the senses.

4. The fact that the best results of cerebral activity are largely involuntary, if not unconscious.

Specialism is not peculiar, as some would believe, to modern science or recent civilization ; all the famous Greeks were specialists: one could not conceive of a Socrates, Homer, Phidias, Pericles, Demosthenes, and Sophocles, combined in a single individual. Although poetry and philosophy, being nearly allied, have been the twin products of one superlatively endowed intellect—although Goethe has demonstrated the possibility of uniting the genius of song with the genius of speculative science—yet no human being as yet proved himself at once great in poetry and mathematics. The combination of a Newton and Milton seems impossible; a conclusive and crushing deductive argument against the theory of the Baconian origin of Shakespeare's plays is, that no single brain could have produced the "Novum Organum" and "Hamlet."

In the present century, science has become so specialized that all the advances are made by specialists in comparatively restricted fields, by men whose entire energies are concentrated for a lifetime in some single path of research beyond which they never wander, and in which alone they are accepted as guides. So universal is this law of specialism that the instincts of men regard with suspicion any one who attempts to become an authority on more than one branch of science, while literature is so split up into divisions and subdivisions that eminence in all is unattainable. The lopping away of all superfluous branches, that bearing boughs may live, is carried to such an extreme that only one branch remains, and through this the whole cerebral force circulates. The human mind is like a stream which carries along the same amount of water, whether it flows through one channel or many. In spite of all the criticisms of specialism and specialists, the work of specialization has gone on, and in obedience to the law of evolution must yet go on; specialists are our sole authorities, even among those who despise them:

in certain grooves, as it were, the result is more rapid succession. Thus one student was able to think in a minute of thirty different kinds of actions, forty-six animals, fifty places or fifty persons. I can myself think, without much effort, of thirty-two animals or forty places or persons, in a minute. Even in these cases, however, it will be found that the rapidity greatly depends upon the degree in which the objects have been associated. When thoughts have been very closely and frequently linked together, the number of which may be compressed within a minute is much greater. I find that I can count about ninety-six in half a minute, which, without allowing for the two places of figures, gives one hundred and ninety-two thoughts per minute. I can think of every letter in the alphabet in five seconds at most, which is at the rate of more than three hundred per minute. Finally, by counting the first ten numbers over and over again, I have compressed nearly four hundred changes of idea within the minute.'"

science and specialism are identical; not to specialize is to lose the prizes of life. Germany, which in philosophy and science does the original thinking of the world, is, as we all know, a nation of specialists.

There are, it is true, degrees of specialism, and the term is largely a relative one: in medicine, where the word is mostly used, and where until recently it has been a term of more or less reproach, all general practitioners are really specialists, since medicine and surgery are both offshoots from the professions of the priest and the barber; in biology, some are authorities only on paleontology, others on natural history in general, others on some special branch, as entomology, others still on some one insect, as the bee; and this subdivision is continually going on with the evolution of systematized knowledge. These statements may be truisms to students of sociology, but they are truisms that are forgotten by all the writers on testimony, although, as we shall see, they lie at the root of the reconstruction of the principles of evidence.

Equally important in its bearings on the scientific study of testimony is the recognition of the fact that memory is far more untrustworthy than has been commonly supposed. But a very small fraction of the impressions made on the cerebrum are so far retained as ever to be called up at will. Theoretically, the brain is like a target on which every idea that is evolved makes a permanent impression which no subsequent impressions can thoroughly destroy; practically, it is rather like a series of sieves by which thoughts are sifted through various stages below and on the borders of consciousness and recollection, while only the coarser and larger grains are retained where they can be used when needed. Under the stress of special excitements—as in the terror of drowning or protracted falling, or in trance, impressions long forgotten are revived and rise to temporary consciousness, so that men suppose that the panorama of all their past lives is passing before them; but, even under such exceptional crises, it is certain that only a comparatively few of our mental impressions actually reappear; some long-forgotten events arise with vivid distinctness, and the startled subject believes that all his life is let loose.

Nearly all the acquisitions and experiences of life are forgotten, even by the best memories; only the tiniest trifle of past events or past knowledge can ever be recalled. How dreams are forgotten we all know, but the difference between the recollection of sleeping and waking thoughts is only one of degree; by the standard of memory, all life is a dream. The pleasant experiences of infancy and early childhood, which, if they could be recalled at will, would so enrich and glorify human existence, are to us as though they had never been; as maturity appears, childhood dies.

Children really, as compared with adults, have very poor memories; they forget almost everything; even in infancy the experiences of each year are wiped out by the experiences of the succeeding year; bright babies pass through a succession of hobbies in their various games and sports, and methods of speech and conduct, likes and repulsions, and so forth, which are successively and almost completely forgotten. The whole process of education, public and private, is based throughout on the imperfections and uncertainties of memory. If it were possible for youths to retain what they read, or hear, or see, our schools and colleges might be closed, or, at least, remain open but one month in a year. With children, as with adults, life is but a series of unrememberable experiences; to live is to forget.

All boasted human learning is a temporary treasure, a loan rather than a permanent gift, which must be watched and tended every moment lest it slip from our possession. Truly has it been said that scholarship consists not in knowledge but in knowing where knowledge can be found: he is the learned man who knows not the contents of books but what the best books in any specialty are. School and academy and university graduates, who after years of active and it may be eminent professional life look over the examination-papers of *alma mater* and the catechisms of their childhood, find invariably that outside of the special lines of their lives they are unable to answer correctly and with certainty the simplest questions, and must conclude that all the wisdom of the world is with sophomores and school-children. Even special departments are, through the limitations of human capacity, so minutely specialized that one soon despairs of remembering anything more than what belongs to the daily routine in the pursuit of a specialty; an original author in science must continually refer to the books he has written, lest he forget his own discoveries.

Some experiments that I have made with the memory, the full details of which are to be published elsewhere, give results that are of the highest significance in their bearings on the study of human testimony. These experiments were modeled in part on the familiar "Russian game," so called, which is sometimes practised by the young as an amusement, and which consists in telling some short story to a party, who at once repeats it, or all that he remembers, or thinks he remembers, to another party, and so on through a series of half a dozen or more individuals. In order to make the experiment a fair one, and of value in the study of memory, the story designed as a test should be short and simple, and should be written out and clearly stated to the individual who stands second in the series. The second individual takes a third individual into another room, writes out the story from his recollection and reads it, the third party does the same by the fourth, and so on. When all the stories are compared, at the close of the experiment, this general result is invariably reached:

1. No two of the stories agree. All have departed more or less widely not only from the original, but from the account which they themselves directly received from the person next to them in the series.

No one has succeeded in remembering just what his neighbor told him, although he wrote down instantly what he heard.

2. In some of the stories interpolations occur, as well as omissions. These additions are sometimes of an important nature, seriously modifying the thought of the original, and, what is more strange is, that these are frequently believed by the authors to be parts of the original; they are sure that they have given only what was given to them, and are astonished and incredulous when a comparison is made between the original and the others in the series. Not only the phraseology but the thought is changed.

Another method of experimenting with the memory is, to repeat the same story to a number of individuals separately, and then, after all have written out by themselves without conference what they can remember, to compare the results.

Experiments of this kind, it will be observed, are made under every conceivable advantage: there is no haste; there is no excitement, at least after the novelty is over; there are no distractions; the power of recollection of words and facts is at its best. The accounts are written down instantly as they are received; they are consequently the virgin impressions on the brain. I have made these experiments with intelligent, liberally-educated persons of both sexes, and have repeated them sufficiently often to demonstrate that the results noted here are laws and not exceptions; and it is as clear as any fact in science can be, that works like Boswell's "Life of Johnson," and Goethe's conversations with Eckermann, and Luther's "Table-Talk," and indeed all conversational literature, must be regarded as representing the tendencies of the heroes of the conversations, the general drift of their uttered thought, rather than the precise language employed, or the order in which the statements were made. Certain phrases often repeated by an eminent man in the presence of his friend may be in some instances literally transcribed, especially if they are of an original and striking character; but exact details of long conversations are never recalled—except perhaps by certain prodigies of whom I shall presently speak. Interviewing reporters are sometimes unjustly censured for intentionally interpolating errors in their published statements. The day following an interview, or even five minutes after, neither party can tell precisely what has been said, although sufficient may be remembered for practical needs. Conversation can only be accurately reported when it is taken down at once as the words are uttered. Conversations reported weeks, months, and years, after their occurrence, must be not only wide, but very wide, of the facts; and, besides the positive omissions, there must be, in all cases, interpolations or additions both of fact and of language which the author is confident, and very likely has all along been confident, that he received from the original. The subjective is confounded with the objective, and there is no way by which they can be distinguished.

These experiments bear directly and obviously on history and on legal testimony, they show the hollowness of much of what is called historic evidence, and the uselessness of the attempt so often made in court to force or coax witnesses to give the exact language used by them, or to them, or in their presence. I once told a short story to a person who has the most remarkable memory both for words and facts of any one whom I have ever met, and requested him to at once repeat it. He attempted to do so, and not only changed the phraseology, but left out one of the most important details. In some cases I have requested the subjects experimented on to wait a week or ten days, and then to write out what they remember, or think they remember, of what was told them. In all cases there will be variations from the original of greater or less importance, according to the nature and complications of the story, and the special memory of the individual. One person, a scholar of unusual verbal memory, after carefully studying a short story, consisting of less than one hundred words, and waiting ten days, made eight blunders.

In elaborately comparing the recitations of experienced and eminent actors and actresses with the originals of plays, I find that serious verbal changes, both of omission and interpolation, are constantly made. Dramatic teachers say that pupils cannot accurately retain a long part; that blundering is everywhere the rule. Shakespeare, in his choicest passages, is almost always, unintentionally if not unconsciously, altered even by his most skilled and practised interpreters.

The statement made by Renan in his latest work, on "The Origins of Christianity," that persons who do not know how to read and write have a better memory for oral communications, is not confirmed by my experiments thus far; scholars and thinkers remember words and ideas better than the ignorant and unreading classes. Those who do not know how to read and write find it hard, according to my experiments, to retain in memory a short and simple sentence, even for an instant. Not only memory of words, but of facts and objects of common observation, is more limited than is supposed.

In another series of experiments I tested the power of recalling the objects that fell upon the vision. If a number of persons enter a room containing a number of articles of furniture, with various colors on the walls and in the carpet, and in which certain complex gestures or motions or manœuvres are made by some one, there will be no agreement in their reports, even if made at once, and no report will be accurate.

For years philosophers and critics have been asking how long time is required to make a myth. The answer is found in these experiments. A myth can be made in a minute. These interpolations and additions to reported conversations, of the truth of which the reporter, at the time and subsequently, is so fully persuaded, that only by a comparison with the written original can he be undeceived, are the products of the reporter's own mind—the unconscious substitution of the subjective for the objective words and phrases and thoughts of his own brain, which, perhaps, have long been parts of his mental possessions, rise up like ghosts in the midst of his narration, throw aside the original words and phrases and thoughts, and take their places so perfectly and so harmoniously that the intrusion is not suspected.

It may be said—indeed, it is often said—that memory is a distinct and narrow faculty, in no way correlated to other and more important faculties, and that its perfectness or imperfectness has little relation to the cerebral force. Even if this view of the nature of memory were the correct one, it would not invalidate what is here claimed of the relation of memory to human testimony. But this theory of the nature and office of memory is not the correct one; it is opposed to all that is known of the brain and of its functions, whether studied physiologically or psychologically. Memory is simply a register of a small fraction of the impressions made on the brain; there are, therefore, as many different kinds of memory as there are different faculties or combinations of faculties. Memory is a measure of mind; but, as there are as many varieties of memory as there are varieties of talents in man, the memory of any man can only measure the talent peculiar to himself. We remember what we have a capacity to comprehend. Any man, it has been said, is willing to admit that his memory is poor, but no one will admit that his judgment is poor; and yet judgment is largely the result of memory. One may have a good judgment in some departments, but a very poor judgment in other departments; but, in those departments in which the judgment is good, the memory must also be good.

The relation of memory to mind is illustrated, if not demonstrated, in the early and late history of infant prodigies, such as blind Tom the musician, Colburn the mathematician, and the famous "boy orator." An analysis of the mental powers of any of these prodigies brings out these four facts common to them all: 1. Extraordinary memory in some one department; 2. Correspondingly extraordinary genius in that department; 3. Marked and unusual deficiency of other mental qualities, amounting in some instances to idiocy; 4. Decline of their special gifts corresponding to the development of other faculties on reaching maturity. "In monstrosities Nature reveals her secrets;" the physiology of mind, the general relation of mind to brain, and the relation of memory to mind, can all be studied effectively through infant prodigies. In no class of beings are the limitations of the human brain so thoroughly demonstrated as in these very prodigies that are supposed to illustrate in a marvelous way the capacities of intellect: all their special endowments are bestowed at the price of general endowments; the ordinary is sacrificed to the extraordinary. If they ever mature and become well-balanced citizens, the particular genius that made their childhood famous must correspondingly suffer. Even the average child, as we have seen, loses its memory in certain directions as it advances to maturity; hence the common but erroneous belief that the memory of children is better than the memory of adults. In truth, average children remember far less in quantity than adults, and they remember different things according to their age and taste. With children as with adults, and as with prodigies, the memory, scientifically studied, is an exact measure of mind, and in all, old and young, its limitations are so great as to impair most seriously the value of most of human testimony, even in matters of every-day life; while in all science, or the capacity of the human brain for observing systematized knowledge, for thinking and for remembering, is so limited that the world must defend, and practically, in the face of all the teachings of logicians and authorities on evidence, does defend, and rests its faith exclusively on, the testimony of experts, and in claims of new discoveries, especially against antecedent probability, on the testimony of a few only, and those of the very highest character—experts of experts—the opposing testimony of millions and millions of non-experts, though concurring and including the best and wisest of mankind, through all the ages being justly regarded as worse than worthless.

THE GROWTH OF THE STEAM-ENGINE.[1]

By Professor R. H. THURSTON,
OF THE STEVENS INSTITUTE OF TECHNOLOGY.

VI.

THE STEAM-ENGINE OF THE FUTURE, AND ITS BUILDER.

HAVING thus rapidly outlined the history of the steam-engine, and of some of its most important applications, we may now take up the question—

What is the problem, stated precisely and in its most general form, that engineers have been attempting here to solve?

After stating the problem, we will examine the record with a view to determine what direction the path of improvement has taken hitherto; and, so far as we may judge the future by the past, by inference, to ascertain what appears likely to be its course in the present and in the immediate future. Still further, we will inquire what are the conditions, physical and intellectual, which best aid our progress in perfecting the steam-engine.

This important problem may be stated in its most general form thus:

To construct a machine which shall, in the most perfect manner possible, convert the kinetic energy of heat-motion, as derived from

[1] An abstract of "A History of the Growth of the Steam-Engine," to be published by D. Appleton & Co.

the combustion of fuel, into mechanical power, using steam as the receiver and conveyer of that heat.

The problem embodies two distinct and equally important inquiries: The first, *What are the scientific principles involved in the problem, as stated?* The second, *How shall we construct a machine that shall most efficiently embody and accord with not only known scientific principles, but also with all well-settled principles of engineering practice?*

The one question is addressed to the man of science; the other to the engineer. They can only be satisfactorily answered, even so far as our knowledge at present permits, after studying with care the scientific principles involved in the theory of the steam-engine, under the best light that science can afford us, and by a careful study of the various steps of improvement that have already taken place, and of accompanying variations of structure, analyzing the effect of each change and tracing the reasons therefor. The theory of the steam-engine is too important and too extensive a subject to be treated in even the space available for a complete course of college lectures; and we can only here attempt an exceedingly concise statement of the principles, pointed out by science, as those applicable in the endeavor to increase the economic efficiency of the steam-engine.

The teachings of science indicate that, in the modern steam-engine: *Success in economically deriving mechanical power from the energy of heat-motion will be the greater as we work between more widely-separated limits of temperature, and as we more perfectly provide against losses by dissipation of heat in directions in which it is unavailable for the production of power.*

Scientific research has proved that, in all varieties of heat-engines, a very great loss of effect is unavoidable from the fact that we cannot reduce the lower limit of temperature, in working, below a point that is far above the absolute zero of temperature : the point corresponding to the mean temperature of the surface of the earth in our latitude is now practically our lower mean limit of temperature. The higher the temperature of the steam, however, when it enters the engine, and the lower the temperature at which it leaves the cylinder, and the more thoroughly we provide against waste of heat by conduction and radiation, and of power by friction, the greater will be our success.

Now, looking back over the history of the steam-engine, we may rapidly note the prominent points of improvement and the most striking changes of form ; and we may thus obtain some idea of the general direction in which we are to look for further advance.

Beginning with the machine of De Caus, at which point we may first take up an unbroken thread, it will be remembered that we there found a single vessel performing the functions of all the parts of a modern pumping-engine ; it was at once boiler, steam-cylinder, and condenser, as well as both a lifting and a forcing pump.

The Marquis of Worcester, and, still earlier, Da Porta, divided the engine into two parts; using one part as a steam-boiler, and the other as a separate water-vessel.

Savery duplicated those parts of the earlier engine which acted the several parts of pump, steam-cylinder, and condenser, and added the use of the jet of water to effect rapid condensation.

Newcomen and Cawley next introduced the modern type of engine, and separated the pump from the steam-engine proper: in their engine, as in Savery's, we notice the use of surface-condensation first; and, subsequently, that of a jet of water thrown into the midst of the steam to be condensed.

Watt finally effected the crowning improvement of the single cylinder-engine, and completed this movement of differentiation by separating the condenser from the steam-cylinder, thus perfecting the general structure of the engine.

Here this movement ceased, the several important processes of the steam-engine now being conducted each in a separate vessel. The boiler furnished the steam; the cylinder derived from it mechanical power; the vapor was finally condensed in a separate vessel; while the power, which had been obtained from it in the steam-cylinder, was transmitted through still other parts to the pumps, or wherever work was to be done.

Watt also took the initiative in another direction: He continually increased the efficiency of the machine by improving the proportions of its parts and the character of its workmanship; and thus made it possible to render available many of those improvements in detail which are only useful when the parts can be skillfully made.

Watt and his contemporaries also commenced that movement toward higher pressures of steam, used with greater expansion, which has been the most striking feature noticed in the progress of the steam-engine since his time. Newcomen used steam of barely more than atmospheric pressure, and raised 105,000 pounds of water one foot high, with a pound of coal consumed. Smeaton raised the steam-pressure to eight pounds, and increased the duty to 120,000. Watt started with a duty of double that of Newcomen, and raised it 320,000 foot-pounds per pound of coal, with steam at ten pounds. To-day, Cornish engines of the same general plan as those of Watt, but worked with forty to sixty pounds of steam, and expanding three to six times, do a duty that will probably average, with good ordinary engines, 600,000 foot-pounds per pound of coal.

The increase of steam-pressure and expansion which has been seen since Watt's time has been accompanied by a very great improvement in workmanship, a consequence of rapid increase in the perfection and the wide range of adaptation of machine-tools, of higher skill and intelligence in designing engines and boilers, increased piston-speed, greater care in obtaining dry steam, and in keeping it dry until thrown out of the cylinder—either by superheating, or by steam-jacketing, or by both means combined; and it has been further accompanied by greater attention to the important matter of providing carefully against losses by conduction and radiation, and by internal wasteful transfer of heat. The use, finally, of the "compound" or double-cylinder engine for the purpose of reducing friction, as well as of saving some of that heat which is usually lost in consequence of internal condensation and reëvaporation due to great expansion, has already been considered when treating of the marine engine.

It is evident that, although there is a limit, which is tolerably well defined, in the scale of temperature, below which we cannot expect to pass, using the now standard type of engine, a degree gained in approaching this lower limit is more remunerative than a degree gained in the range of available temperature, by increasing the maximum temperature. Hence, the attempt made by the French inventor, Du Trembly, a quarter of a century ago, and by other inventors since, to utilize a larger proportion of heat by approaching more closely the *lower* limit, was in accordance with what are now well-known scientific principles.

The form of engine here referred to is known among engineers as the Binary Vapor-Engine. In it the heat usually carried away by the water delivered from the condenser of the steam-engine is made to evaporate some very volatile liquid, as ether or carbon bisulphide, which, in turn, by the expansion of its vapor, develops additional mechanical power. Mechanical difficulties have hitherto prevented the success of this form of engine; but it cannot be pronounced impossible that coming inventors may make the system commercially valuable.

An important consequence of the still unchecked rise of piston-speed in the modern steam-engine is the approach to a limit beyond which the now standard form of "drop cut-off," or "detachable" valve-gear, cannot be used. For the piston would, at that limit of speed, reach the end of its stroke before the dropped valve could reach its seat, and the point of cut-off and degree of expansion could no longer be determined accurately and invariably by the governor. This limit has probably already been attained in some engines; and the engineer adopting such piston-speeds as 1,000 feet per minute or more is driven back to the use of the older types of "positive-motion" valve-gearing, and is compelled to devise special forms of governor which shall have sensitiveness, and yet power sufficient to control these less tractable kinds of mechanism, and to invent reliable and durable forms of balanced valves, and to practise every practicable expedient for making the movement of the valve, and its adjustment by the regulator, perfectly easy. Positive motion and ease of adjustment by the governor are, therefore, evidently the requisites of a successful valve-gear for the engine which will probably succeed the standard engine of to-day.

We may now summarize the results of our examination of the growth of the steam-engine thus:

1. The process of improvement has been one, primarily, of "dif-

ferentiation;" the number of parts has been continually increased, while the work of each part has been simplified, a separate organ being appropriated to each process in the cycle of operations.

2. A kind of secondary process of "differentiation" has, to some extent, followed the completion of the primary one, in which secondary process one operation is conducted partly in one and partly in another part of the machine. This is illustrated by the two cylinders of the compound engine, and by the duplication noticed in the binary vapor-engine.

3. The direction of improvement has been marked by a continual increase of steam-pressure, greater expansion, special provision for obtaining dry steam, higher piston-speed, careful protection against loss of heat by conduction or radiation, and, in marine engines, by surface condensation.

The direction of improvement, as indicated by science as well as by our own review of the actual steps already taken, would seem to be: *En résumé*, working between the widest attainable limits of temperature, and the saving of heat previously wasted in the apparatus or rejected from it.

Steam must enter the machine at the highest possible temperature, must be protected from waste or loss of heat, and must retain, at the moment before exhaust, the least possible proportion of originally available heat. He whose inventive genius, or mechanical skill, contributes to effect either of these objects—to secure either the use of higher steam with safety, or the more effective conversion of heat into mechanical power without waste, or the reduction, by transformation into work, of the temperature of the rejected working-fluid—confers an inestimable boon upon mankind.

In detail, in the engine proper the tendency is, and may be expected to continue, in the near future at least, toward higher steam, greater expansion in more than one cylinder, steam-jacketing, superheating, a careful use of non-conducting protectors against waste, and higher piston-speed with rapid rotation, and to the adoption of special proportions and of forms of valve-gear adapted to such high-speed engines.

In the boiler, more complete combustion, without excess of air passing through the furnace, is sought, and a more thorough absorption of heat from the furnace-gases. The latter may be ultimately found most satisfactorily attainable by the use of a mechanically-produced draught, in place of the far more wasteful method of obtaining it by the expenditure of heat in the chimney.

In construction, we may anticipate the use of better materials, as already seen in the substitution of "mild steels" for the cruder material, iron, and more careful workmanship, especially in the boiler, and still further improvement in forms and proportions of details.

In management, there is an immense field for improvement, which improvement we may feel assured will rapidly take place, as it is now becoming well understood that care, skill, and intelligence, are absolutely essential to economical management, as well as to safety, and that they repay liberally all the expenditure of time and money that is requisite to secure them. It is truer of labor than of anything else in the market that "the best is the cheapest."

In attempting improvement in the directions that I have indicated, it would be the height of folly to assume that we have reached a limit in any one of them, or that we have even approached an impassable limit. If further progress seems checked by inadequate returns, when efforts are made to advance, in any promising direction, beyond present practice, it becomes the duty of the engineer to detect the cause of such hinderance, and, having found it, to find a way to remove it, if such removal is not physically impossible.

A few years since the movement toward the expansive working of high steam was checked by experiments seeming to prove positive disadvantage to follow advance beyond a certain point. A careful revision of results, however, showed that this was true only with engines built, as was then common, in utter disregard of all the principles which should have been observed in such use of steam, and of the precautions necessary to be taken to insure the gain which science has taught us should follow the intelligent use of higher pressures of steam. The obstructions are purely physical and mechanical, and it is for the engineer to remove them.

An analysis of the methods of waste of heat, in the operation of the modern steam-engine, would show that a very large proportion—nearly all, in fact—is due to the rejection of unutilized heat with the exhaust-steam. In the best engines in general use this loss amounts to from eight-tenths to nine-tenths of the total amount of heat derived from the fuel. Modern steam-engines lose nearly all wasted heat in this way; the losses by conduction and radiation are comparatively small. It is at once evident that the only way in which any very great additional economy can be secured is to reduce to a minimum the quantity of heat remaining at the opening of the exhaust-valve, and then to retain this rejected heat within the system, so far as is possible, and to thus prevent its waste by escape from the system. The reduction of the great quantity of heat left for rejection at the end of the stroke of the piston can only be effected, to any important degree, by expedients which check that internal condensation and reëvaporation which, with great expansion, transfer to the condenser, unutilized, an immense amount, often, of the heat supplied. As already stated, these expedients are the use of dry steam, the adoption of the steam-jacket and of high engine-speed, and the use of a material for the interior lining of the cylinder which has the least possible conductivity.

The retention of the heat actually rejected from the cylinder, and its complete utilization by reworking, is practically a matter of difficulty, although not certainly impossible;[1] and the author has proposed a new type of steam-engine, in which the water of condensation and the steam rejected from the engine shall be separated and returned, by pumps of proper proportion and construction, to the boiler. The return of the water demands the expenditure of an insignificant amount of power. To return the rejected steam with its charge of heat—which usually forms so large a proportion of the total heat generated by the combustion of the fuel, assuming all transfer of heat to the exhaust by the operation of internal condensation and reëvaporation to have been prevented—demands the expenditure of precisely the amount of power which has been developed by its expansion. In an ideal engine of this type, therefore, the efficiency is perfect, and all heat-energy is utilized by transformation into mechanical energy; but the engine cannot develop as much power as an engine of the common type of the same size. The size of engine will be nearly inversely proportional to the "efficiency of the fluid" under similar conditions in this and the ordinary type of engines. The heat rejected from the cylinder has been degraded so low on the scale of temperature as to be no longer available for the production of power; nevertheless, restored to the boiler, it serves with perfect efficiency as a basis upon which to "pile up a new stock of utilizable energy" in the form of heat derived from the furnace, and at a higher temperature.

The obstacles to the realization of this theoretically perfect type of engine are those which make it so difficult to reduce internal condensation and reëvaporation, and those conditions of practice which make the engine of this type exceptionally bulky and mechanically inefficient.

Whether this type of heat-engine can ever be made of practical value will be determined by the rate of condensation of steam expanding against a resisting piston; the extent to which high pressures and great expansion can be practically carried; the extent to which internal transfer of heat, without doing work, can be reduced; the practical limit of engine-speed; and the perfection attainable in the engine considered as a piece of mechanism. All these conditions remain to be experimentally determined, and it is only by their determination that it can be known whether the "Steam-Engine of the Future" will greatly exceed the engine of to-day in efficiency, and whether this newly-proposed type may ultimately succeed.

That the changes in practice already indicated may go on almost indefinitely seems unquestionable. That this latter modification of the steam-engine will ever actually take place, and become generally adopted, cannot be as positively asserted. We may, at least, hope that it may.

We have seen that the most important problem offered the engineer

[1] "On a New Type of Steam-Engine," etc., by R. H. Thurston, *Journal of the Franklin Institute*, October, November, December, 1877. "Proceedings of the American Association for the Advancement of Science," 1877.

for solution is a double one, and that it requires the aid of both the scientist and the mechanist in its solution.

But it is sufficiently evident that, before the engineer can determine what form of machine will best yield to him full control of these forces of Nature, he must have sufficient knowledge of science to be able to understand what scientific principles are to be rendered available, and what phenomena of Nature are operating in the production of the power which he is to seize upon and usefully to apply. Otherwise, he will grope in the dark, and will only learn, by the bitter experience of costly failures, to make slow progress toward perfection.

We have seen that the larger proportion of the principal improvements which have yet been effected in the steam-engine were due to the united engineering skill and experience and scientific attainments of James Watt. We have seen that his improvements followed a long course of intelligent and truly scientific research ; and that, directed by the results of this investigation, the engineering talent and the mechanical knowledge of the great inventor accomplished more in a single lifetime than had been previously accomplished in the whole period embraced in the history of civilization.

This great example confirms what we should infer from the nature of the problem itself, that—

He who would accomplish most in the profession of the mechanical engineer must best combine scientific attainments—and especially experimental knowledge—with mechanical taste and ability and a good judgment refined by engineering experience.

As one of our oldest engineers[1] tells him, he must "cultivate a knowledge of physical laws, without which eminence in the profession can never be securely attained." He must become familiar not only with science and the arts, but he must train himself to make the one assist the other; he must learn just how to make use of scientific principles in planning his work, and how to do his work most thoroughly, efficiently, and economically, when he has determined his general design. He must be able to determine how far standard designs are in accordance with correct scientific and mechanical principles, to detect their defects and the causes of those defects, and to provide a remedy correct in principle and mechanically efficient. Science and Art must always work hand-in-hand.

But how are the rising generation of engineers to acquire this proficiency in both branches of knowledge? How are they to be made mentally and manually accomplished; how fitted for the great work which is laid out for them?

The time has gone by when, in any art, the ignorant and merely dexterous workman can compete with even a less skillful shopmate, who possesses and uses brains as well as hands, and knows how to make the the one direct and aid the other. We to-day find him occupying a

[1] Charles Haswell.

decided vantage-ground who is at the same time familiar with the schools and at home in the workshop. For whatever department in the arts a youth may be designed, he must, to insure success in the future, be taught not "*in either the school or the workshop*," the alternative formerly offered him, but in the school *and* the workshop.

Here, then, arises the necessity for TECHNICAL AND TRADE SCHOOLS, in which, if properly conducted, knowledge is imparted so as not only to train the mind to habits of thought and study, to give it capacity for logical deduction and the rapid acquirement of information, but in such manner as shall at the same time make the student familiar with the principles of the art which he is to practise, and shall prepare him to learn the lessons taught, in the workshop and in the manufactory, rapidly and well.

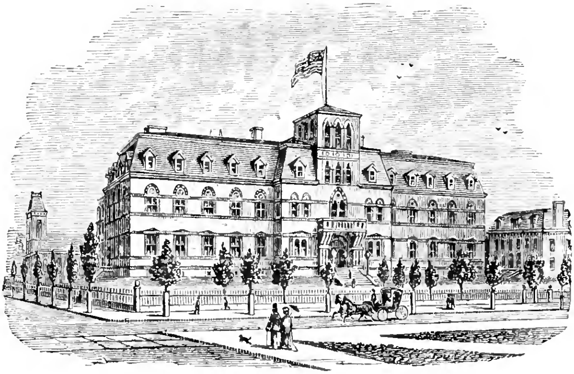
It is the tardy recognition of these facts, of this vital necessity, that has placed a great nation, formerly far in advance of all others in manufactures and the useful arts, in a position relatively to her neighbors that is causing the greatest uneasiness to the more intelligent of her people and to all her statesmen. They see other nations, who were formerly far behind, now rapidly overtaking her, if not already taking the lead, in consequence of their earlier adoption of a system of technical instruction for their people.

Two hundred years ago, Edward Somerset, the second Marquis of Worcester, the inventor, whose work has become familiar to us, admonished his fellow-countrymen of the growing necessity of such a system of education for the people, and urged the establishment of technical schools. For this he deserves higher honor than for his improvements in the steam-engine. But the system first took a definite shape, a century ago, upon the Continent of Europe ; and, during the past half-century, it has grown with the growth and strengthened with the strength of the western European nations, until, to-day, it has become a most important element of their national power.

In our own country, this great need has long been recognized ; but the policy of our Government has not permitted it to institute systems of teaching at the expense of the nation, as has been done in European countries, and it has remained to a great degree unprovided for. It is to our sad deficiency in this respect, and to the tardy and unconcerted action of our educators and our legislators—few of whom seem to have the calibre of the real statesman—that we are to-day so seriously behind Continental nations in the industrial education of youth, and are threatened with serious evils in the future. Without general and systematic technical and trade education, the most enterprising people on the globe, brought into competition in the markets of the world with better-educated people and with nations of trained artisans, must inevitably become a great nation of paupers.

Such education cannot be provided at the small cost that the working-man can afford to pay ; and, even if that were possible, it is doubtful whether the vital necessity of such education, to the people rather than to the individual, and to the coming rather than to the present generation, would be sufficiently well understood by the average citizen to induce the payment of its actual cost, far below its full value as it may be.

It becomes, therefore, the privilege and the duty of the wealthy among our citizens to provide this great want of our country, and to aid thus most effectively in giving her that preëminence among nations that every patriotic citizen desires her to attain.



THE STEVENS INSTITUTE OF TECHNOLOGY.

THE RELATION OF THE FINITE TO THE INFINITE.

BY N. J. GATES.

ALL human knowledge is limited—limited by the power of the senses, limited by the scope of the senses, limited by the imperfections of the senses. The eye cannot see an atom, because of its minuteness; it cannot measure the sun or the stars, because of their vastness; it can only be trusted to take the approximate and comparative measure of a limited class of objects within certain distances.

This conscious narrowness is realized in all the special senses and all the faculties of the intellect.

We have pains so slight that we never feel them, yet in their aggregate effect they may be fatal; and a fatal blow that shall at once strike down every nerve of sensation would produce as little conscious pain. Consciousness cannot mark its own beginnings or endings; it can only realize intermediate stages. We have no consciousness of how or when we *began* to see, or feel, or think, and we will probably have as little as to their mode of termination. As conscious physical beings (we are not discussing the question of immortality), the cradle and the grave meet in one mystery. It is the putting *on* and the putting *off* of consciousness; all that lies between we call life—finite, limited life.

Now, it seems plain that a mind so restricted by the senses can never form a just conception of the infinite. How utterly impossible it is for us to grasp the idea of endless space or endless time! To suppose there is an end to space is to suppose something *beyond*, and this must be space. To suppose there was a moment when time began is to suppose there was a moment *before* it began, and this must have been time also. Let us conceive God to be the highest possible ideal of the Infinite; let us assume that he had no beginning, and that he fills with his presence all space. But we cannot conceive of a universal, all-pervading God without all-pervading space; and, consequently, if God had no beginning, neither had space, and if space had no beginning, neither had time. Then, as a sequence, God did not *create* time or space, for they were prerequisites to his own existence. Hence our highest conceptions of God *condition* him of necessity.

Now, it may be asked, "Does this line of reasoning prove there is no God?" Not at all. It simply proves that the *finite* mind is utterly impotent to apprehend God. It proves that we do not and cannot comprehend primary causation; that our perceptive faculties are so limited by the very nature of their constitution that they cannot apprehend the primary nature of the simplest natural law; and if we cannot comprehend the nature of the *force* called gravity, or heat as a mode of motion, except as physical *facts*, how can we have any rational conception of any of those matchless qualities of mind that produced these laws? If the rude savage, after examining for the first time a complicated piece of machinery, can form no just conception of the forces that impel it, or even of the purpose it serves, how much less can he understand the peculiar qualities of mind that invented and produced it! If, by dint of deepest research, we cannot analyze the subtile law that connects the molecular movement of the brain with thought, how can we analyze the thoughts of an Infinite mind of which this law was but a thought? Is it not plain that, in attempting this, we attempt the impossible?

Let us give a simple illustration to show how utterly incompetent is the finite mind to grasp the idea of creation—we mean *absolute* creation. It must be conceded that matter has either had an eternal existence (whatever that may mean), or it has been called into being—created by a Creator. But it may not have occurred to every one that to the finite rational mind the latter idea is as incomprehensible as the former, for we cannot conceive of the creation of *something* out of *nothing*. "From nothing, nothing can come." The science of geometry is based upon axioms not more self-evident. So far as the finite mind can reason, it is as impossible for God to create something from nothing as it is for us to prove that a whole is not greater than any of its parts, for it is a self-contradiction. The reader will bear in mind that we are not discussing the *facts* of the creation, but the incompetency of the human mind to grasp the facts, whatever they may be. However humiliating, then, it may be to the pride of human intellect, we are forced to the conclusion that there is a vast field of thought, open to anxious inquiry it is true, over the gateway of whose entrance we may well inscribe, "THE UNKNOWABLE." Somewhere within this vast field, from which the human intellect is excluded, lie absolute time and space, and all we call creation, or primary causation. It is the futile attempt to explore this field that has brought philosophers and theologians alike into deserved contempt—the old folly of perpetual motion by the construction of a clock that shall wind up itself.

It is now time for science to define, in some way, the limitations of human knowledge, and thus confine all research strictly within the sphere of the knowable. Is it not safe to assume that the finite mind is so conditioned that it cannot possibly perceive or comprehend ultimate antecedent causes? To say that God was the first cause seems at first an easy solution, but it is only another way of saying we do not know, for we ask at once, "Had God a beginning? and if not, then for an infinite period of time he was *alone*, or else matter has been coeternal with him, and we come back to the Hindoo idea that God is the universe. Our conception of God must be the essence of our conception of eternity, and of that the finite mind can of necessity form no conception. There is a mathematical ratio between a second of time and a million million centuries; but there can be no ratio between a million million centuries and eternity, hence our conception of an infinite and eternal God is impossible. The difficulty does not lie so much in the vastness of the idea itself as in the seeming impossibilities the idea involves. It is like attempting to show the necessity for a sixth sense, by expressing this want or necessity in terms of the five senses we already possess ; no such idea can by any possibility be conveyed.

Let us compare an animal as low in the scale of existence as an oyster with one of the highest known type, man, and note the points of agreement and the points of divergence. An oyster, like man, is evolved from a germ, advances to the climax of animal vigor, and then, like him, declines and dies. An oyster's life is conditioned by the elements in which he lives, and so is man's. An oyster, like man, is propagated by well-defined laws, and like him is subject to disease and premature decay. Now, in all the conditions named, there is not only no difference in kind, but, so far as we know, there is none in quality. They are conditions expressed in universal laws to which the entire organic kingdom is subjected, and over which human agency has little or no control. Let us now turn to those higher qualities in man which are either entirely wanting in the oyster, or are of the most rudimentary nature.

The nervous structure of an oyster is so low that we can no more detect consciousness than we can detect the physical structure of an atom. In man the nervous organization is exceedingly complicated, and centres in a massive brain unparalleled in its activity; to this are added the special senses (probably entirely wanting in the oyster), through which alone all knowledge comes to the mind. Now, we observe that all the inflexible laws that, in the same way, limit and govern these extremes of organic life, are of the infinite order, having their beginnings beyond the scope of the senses, while the differences are of the finite order and grow out of the relation of one thing to another; in other words, the difference is one of degree, and therefore finite. There was a time, in the infantile development of every man, when he was as unconscious of all his higher functions as the passive oyster; but there came a time when, through the special senses, he began to take on thought, which is an impression made upon the brain by external action, and these impressions multiply and accumulate as we come more and more in contact with surrounding objects, until the accumulated thoughts are called knowledge; that is to say, the mind is evolved from *without*, and not from *within*. It is utterly impossible for us to conceive of anything bearing no likeness to anything we have ever seen, or heard, or felt, because our thoughts are the result of impressions already made. We certainly can form no conception of a color unlike any of the prismatic colors and their combinations, because, through the organ of vision, no other impressions have been made upon the brain.

The difference in the scope of the receptive and perceptive faculties of the lower order of organisms, as compared with those of the higher, is vast and almost incomprehensible, just as is the difference in distance between two contiguous atoms and two of the most widely-separated visible stars, but it is a difference of degree and is finite. The great underlying life-principles are the same in each, and for want of a better name we call them principles of the infinite order.

Now, we insist that a well-defined line may be drawn between simple forces of the infinite order and a *result* growing out of the changed relation of one force to another—a difference between simple and resultant forces—the one constant and unvarying, the other forever changing. We may fashion metallic wheels and put them into certain relations to each other, and by employing weights or springs construct a clock that shall mark time in minutes or seconds, and by changing the relation of parts we may measure weeks or months, omitting to note the subdivisions, varying these results at pleasure; but in all this we *create* nothing, nor do we in any way modify a preexisting principle. The mathematical laws of multiples, by which the results of all the wheel-movements are determined, *preëxisted* in the infinite and indestructible laws of numbers and of motion, and the direct motive power preëxisted in the force of gravity, or in the elastic property of the molecular structure of the spring. In bringing the wheels together, and making all the adjustments, we create neither force nor quality—in separating them and breaking the connections, we destroy nothing. The same is true of all mechanism, and indeed of all organisms. Chemical atoms are endowed with definite, inflexible, and indestructible properties that produce different effects only when differently related or correlated.

The difference between organic and inorganic conditions of existence is not a difference in the powers or properties of matter traceable to first causes, but to changed relations due to secondary causes; just as the movement of pieces upon the chess-board does not change the number or the power of the pieces, but, from their changed relations to each other, arise new and highly-complicated effects, that are perhaps never repeated in playing a million games. It is for this reason that no two organisms are ever exact duplicates of each other, nor is the individual ever twice in the same physical or intellectual conditions.

Now, is it not plain that, in the investigation of all the simple forces of which we have the slightest knowledge, there is not one in which we can find a comprehensible beginning? We trace them one by one from highly-involved conditions, through the less and less involved, until at last the simple force, divorced from all associated relations, is lost in the azure blue of the *infinite*—*infinite* in the space it may occupy—*infinite* in its duration—*infinite* in the diversity of effects that may arise from association with other simple forces, and *finite* or *comprehensible* alone in the *duration* of these conditions. It is at just this point we desire to draw the line between the knowable and the unknowable. All attempts to find the relation existing between *first cause* and any sequence or effect must utterly fail, for, as we have already seen, it is an effort of the mind to comprehend infinite conditions—to produce something from nothing. To say that God, in his creative energy, was the first cause, is to say that all the conditions of creation *preëxisted in him*, and, if all the conditions and possibilities of creation preëxisted in God, *creation itself* preëxisted in him, and consequently had no *beginning*, for the conditions by which creation was alone made possible, and which were its foundation-stones, were certainly *first causes*, and, if God created them, he created himself, which is absurd.

When we grant that the material universe contains in itself no creative energy, and that all the manifold laws by which seemingly blind atoms rise by intelligent coördination to organic conditions, and thus to intellectual activities, have not created themselves, we have exhausted the argument for materialism as a possible explanation of First Cause. And now we appeal to an Infinite Intelligence, a spiritual essence, superior to material conditions, and attempt to satisfy reason by making the universe the sequence of a Sovereign Will? But have we advanced a single step toward the comprehension of First Cause? We say, no! but on the contrary are receding from it; for we assume that the vast continuity of effects which we call the universe, past and present, must have had an antecedent cause, and this First Cause, which certainly must be more potent than the universe it created, we assume existed and preëxisted without cause. That is to say, we rise from the smallest phenomenon in Nature by slow gradations, connecting cause with effect, until we reach the highest phenomenon above Nature, and this we assume came into existence without cause, or in other words the source of all other powers is itself an underived power, and either created itself or was never created, either of which is unthinkable. It is, indeed, the conception of a vast and stately intellectual pyramid resting upon a vast base, which it is assumed requires no support.

Let no devout critic challenge the physicist to explain primary causation until he can show the capacity of the finite mind for the reception of such an idea, nor on the other hand deceive himself with the idea that he has removed the difficulty by simply covering it with a name, the meaning of which is utterly incomprehensible.

LIQUEFACTION OF THE GASES.[1]

By GASTON TISSANDIER.

II.

AT the very moment when Cailletet was subjecting successively to the test of his apparatus the six permanent gases, and was conquering their resistance to compression, M. Raoul Pictet was making his experiments, first on oxygen, then on hydrogen. But what gives a special interest to the labors of Pictet is the fact that he has succeeded in producing a quite appreciable volume of these gases in the liquid or in the solid state. He describes his apparatus as follows:

A and *B* (Fig. 1) are two compound exhausting and forcing pumps, so coupled as to produce the widest possible difference between the pressures of exhaustion and compression. These pumps act on anhydrous sulphurous acid contained in the tubular receiver *C*. The pressure in this receiver is such that the sulphurous acid evaporates at the temperature of −65° C.[2] The sulphurous acid pumped out is carried into a condenser *D*, cooled by a current of cold water; it is there liquefied at a temperature of −25°, and at a pressure of about 2¾ atmospheres. The sulphurous acid returns to the receiver *C* by a small tube *d* as fast as it is liquefied.

E and *F* are two pumps precisely the same as the preceding, and

[1] Translated, with some abridgment, from *La Nature*, by J. Fitzgerald, A. M.

[2] The degrees of temperature here noted are all according to the centigrade scale.

with the same kind of coupling. They act on carbonic acid contained in a tubular receiver *H*. The pressure in this receiver is such that the carbonic acid in it evaporates at a temperature of $-140°$. The carbonic acid drawn out of it by the pumps is passed into the condenser *K* which is surrounded by the sulphurous acid receiver *C*, the temperature of which is $-65°$; it is there liquefied under a pressure of five atmospheres. The carbonic acid returns to the receiver *H* through the small tube *k*, in proportion as it assumes the liquid state.

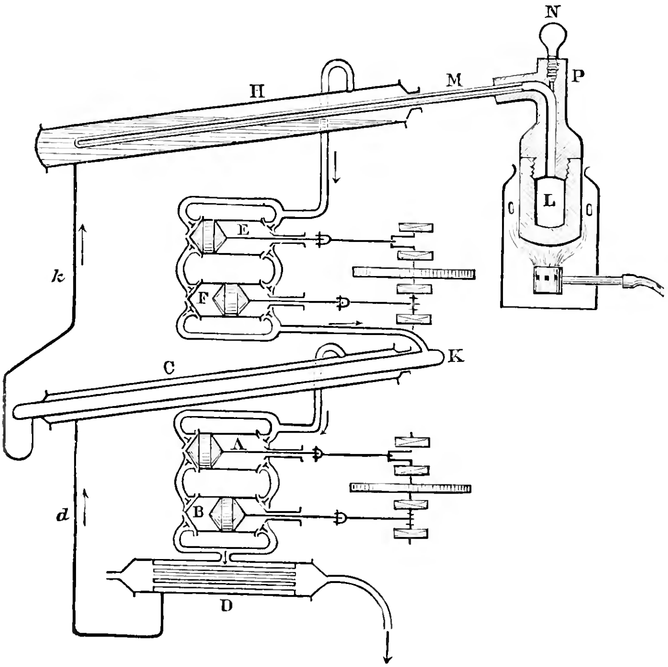


Fig. 1.—Diagram of Pictet's Apparatus.

L is a wrought-iron retort of sufficient thickness to withstand a pressure of 500 atmospheres. It contains chlorate of potash, and is heated so as to give off pure oxygen. It communicates by a tube with a sloping tube *M*, of very thick glass, one metre in length and surrounded by the carbonic-acid receiver *H* whose temperature is $-140°$. A screw-stoppel *N*, situated above the tubulure of the retort, gives to the latter communication with the external air.

After the four pumps have been at work for several hours, driven by a 15-horse-power steam-engine, and when all the oxygen has been liberated from the chlorate of potash, the pressure in the tube is 320 atmospheres, and the temperature $-140°$.

On suddenly opening the orifice *P*, the oxygen escapes with violence, producing an expansion and an absorption of heat so great that a portion of it, in the liquid state, is seen in the glass tube, and spurts out of the orifice on the apparatus being inclined.

A sufficiently clear idea of M. Pictet's method can be had from the above diagram and description; but, as yet, the reader can hardly imagine what the apparatus looks like. Fig. 2 (after a photograph)

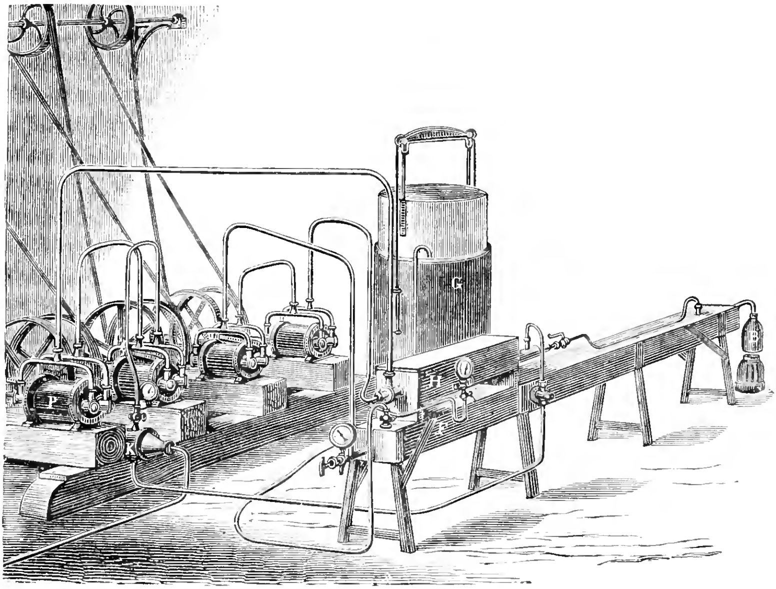


Fig. 2.—Pictet's Apparatus (from a Photograph).

and Fig. 3 will supply this deficiency. Fig. 2 is a general view of Pictet's grand liquefaction apparatus, as it stands in his establishment at Geneva; and Fig. 3 exhibits the same in section. This apparatus possesses considerable size; for instance, the head of a man standing would be on a level with the manometer seen near the letter *H* in the engraving.

The perfected apparatus as shown in Fig. 2 differs in sundry respects from the diagram Fig. 1, as will be seen at a glance. One essential difference consists in the arrangement of the liquefaction apparatus proper, Fig. 4. Here *D* is an iron shell (or retort), with walls 35 millimetres in thickness; it contains 700 grammes of chlorate of potash when oxygen is the gas to be liquefied. Its orifice communicates with an iron tube five metres in length, 214 millimetres internal diameter. This tube, bent as in the figure, is closed at both ends, but one end may be opened by means of the cock *E*. A Bourdon manometer, graduated to 800 atmospheres, shows the inside pressure. The tube *c E*, in which the disengaged oxygen is compressed, is completely immersed in liquid carbonic acid, which, by the mechanism of the pumps before described, enters the apparatus at a and passes out as vapor from the orifice b, after volatilization.

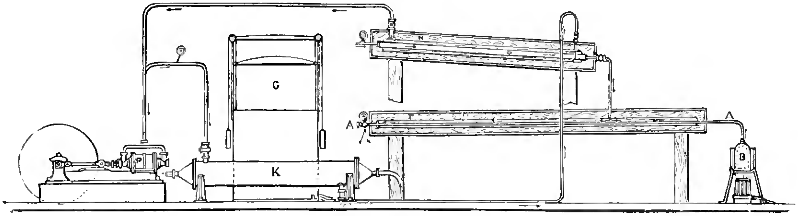


FIG. 3.—SECTION OF THE SAME.

B, cast-iron shell containing chlorate of potash; *A A'*, closed iron tube in which the gas is condensed; *C*, refrigerating cylinder in which liquid carbonic acid is volatilized; *F*, wooden case packed with some bad heat-conductor; *D*, reservoir holding liquid carbonic acid, surrounded by a refrigerating cylinder in which liquid sulphurous acid is volatilized; *H*, case packed with a bad heat-conductor; *G*, gasometer containing gaseous carbonic acid; *K*, reservoir for liquid sulphurous acid; *P*, one of the double-action pumps; *A'*, cock which can be opened so as to give an exit to the liquefied gas which escapes in the direction shown by the arrows.

With this apparatus, M. Raoul Pictet, on Monday, December 24, 1877, in the presence of members of the Physical Society of Geneva, three different times obtained violent jets of vapor which contained globules of liquefied oxygen. On the following Thursday the experiment was made for the fourth time. The manometer, which had risen to 560 atmospheres, after a few minutes fell to 505, and there stood for

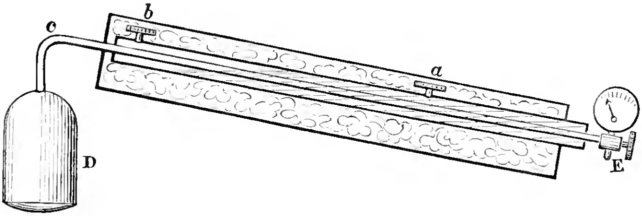


FIG. 4.—THE RETORT AND THE TUBE IN WHICH THE GAS IS LIQUEFIED.

over half an hour, showing by this diminution of pressure the transition of a portion of the gas into the liquid state, under the influence of the —140° temperature to which it was subjected. The cock closing the orifice of the tube was then opened, and a jet of oxygen escaped with extraordinary violence. A beam of electric light, projected on the cone of escapement, enabled the spectators to see that the jet consisted of two distinct parts: the one central, a few centimetres in length, whose white color gave evidence of liquid or even solid elements; the other external, whose blue color showed the return of the compressed and frozen oxygen to the gaseous state.

In later experiments M. Pictet succeeded in collecting a very appreciable volume of liquid oxygen, and in liquefying all the other "permanent" gases.

METRIC REFORM.

By SAMUEL BARNETT.

THE ultimate triumph of the metric system may be regarded as safe, beyond peradventure; no event still in the future is more certain. A universal system of weights, measures, and currency, is an imperative demand of advancing civilization; and this particular solution is worthy of the great problem, fit for all countries and for all time. It has the start, the prestige, the substantial merits, the already large adoption, which insure universality.

Its progress has in many respects been most gratifying. One nation after another has yielded to the arguments in its favor. Dr. Barnard's tables show that in Europe in 1872 France, Germany, Holland, Belgium, Spain, Portugal, Italy, Roumania, and Greece, had adopted it in full; Austria, Denmark, Switzerland, Turkey, Baden, Hesse, Wurtemburg, and Bavaria, adopted metric values, and even conservative England rendered the system permissive. The whole map of Europe is thus riddled—little of it left; the rest is sure to follow. So in North America—the United States, Canada, and Mexico; in South America—New Granada, Eucador, Peru, Brazil, Uruguay, Chili, and the Argentine Confederation; and, among other countries, British India, the French, Dutch, and Spanish colonies, and Japan, are numbered. Thus, nearly all the most advanced nations of the earth are committed to it, and its universality is but a question of time. There will be no steps backward now, but only forward.

All this seems highly satisfactory and encouraging, and it may be asked, "What more could be desired or expected?" But there is another side to the picture.

Among the common people its progress has been as conspicuously slow as rapid among the nations. The statistics of its *actual use*, could they be had, would be heartily discouraging. In some way, and for some reason, upon the common mind it does not *take hold.* Indeed, in a discriminating view, its reception, even among the nations, compares unfavorably with that of many other inventions and devices of modern times: steam, railroads, telegraphy, photography, already cover the earth—all of later date than this system.

With all its admitted merits, the activity of its friends, and the coöperation of governments, the metric system makes no headway among the masses of mankind. As yet but a barren triumph has been achieved; the consent of the government, and not of the people, is the assent of the parents, but not of the maiden. Permission to *woo* is all we have obtained.

Even in France, although the system was provisionally established as early as 1793, and made obligatory, a full generation ago, in 1840, yet the want of real progress may be seen in the following statement ("United States Dispensatory," Wood and Bache, edition of 1870, p. 1737):

> "Though the decimal system of weights and measures was established by law in France, it was found impossible to procure its general adoption by the people, . . . If they adopted new weights, they gave them the names of the old weights. . . . So that three systems are now more or less in use in France—the original *poids de marc*, the decimal system, and the metrical pound, with its divisions."

If such be the case in France, the birthplace of the system, what elsewhere? In the United States its use has been authorized for more than ten years; yet how many business men in the United States avail themselves of their *legal privilege?* How many druggists and physicians? What merchant uses the metre? What surveyor computes in hectares? What farmer measures corn in a hectolitre? Who weighs by kilogrammes, or buys wood by the dekastere?

The words are strange and the things unknown among men of business.

It is worth while to inquire into the impediments. Among these certainly cannot be numbered the merits of any existing system of weights and measures. Take the English tables, for example; they are utterly barbarous—the whole scheme confusion worse confounded; no one defends it as it stands. But there is nevertheless an impediment connected with this *no-system* which has been a serious bar to reform—a vague hope that somehow something might possibly yet be made of it hereafter. This indefinite hope is totally fallacious. There are two tests—the decimal scale, and a proper interrelation of the tables. The English method wants both. Nor can it be altered so as to conform to either.

Take, for example, the leading table of all, long measure, and apply the decimal test; it cannot stand it at all. If you keep the yard, for example, you can keep no other denomination—not one—for no other is decimally related to it; away go the inch, $\frac{1}{36}$ of a yard; the foot, $\frac{1}{3}$; the rod, $5\frac{1}{2}$ yards; the rood, mile, and league; the prime, $\frac{1}{12}$ of an inch; the second and third, the fathom, the chain, link, etc., and all the promiscuous tribe of unrelated units. So it is impossible, if you choose the foot, to keep anything else. Indeed, make your own selection of a unit, and only that selected unit can be retained.

It is the same case with all the other tables; though, instead of *one* table of weights, you have *three*—apothecaries' weight, troy weight, and avoirdupois. Yet, among them all, there is not one single denomination decimally related to any other—not one of the ounces, drachms, scruples, or pennyweights. Even the so-called hundred-weight is not really 100 pounds, but 112.

It grows worse and worse as you study the uncivilized, unkempt system. If the decimal test did not at once and forever dispose of it, the second test would, viz., hopeless want of proper relations among the tables. Our proper attitude toward the present English tables is that of wholesome and final despair!

Addressing ourselves to the task of reform, we proceed to remark what *the metric system, in substance, will do.* It stands the two tests, perfectly; indeed, it was *made to order* for that very purpose. To provide a system with a proper scale and relations was the work undertaken by Science, and that work has been diligently and well done. Its merits are great and substantial; so full is it of practical utility as well as theoretical beauty, that President John Quincy Adams did not hesitate to pronounce it "a greater *labor-saving machine* than steam itself."

Our object, however, is not to make an argument in its favor, but to inquire into the impediments to its progress. These, though not obvious, are certainly formidable, as is shown by results. There are two sets of conditions to be fulfilled which may be distinguished as the *natural* and the *human* conditions of the problem. The difficulty is not to be found in the non-fulfillment of the former; as has already been remarked, the natural conditions have been well met by Science. But, after all the successful work laboriously done upon these—chiefly in the *verification* of the units—the hardest part of the problem yet remains, viz., such an *adaptation of the system to mankind* that the peoples to be benefitted shall adopt and use it in the daily business of life.

Nor are men of physical science, as such, specially qualified for this task. To adapt the system to man requires a different sort of observation from theirs, for which there are no instruments, but only the patient observation of the ways of this fastidious creature. The huge inertia of this ponderous mass of humanity, as results show, is yet to be overcome. Until this adaptation to man is complete, *the problem is not solved.*

Were a Pacific Railway begun upon the wrong general line, the best remedy would be a change of location. In our present problem the human conditions furnish *guiding principles*—the great salient points of our Pacific Railway—more stubborn than Nature itself. The system is for man—not man for the system; and, if the two do not tally, *it* must yield, not *he!*

What modifications of the metric system are needed to fit it for common use?

Roughly, directness and simplicity. In aiming at these we should study actual human experience. The currency system of America furnishes invaluable guidance. One of its chief lessons is, that *men like not many denominations.*

In our decimal currency, five denominations are proposed—mills, cents, dimes, dollars, and eagles. Of these but two are practically used—dollars and cents. Had the other three been omitted, we should not have missed them.

Look at bank-bills. There is the $10 bill, the $20 bill, the $50 bill. Technically, by the tables they should be bills for 1, 2, 5 eagles. Not so, in fact. Never yet did bank in America promise to pay to bearer, on demand, one eagle! So with fractional currency. You see 10-cent pieces, 50-cent pieces, but none for 1 dime or 5 dimes. Dollars and cents suffice.

"What of all this?" you may ask. Much. It is the embodiment of the ways of men: it is full of practice and suggestion to those who have eyes.

According to the tables, a certain sum is 253 eagles, 5 dollars, 4 dimes, 6 cents, 3 mills. Never was it so called. What says our curt mankind? 2,535 dollars, $46\frac{3}{10}$ cents. The mind *scants* denominations. It seldom uses *more than two*, if it can help itself.

On broad principles, indeed, it might be asked, "*Why have denominations* at all?"

Number, whole and decimal, with one unit for each subject-matter, is *adequate to express any quantity whatever.* No second denomination is *essential* in any table. Any weight, for example, can be expressed in pounds and decimals of a pound, without reference to other units. The largest quantities can be so expressed, and the smallest. In currency we express a national debt reaching to billions in the self-same unit which is used for small daily transactions, say in dollars or in francs. This shows the unlimited capacity of number for exact expression without any table of denominations at all.

Indeed, in England and America it may safely be said that *a single denomination in each table would be better than the present method* with its irregularity and confusion, better for mental grasp of the quantity expressed, and better for calculation. A clearer idea is obtained by the expression 13,518.6 lbs. than by its equivalent in numerous denominations, 6 tons, 13 cwt., 3 qrs., 17 lbs., 11 oz., 5.6 drachms.

We would not be understood to limit a system to one denomination, or even to two. Yet *two* well-chosen units in each table, as compared with the present English system, would be a decided improvement. Suppose we had pounds and *pound cents*, yards and *yard cents*, etc., corresponding with the dollars and cents of currency; they would furnish incomparably superior advantages to the existing methods.

We will not, however, discuss the exact denominations needed for each table, and the maximum and minimum for each; nor the scale, whether it should be strictly decimal (a denomination for every 10), or one for every 100 (the cental scale); or *eclectic*, varying with the subject-matter. We will, however, remark that in nearly every table the number of denominations can be reduced, not only safely, but advantageously.

Our object, however, for the present is to suggest principles, not to elaborate details; too many denominations perplex, instead of aiding, the mind.

Besides the *units* of a system, the *names* are to be considered; this leads us to by far the most important subject of discussion—

Nomenclature.—Let us with this begin a lesson derived from the actual observation of human habits. The case of the French has been already cited: *they adopted the new units, but rejected the new names.* This is very suggestive. In the United States a similar instance occurs in the names of coins. We still have, in many parts of the country, shillings, sevenpences, thrips, etc. In New Orleans we get *bits* in change. In the great commercial city of New York prices are still given, and goods marked, in shillings, viz., 6 shillings a yard, not 75 cents; ten shillings, not $1.25.

What is the lesson from all this? Plainly, that *new words* are harder than *new things.* How much easier, too, were the names of the new coins than the long and learned names of the metric nomenclature!

"None of your Latin for me!" begs the Frenchman, unfamiliar with that tongue. "Especially, none of your Greek! It is enough if I accept your units; pray excuse me from your names." And even the French Government, which attends to everything, has had ill success in this. The Englishman finds in French forms and accents additional impediments. Unless corrected, he would, to begin with, *mispronounce* fully half the words; knowing barometer and thermometer, he would be sure to say "ki-*lom*-e-tre" also.

Seriously, it were easier for the learned to acquire a nomenclature founded on Hottentot and Sanskrit, dressed off in Kamchatkan forms, than for the unlearned to acquire one in Latin and Greek with French forms; the learned have some familiarity in dealing with new languages to start with. The metric words are *feræ naturæ* to all people, and will not domesticate. To the common people they are simply *outlandish*, and "neither have the accent of Christians, nor the gait of Christian, pagan, nor man."

Broadly, a system of weights and measures furnishes no case for learned nomenclature. The system is intended for wholly untechnical uses and people, while the words are adapted only to the learned, and even for them are too stiff for daily use. It is clearly a case for easy and familiar names.

More results hinge on the nomenclature than on any other feature of the system; yet it has received little real discussion; it has been simply taken for granted on its looks and outside. Indeed, it has been the boast and pet of the whole metric system, unsuspected as really the chief clog upon its progress. Brought to the tribunal of fair criticism, it is thoroughly unphilosophical, and needs to be remodeled in the light of modern investigations into the first principles of language, all of which principles it violates.

Take the first word of the first table—millimetre—*without explanation, aliunde*, it conveys no information even to a learned man. *Metre* is merely *a* measure, not any *definite measure*, not even necessarily a measure of length. Nor does it at all, of its own force, tell how long.

Milli, the prefix, means a thousand; but by explanation, not by its own force, is made to indicate the $\frac{1}{1000}$ part. After both these explanations, leave the most learned man alone with it, and he is entirely at a loss as to the actual length of the $\frac{1}{1000}$ part of a metre. He can form an idea of a half, a fourth, or other like fraction, but of the $\frac{1}{1000}$ part none, unless by a long process, or by being told.

Again, the nearer alike things are, the greater the difficulty of distinguishing them. Every one has observed how hard it is to recognize people in uniform. Upon this obvious principle *the* UNIFORMITY *of the metric names in sound and general aspect* is a serious practical hinderance. To an Englishman they are like a party of foreigners: they all look and jabber alike; he can hardly tell them apart.

It is unfortunate that in the metrical household every family has the same Christian names. We can imagine some wag proposing middle names just to break up the monotony. When you hear *deci*, your active mind, always anticipating, calls up a member of each family, and you think of deci-gramme, deci-metre, deci-are, deci-stere, and deci-litre.

All this is diametrically wrong. Really, one is tempted to remark that the metric nomenclature got, indeed, upon exactly the right road, but took exactly the *wrong end* of it. It struck out toward the hard, the learned, the abstract, instead of the easy, familiar, and concrete. Observe how terse and expressive, and how perfectly *distinct* and unlike, ordinary words are—God, man, world—each freighted with meaning, and, in English, all frequently in one strong syllable. Take the objects in this room—desk, books, chairs, sofa, pen, ink, paper, knife—how thoroughly unlike, how instantly expressive, and nearly all monosyllables!

The great trouble with these metric words is that they will not *nick;* otherwise *myriametre* would cast a syllable a day, and soon become short and easy. That is a way the English have. But these words will not nick at either end, head or tail. Ingenious efforts for *nicking* have been devised by Prof. McVickar and others, which may help men of learning; but they presuppose too much familiarity already for common people.

And, after all, the true point has been missed, which is not sameness of *words*, the world over, but merely sameness of *units;* the object being not to save *translation*, but to save *calculation*. Even natural units need translation, and the artificial units we devise might be content to get on a footing with natural ones. How small a purpose, indeed, would be served if the names of the measures were the same, but of the numbers not the same, nor of the things measured! Such are some, by no means all, of the incurable faults and defects of the metric nomenclature.

The obstacles to metric reform have been chiefly artificial. Like little David in Saul's armor, the system has been weighed down with superfluities. A simple illustration may be given of its highly artificial character. A sufficient table of currency would be—

100 cents make a dollar.

What would this become, subjected to nomenclature? For dollar, we should have to substitute some Greek word, say *argurion*, or *argur*. But give the benefit of familiarity by keeping the word dollar, the above table, *metricized*, would assume this form:

10 millidollars make a centidollar.
10 centidollars make a decidollar.
10 decidollars make a dollar.
10 dollars make a dekadollar.
10 dekadollars make a hectodollar.
10 hectodollars make a kilodollar.
10 kilodollars make a myriadollar.

What is needed?—The utmost simplicity and straightforwardness. The system should carry no dead weight. Starting with no superfluous units, these units need—

Names.—And here comes in the process of "conscious word-making," the conditions of which have only recently been much studied. The department of science which qualifies men to suggest suitable names or principles for their selection is not physical but linguistic.

The *extraordinary vitality of old words* was observed by Lord Bacon with his usual practical sagacity. Even in philosophy, addressed to the learned, he remarks, "I am studious to keep the *ancient terms* . . . though I sometimes alter the uses and definitions." Again, with unwonted earnestness (still referring to language), he declares himself "*zealous and affectionate* for antiquity." Taking pains to explain the modifications of meaning, he retained *ancient terms*, knowing how bewildered men become with a strange vocabulary, especially when, as in the metric nomenclature, a great batch of new words is thrown upon them at once—long and strange, and slow to yield their meaning.

These sagacious anticipations of Bacon have been abundantly confirmed by modern observations. Prof. Whitney, whose works exhibit great good sense and clear-headedness as well as ample learning, uses such expressions as these, showing the habits of mankind in the formation of words, "Stretch a familiar name to cover it;" i. e., a new idea. Again, he speaks of "new applications of old (word) materials," and of "the short cuts" which language frequently makes.

One pregnant sentence we will quote in full: "We have had to notice, over and over again, the readiness on the part of language-users to forget origins; to cast aside, as cumbrous rubbish, the etymological suggestiveness of a term, and concentrate force upon the new and more adventitious tie."

How much "cumbrous rubbish" impedes the metric names!

The principle on which names should be given is sufficiently clear. The names should simply answer the natural questions: "How long is it? How big square? How heavy?" etc.

To illustrate by long measure—the base-unit is now called the metre—"How long is that?" is the first question. A *pace*, a long *step*, a *stride*, would answer the question; probably, in England and America, despite all objections, a *new yard*, or a *long yard*, is the best name. The *new* would be dropped in due time (as in new style and old style), and the name becomes simply *yard*.

To proceed with the table. Each and every unit in each table should have its own *strong, independent name*, instead of a name referring to the base-unit, so called. The actual relation between the units is important; but to express this in the name is worse than superfluous, it is a mere incumbrance. *There is no danger of forgetting the decimal scale.*

The metric tables provide names for—

$\frac{1}{1000}$, $\frac{1}{100}$, $\frac{1}{10}$, 1, 10, 100, 1,000, 10,000 metres.

Some of these we would omit, and perhaps provide others not given, beginning with the $\frac{1}{10000}$ part, for microscopic uses.

What should the name be? It should *suggest* the length intended, say, a hair's-breadth, or a leaf's-thickness; soon, by shedding, a hair or leaf.

The name of the $\frac{1}{1000}$ part? Still suggestion—say, a pin's-breadth (soon, a pin), a straw's-breadth, a narrow braid, a coin's-thickness, or a card's or knife-blade's. The words "breadth" or "thickness" would serve the purpose of explanation at first, and then shed, leaving only pin, straw, braid, knife-blade, card, etc.

Some such name would serve—*not*, millimetre in Latin and Greek; *not*, even metre-thousandth in Greek and English; *not*, any name expressing a *numerical* relation to some other unit. If any numerical relation at all, *not* to a unit at 1,000 removes. Finally, not a fractional relation, if any, but one expressed by a whole number. All these *negative limitations* are full of matter.

The next name—the $\frac{1}{100}$ part—might be nail's-breadth, nail.

The next, now decimetre, hand.

Then, the new yard, or long yard, finally to become yard.

The fifth unit, 10 metres, half-chain. Really no name needed.

100 metres = stone's-throw; bow-shot = throw, cast, shot.

1,000 metres = a short mile, new mile. An accidental association would make the word *kile* serve. The learned would know the Greek derivation; the unlearned would remember it by the rhyme. Numerous illustrations occur, equally casual. The objection is not to Greek, but to the want of some familiar association, no matter how trifling.

10,000 metres = a great league, or double league.

Observe that each unit thus named is as much a *base-unit* as any other.

Had the units of the old English system been properly related, the names were all right. Each name could *stand alone!* Twelve inches did not make one "*duodecem unciæ*," but *one foot;* three feet, not the Latin for three feet, but a terse English word, one yard (i. e., a shoot or switch—the first yard-stick). Five and a half yards made (the *scale* being all wrong, but the name all right) one rod, pole, or perch.

The following brief table might approximate to a sufficient one for linear measure:

100 hair's-breadths make 1 nail's-breadth.
100 nail's-breadths make 1 long yard.
1,000 long yards make 1 kile.

Soon to dwindle to this form:

100 hairs make a nail.
100 nails make a yard.
1,000 yards make a kile.

For astronomical purposes we might add:

10,000 kiles make 1 great quadrant.

Of course, the above names are not suggested as final, but only as illustrative. Again, the actual lengths would be perfectly definite, and the modes of verifying fixed by science.

If any object to the omission of the millimetre, how easy to say ten hairs! The cental scale usually suffices—witness "ten cents" *vice* a "dime."

Ah! but how meagre and shabby is this in comparison with the beautiful and learned nomenclature, with its long words, rolling *ore rotundo* from learned lips!

Alas! that system is too pretty for use—like a mowing-machine, gilded and decorated, which cuts too high, and passes *above its work*, leaving no grass in its trail. This humble blade is intended to *cut low;* it must even scrape the ground, and rake the very dust, rather than *not mow*. Plain, ignorant people are to be reached; children, servants, the dullest plodders, are all to use whatever names we adopt. We do well to be humble. The lofty, high-sounding names heretofore proposed have gained no currency; they have been "*stifled by general neglect*."

But how about universality?

A ready means for this is found in *notation*.

Universal symbols are as easy as a universal nomenclature is difficult. Take, for example, the nine digits. Englishmen, Frenchmen, Germans, Japanese, look at the figure 3; they call it by different names, each in his own mother-tongue, but they all think of the same thing. The *thing*, the *thought*, the *mark*, are all the same—the *words* differ. So is it with the notes in music, the symbols in algebra and geometry, etc.

A notation may be devised which addresses the eye, and is self-explanatory. The base-units may be represented, for example, as follows:

That of length, by a straight line, graduated, to distinguish it from *minus*.

Surface, by a	square.
Solid	cube or block.
Capacity	cup.
Weight	pound-weight.
Money	coin, stamped.
Angle	two lines, meeting.
Time	waving line.

We only suggest, and do not expand.

The substance of the foregoing suggestions, summed up, is as follows:

Adhering to the metric system as a basis—its modification by the following features:

1. The entire abandonment of the present elaborate and ingenious system of nomenclature, and of any attempt at universality in the *words* employed to designate the units of the system.

2. The expression of each unit by each nation in its own vernacular tongue—the units themselves being the same everywhere, but the expression in language adapted to the familiar tongue of each people.

3. A common notation as the means of universality, instead of a common system of names, the units and their *written* expression being thus universally the same, while the spoken expression conforms to familiar national usages.

4. The words selected to express the several units to be suggestive of easy standards of comparison with familiar objects.

5. The *notation* also to be suggestive to the eye, as the nomenclature heretofore in use was to the learned ear, but not to the unlearned.

6. The number of denominations to be reduced in conformity with an observed tendency among men to use numbers instead; oral expression to be simplified; and a suitable actual system of notation suggested.

7. The transition to the new system to involve the least practicable loss of familiarity—either with familiar *objects* or familiar *names*.

These modifications adapt the metric system to the needful human conditions. Accepting its solutions of the natural conditions, they conserve all that is really valuable, and reject only what is cumbrous. The metric nomenclature is quite as unphilosophical as the English scales; both are fit only for decent burial. The real desideratum is to reduce to a minimum the difficulty of introducing the new units. Can the transition be better effected than on the foregoing principles?

This ponderous and scattered human family—a huge class of grown pupils, not gathered into school-room, nor used to formal instruction—

complains of its lessons; it begs for a less task. We propose to excuse you from your Greek and your Latin, and from French forms, from long words and hard names, from the queer pronunciations and the wrong accents. We let you off from half the units, perhaps two-thirds, and furnish you with familiar standards of comparison for those which are left, and give you English names to boot—Anglo-Saxon when possible, short, terse, and significant—though we take care, on our part, to have them properly related, not leaving that matter to you.

What! not yet satisfied? Unreasonable mankind! let us convince you that this is the least cost you can pay, and insure the desired benefit.

Scarcely another so important reform awaits the human family. But it will not take care of itself. We have referred to two aspects of progress—progress among governments, want of progress among the people. The latter is incomparably the more important. The one is semblance, the other substance. Until the metric system is used, it is not a labor-saving machine for service, but a mere toy to look at—an anticipation, a dream, not a reality and a possession. And such it is now.

We must not rely on a change in human nature, but must adapt our system to it; otherwise, indeed, mankind may, perhaps, in the distant future, wear out to the system, like a Chinese foot to a shoe. Should we await this slow and painful process, or should we not rather adapt the shoe to the foot?

Can we look forward to a time when these long foreign words shall be as familiar to every child in Christendom as the words foot, yard, bushel, pound, now are to English ears? And yet this is the proper standard of familiarity; it must be absolute and unhesitating. Do the long words, indeed, deserve to be as familiar? Are they formed to be? No; we must reach the mother-tongue of each people.

Nor can we afford to wait, to bring the matter home.

Can the English and American peoples—the two most commercial peoples on the globe—be content, on the one hand, with permanent isolation, founded on inferiority? or, on the other, can they ask mankind *to accept* their system, forsooth, as worthy of universal use? Will England, for example, ask America to return to £ *s. d.* and *qrs.?* Or America, for very shame, present her compound reduction tables for the admiration and universal adoption of all nations?

Let not the friends of metric reform be deceived with vain hopes. Government work, and the work of colleges and schools and scientific associations, all put together, are not equal to *adaptation!*

THE QUESTION OF PAIN IN DROWNING.

By ROGER S. TRACY, M. D.

EVERY one has tried the experiment of "holding the breath," and has found that after the lapse of a minute, or a minute and a half at the farthest, there supervenes a most peculiar and intolerable kind of anguish. Nature then takes the management of the lungs out of our hands into hers, and we breathe in spite of ourselves. The distress felt at such times we think of when we read of a death by drowning or hanging; and, although it has been asserted over and over again that such a death is painless, hardly any one really believes it. And yet I think it can be shown not only that drowning and hanging *are* painless modes of death, but *why* they are so.

When a person, who cannot swim, falls into deep water, he is seized with a sudden and tremendous fright. The exceptions to this rule are too few to be worth noticing. This fright, of itself, kills some persons, and they go to the bottom like a plummet. Women are very apt to faint, and, as they sink beneath the surface and respiration still goes on involuntarily, they probably drown before they regain consciousness. Plethoric persons, or those in whom the degenerative processes of old age have weakened the coats of the arteries, may have a stroke of apoplexy, partly from the sudden emotional shock, and partly from the chill of the water, which, by driving the blood from the surface, overfills the vessels of the internal organs. In fact, it is estimated by Taylor, in his "Medical Jurisprudence," that of all drowned persons twenty-five per cent. die of pure asphyxia, and in the remainder the asphyxia is complicated by syncope and apoplexy. The chances are, then, three out of four, that a person who falls into the water and drowns will die a painless death, because he becomes insensible on the instant. But what about the remaining fourth?

In the first place, it is to be remarked that persons who have come so near drowning as to be unconscious when taken from the water, and so must have passed through all the suffering that attends death by drowning, say that they remember no feeling of pain whatever. This declaration must have great weight, for it is not to be supposed that they could forget such terrible distress as that which follows when the respiration is suspended voluntarily. They all describe their feeling much in the same way: "I remember falling into the water. It was dreadfully cold. I felt my clothes clinging about me and hampering my movements, and as I rose to the surface I gasped for breath. My mouth was filled with water, and I sank again. I was chilled through and through; then a sort of delirium came over me, and there was a ringing in my ears. I remember nothing more." The last symptom mentioned immediately precedes unconsciousness, as all who have taken anæsthetics know.

It is probable that the entrance of water into the lungs has a great deal to do with the painlessness of drowning. It is certain that unconsciousness comes on more quickly when the person is deprived of air because the lungs are filled with water, than when the air-passages are closed, while the lungs remain intact. Most persons can hold their breath for a minute, very many for a minute and a half, some for two minutes. In one of the variety theatres of New York appeared recently "The Brilliant Pearl of the Enchanted Grotto, christened Undine, who performs, while under water, incased in a mammoth crystal illuminated glass tank, feats of astonishing suppleness and almost unbelievable endurance." This performer can probably remain under water, holding her breath voluntarily, two minutes and perhaps more. I have myself, watch in hand, seen Johnson, the celebrated ocean-swimmer, remain under water, in a tank before an audience, for the astonishing space of three minutes and twenty seconds, and, before he rose, the involuntary contractions of his respiratory muscles were uncomfortable to witness. In such cases, although extreme distress may be felt, there is no approach to unconsciousness. But if a person's head is under water, and he does not hold his breath, unconsciousness will usually come on in one or two minutes at the farthest.

If this be so, it is evident that a person will drown more quickly if he loses his presence of mind on falling into the water than if he retains it. In the former case he will swallow water with his first gasp after sinking, while in the latter case he will hold his breath as long as he can. The latter will suffer more than the former. There is also a difference in the amount of mental agony in the two cases. A person who cannot swim sinks at the first plunge, but, as soon as the impetus of his fall is destroyed, his frantic struggles or a kick against the bottom, if he happens to touch it, sends him up to the surface, for the specific gravity of the body is so nearly that of water that a very slight motion of the hands or feet is sufficient to keep one afloat. Arrived at the surface, he gasps for breath, swallows a quantity of water, sucks some of it into his lungs, catches hold of straws or small floating objects in a wild, senseless way, and, every time he lifts his arm above the surface, produces the same effect as if a piece of lead had been tied to his feet. So down he goes again half strangled, and the same process is repeated. As soon as unconsciousness comes on, the struggles cease, and the body remains beneath the surface. During all this agony the suffering of the drowning man is undoubtedly chiefly mental. It comes from the instinctive dread of death which even the stoic cannot rid himself of, and is of the same nature as the mental agony of the condemned man before his execution, though less prolonged. And it is probable that even this mental suffering is so much affected by the convulsive and tremendous physical agitation that, in a measure, the two counteract each other, and the drowning person, from the moment he strikes the water, is hardly conscious of what is going on.

A swimmer, or a person whose presence of mind enables him to keep his head above water for some time before drowning, passes through a different experience. But, although data are wanting on this point, it is probable that his final agony is short and painless. His physical exertions, kept up for a long time in the hope of relief, together with his exposure to cold and wet, and the lack of nourishment, combine to reduce his strength very rapidly, and it is not altogether a conjecture to suppose that a single draught of water into the lungs, when he finally gives up, is enough to bring on unconsciousness. His suffering, too, is chiefly mental, but he experiences the additional discomforts of exhaustion, cold, and hunger, if his struggle for life is a prolonged one.

It is believed that the rapidity and painlessness of death by drowning are due chiefly to the speedy obstruction of the circulation of the blood through the lungs. In ordinary asphyxia, by the simple deprivation of air, the blood throughout the body becomes charged with carbonic acid, and the arteries as well as the veins become filled with venous blood. Now, venous blood does not pass readily through the capillary vessels, and, when the accumulation of impurities has become so great as to prevent its passing at all, the circulation comes to a standstill. But the dreadful distress of suffocation comes on long before this point is reached. Now, when cold water is sucked into the lungs and comes in contact with their delicate and sensitive mucous membrane, it must cause an instant and powerful contraction of the capillaries, and obstruct the current of blood from the right side of the heart, thus indirectly damming back the venous blood in the brain. This state of things brings on unconsciousness rapidly, preceded by the pleasurable tingling sensations, rapid succession of ideas, and flashes of light and color, so often described by persons who have been rescued from drowning.

Drowning persons, then, die in different ways:

1. By syncope, and asphyxia while unconscious. Some of these die instantly.

2. By apoplexy (usually congestive), common in plethoric and aged persons, followed by asphyxia while unconscious.

3. By asphyxia pure and simple.

Deaths which come under the first two heads are rapid and painless, constituting probably a half, and, according to Taylor, three-quarters of all deaths by drowning.

Deaths which come under the third heading we presume are not accompanied by physical suffering for these reasons:

1. Persons who have been resuscitated, after having become unconscious, declare that they have felt no pain whatever.

2. Death is speedy.

3. Persons who lose their presence of mind are so occupied with

their struggles and mental agony that a slight degree of physical pain would be unnoticed.

4. Swimmers, and persons who do not lose their wits, become so exhausted and chilled that, when the final act comes, their powers make but a feeble resistance. And, in both cases, the passage of water into the lungs tends to bring on insensibility by obstructing the circulation, before it is time for the agony of asphyxia to be felt.

So that, in drowning, we have reason to believe, contrary to Taylor's opinion, that pure, uncomplicated asphyxia never occurs.

If death by drowning be inevitable, as in a shipwreck, the easiest way to die would be to suck water into the lungs by a powerful inspiration, as soon as one went beneath the surface. A person who had the courage to do this would probably become almost immediately unconscious, and never rise to the surface. As soon as the fluid filled his lungs, all feelings of chilliness and pain would cease, the indescribable semi-delirium that accompanies anæsthesia would come on, with ringing in the ears and delightful visions of color and light, while he would seem to himself to be gently sinking to rest on the softest of beds and with the most delightful of dreams.

SCIENCE AND MENTAL IMPROVEMENT.[1]

By Professor JOSEPH LE CONTE.

THIS club, as I take it, was formed for mutual improvement. The narrowing and ever-increasingly narrowing tendency of professional pursuits, in these modern times of division of intellectual labor and eager struggle for life, renders the formation of such associations very necessary. The ideal of a life-culture, as I conceive it, i. e., of a culture which, commencing with youth, shall terminate only with death, is briefly epitomized as follows: First, a general culture of all the faculties—a preparation for general efficiency without reference to any special pursuit—to the period of full maturity; then a concentration of the thus strengthened and disciplined powers upon special professional studies, but still in connection with a scheme of liberal culture or university, by which the professional culture shall be impregnated with the lofty spirit of liberal learning; and, lastly, when active professional life commences with its necessary narrowing effects, the formation of associations like this, by which we are brought into contact with the best thought in every department.

If culture be the object of your association, then ought it *not* to be merely an association of *kindred spirits*, as many think. On the contrary, it should consist of persons of the most diverse pursuits—theologians, lawyers, physicians, engineers, merchants, and of all modes of

[1] An address before the Chit-Chat Club in San Francisco.

thought, from orthodoxy to rationalism, from idealism to materialism, from old-fogyism to young-Americanism—with one condition only, viz., that all be imbued with the spirit of liberal culture. Now, among the pursuits which ought to be represented here, I believe none to be so necessary as that of science ; and for the reason that the spirit of science and the methods of science are more diverse from the spirit and methods of other intellectual pursuits than these latter are from each other.

I will say nothing of the glorious achievements of science already set forth in the sentiment to which I am called to respond ; nor even of science as a means of mental discipline, for this would take too long. I wish only to remove some objections which have been brought by her detractors against Science as an agent of general and liberal culture ; for it is with this that your association is chiefly concerned. Among these objections, however, I select only one, but perhaps the chief, viz., the tendency of science to materialism. It is believed by many that science starves all our noblest faculties, quenches all our most glorious aspirations, and buries all our heavenly hopes in the cold earth of a vulgar materialism.

Now, it is indeed true that there has been in these modern times a strong tendency, a current of thought, in the direction of materialism. It is true, too, that this tendency is strongest in the domain of science, and, among sciences, strongest of all in biology and geology; but I believe it is true also that this is only a passing phase of thought, an ephemeral fashion of philosophy. As a sympathizer with the age in which I live, still more as a scientist, and most of all as a biologist and geologist, I have felt the full force of this tendency. In this stream of tendency I have stood, during all my active life, just where the current ran swiftest, and confess to you that I have been sometimes almost swept off my feet. But it is the duty of every independent thinker not to yield blindly to the spirit of the age, but to exercise his own unprejudiced reason ; not to *float* and *drift*, but to *stand*. I think I can show you that materialism is not the necessary outcome of scientific studies and the scientific spirit. For this purpose, I will select that scientific theory which is supposed to be *par excellence* materialistic, viz.: the theory of evolution. I wish to show that even evolution does not necessarily lead to materialism, and that to conclude so is a very shallow view of the subject.

First of all I wish frankly to acknowledge that I am myself an evolutionist. I may not agree with most that evolution advances always *cum æquo pede*. On the contrary, I believe that there have been periods of slow and periods of rapid, almost paroxysmal, evolution. I may not agree with most that we already have in *Darwinism*, the final form, and *survival of the fittest*, the prime factor of evolution. On the contrary, I believe that the most important factors of evolution are still unknown—that there are more and greater factors in evolution than are dreamed of in the Darwinian philosophy. Nevertheless, evolution is a grand fact, involving alike every department of Nature; and more especially evolution of the organic kingdom, and the origin of species by derivation, must be regarded as an established truth of science. But, remember, evolution is *one* thing and materialism *another* and quite a different thing. The one is a sure *result of science;* the other a doubtful *inference of philosophy.* Let no one who is led step by step through the paths of evolution, from the mineral to the organic, from the organic to the animate, and from the animate to the rational, until he lands logically, as he supposes, into blank and universal materialism—let no such one, I say, imagine for a moment that he has been walking all the way in the domain of science. He has stepped across the boundary of science into the domain of philosophy. Yet the step seems so easy, so natural, so inevitable, that most do not distinguish between the teachings of science and the inference of philosophy, and thus the whole is unjustly accredited to science. Now, as most people not only do not make, but have never imagined, any such distinction, I am anxious to make it clear to you. This I can best and most briefly do by some simple familiar illustrations.

It is curious to observe that no sooner do we find out, in any work of Nature, *how* it is made, than we all say that it is not made at all; it made itself. So long as the origin of species was a mystery, every one admitted that species must have had an intelligent Maker. But no sooner did we discover the process, than every one seemed to think that no Maker is necessary at all. Now, the whole object of science is to discover *processes* by which things are done; or *how* things are made. Is it any wonder, then, with this perverse tendency of the present mind, that science should ever and anon seem to destroy belief in a Supreme Intelligence?

Again, it is curious to observe how an *old* and familiar *truth*, coming up in a *new form*, startles us as an impossible paradox. I well remember some twenty-five years ago, when the little instrument the gyroscope first made its appearance, how it startled everybody by its seeming violation of the laws of gravity. Imagine a heavy brass wheel rotating rapidly at one end of an axle, while the other end is supported on a vertical column. So long as it rotated, the heavy wheel, instead of falling, remained suspended in mid-air, revolving meanwhile slowly about the point of support at the other end of the axle. At first sight it seems as wonderful and as paradoxical as the body of Mr. Home, the spiritualist, sailing in mid-air in full view of his gaping and noble audience. In the case of Mr. Home, we suspect some mistake or deception; but there is no mistake about the gyroscope. Yet this strange paradox, which startled people so, and which so flooded scientific literature with explanations, is an old familiar fact in a new form. The problem is precisely the same as that of the *boy's top*, which spins and leans, and slowly revolves in its leaning, but does not fall so long as it continues to spin.

Now, in evolution, also, we have no *new* truth, but only an *old* truth in a *new form:* and lo! how it startles us out of our propriety! *The evolution of the individual* by a slow process from a microscopic germ. Everybody knows this. Yet it has never heretofore interfered with a belief in an intelligent Maker of each of us. Perhaps most of you may remember, when first at your mother's knee, you were asked, "Who made you?" and you answered as you were taught, "God made me." But suppose you had asked in return, "How?" The only true answer would have been, "By a process of evolution." Yes, every one of us was *individually* made (and is not this far more important for us individually than any origin of species, even of the human species?) by a slow process of evolution from a microscopic spherule of unorganized protoplasm—the germ-cell. Yet the knowledge of this fact did not make us ridicule the reverent answer of the little one, or despise the pious teachings of the mother. Why, then, should it be different in this case of the origin of *species* by evolution?

Again, all vexed questions are such, because there is truth on both sides. Unmixed error does not live to plague us long. Error lives only by virtue of a contained germ of truth. In all vexed questions, therefore, there are three views, viz., two opposing, partial, one-sided views, and a third, more rational and comprehensive, which combines and reconciles them.

I can best illustrate this by the familiar story of the fabled shield. You well remember how, in the good old times of knight-errantry, this shield was hung up in the sight of all men in token of the fact that the owner challenged the world to mortal combat. You well remember that the shield having been seen by many knights, these knights, on comparing notes, could not agree as to its color, some declaring that it was *white*, and some equally certain that it was *black*. You well remember that after many lances had been splintered, after many broken heads and bloody noses had been endured in the vain attempt to settle this *vexed question*, by the blundering logic of blows and knocks, as was the fashion in those days (alas! do we not even now settle many questions in the same way, only we call the process now, the "*logic of events*")—after, I say, many blows had been given and taken in the sacred cause of truth, some one who, strange to say, had something of the spirit of science, and who, therefore, thought that truth was to be discovered, not by conflict, but by *observation*, proposed that the shield be examined. The result you all know—*one side was white and the other was black*.

Now, do you not observe that both parties in this dispute were right and both were wrong? Each was right from *his* point of view. Each was wrong in excluding the *other* point of view—in imagining *his* truth to be the *whole* truth. And do you not observe also that the true view combined and reconciled the two partial views? There is an old adage that "truth lies in the middle," between antagonistic extremes. Now, while there is a kind of truth in this adage, yet, as usually understood, I believe it contains a most pernicious error. It is the favorite adage of the timid man—the trimmer, the time-server, the politician, the fence-man. Suppose there had been present on this occasion one of these fence-philosophers. He would have reasoned thus: "These gentlemen are of equal intelligence, equal veracity, and equal *strength* (a most important element in making up an opinion for these fence-men); the one says the shield is white and the other says it is black; now, truth lies in the middle: therefore I conclude that it must be a kind of gray or neutral tint, or perhaps a sort of *pepper-and-salt*." Do you not observe that of all the crowd he is the only one who has absolutely no truth in him? No, gentlemen; truth and rational philosophy is not a mere *mixture* of opposing views—truth is *not* what our English friends might call a philosophic "'alf-n'alf." It is rather to be sought in a more comprehensive view, which combines and reconciles opposing partial views—it is a stereoscopic combination of *two* partial surface views into *one* objective reality.

So is it, gentlemen, with many vexed questions; so is it with the question of *origin of species*. There are three possible views in regard to the origin of species. The first asserts Divine agency by *miraculous* creation, and therefore denies any *process*; the second asserts *evolution-process*, but denies Divine agency; the third asserts *Divine agency by evolution-process*. So, also, are there three corresponding views in regard to the origin of the individual—of you, of me, of each of us. The first is that of the little innocent, who thinks that God made him as he (the little innocent) makes *dirt-pies*; the second is that of the little hoodlum, who says, "I wasn't made at all, I growed;" the third is the usual adult belief—that we are made by a process of evolution. Do you not observe, then, that in the matter of the origin of species many good theologians and pietists are in the position of the little innocent? They think that species were made *without natural process*. On the other hand, most evolutionists are in the position of the little hoodlum; for they think that species, *because they "growed," wern't made at all*. But there is a higher and more rational philosophy than either, which holds that the ideas of *making* and of *growing* are not inconsistent with each other—that evolution does not and cannot destroy the conception of, or the belief in, an intelligent Creator and Author of the cosmos. This view combines and reconciles the two preceding antagonistic views, and is therefore more comprehensive, more rational, and more true. But let us not fail to do justice—let us not overlook the fact that the most important and noblest truths are overlooked only by the hoodlum and materialist. *Of the two sides of the shield, the little innocent and the pietest sees, at least, the whiter and more beautiful.*

The end and mission of science, gentlemen, is not only to discover *new truth*, but also, and even more distinctively, to give *new and more rational form to old truth*—to transfigure the old into the more glorious form of the new. Science is come, *not to destroy*, but, aided by a rational philosophy, *to fulfill* all the noblest aspirations, the most glorious hopes of our race. Sometimes, indeed, the change which she brings about may be like a metamorphosis: the useless shell is burst and cast off, and a more beautiful and less gross form appears, but still it is always a process of evolution—of derivation. We never shall reach a rational philosophy until we recognize this fundamental truth. The *new* must include the *old*—the old must incorporate and assimilate the new, and each must modify and be modified by the other. Progress in all things—in geology, in society, in philosophy—is *by evolution and growth*; not by *successive catastrophes* with alternate destructions and recreations; by derivation, not by substitution. But these modern materialists, while they are evolutionists in geology (they indeed will hear of nothing else), while they may be evolutionists also in social progress, are, strange to say, catastrophists in philosophy. They would raze all previous beliefs, faiths, philosophies, to the ground, and leave not one stone upon another; and then, out of entirely new materials furnished by themselves, they would erect another and entirely different philosophy. They reverse the old dogma, "Whatever *is*, is right," and make it, "Whatever *is*, is wrong."

The great bar to the speedy establishment of a rational philosophy is dogmatism, self-opinion, self-conceit. The rarest of all gifts is a truly tolerant and rational spirit. In all your gettings, gentlemen, be sure you get this, for *it* alone is true wisdom. But do not imagine, however, that all the dogmatism is on one side, and that the theological. Many, indeed, seem to think that theology has a *preëmption-right* to dogmatism. If so, then modern science has "*jumped the claim*." Dogmatism has its roots deep in the human heart. It is born of narrowness and pride. It showed itself first in the domain of theology, only because *there* was the seat of power. In modern times, therefore, it has gone to the side of science, because here now is the seat of power and fashion. There are, then, *two dogmatisms*, both equally opposed to the true rational spirit, viz., the old theological and the new scientific. The old clings fondly to old things, only because they are old; the new grasps eagerly after new things, only because they are new. True wisdom and true philosophy, on the contrary, "tries all things," both old and new, "and holds fast only to that which is good and true." The new dogmatism taunts the old for credulity and superstition; the old reproaches the new for levity and skepticism. But true wisdom and philosophy perceives that they are both equally credulous and equally skeptical. The old is credulous of old ideas and skeptical of new; the new is skeptical of old ideas and credulous of new; both deserve the unsparing rebuke of all right-minded men. The appropriate rebuke for the old dogmatism has been put in the form of a bitter sneer in the mouth of Job: "No doubt *ye* are the men, and wisdom shall *die* with you." The appropriate rebuke for the new dogmatism, though not put into the mouth of any ancient prophet, ought to be uttered.

SKETCH OF PROFESSOR EDWARD S. MORSE.

PROF. MORSE was born in Portland, Maine, in 1838. He had an early love of natural history, and at thirteen years of age he commenced a collection of shells and minerals. At the outset he made a specialty of shells, and in 1857 gave his first contribution to the Boston Society of Natural History. He attended school in Bethel, Maine, and while following the usual course of an academy took but little interest in the classics, but busied himself with the woods and streams, and during this time added many new and minute species of land-shells to science.

For several years he followed the profession of mechanical draughtsman in the locomotive-works in Portland; and he also drew on wood for a while in Boston, thus cultivating that remarkable gift of graphic illustration which has since been of such great use to him both in his scientific work and in his public lectures. In 1852 Mr. Morse became a special student of Prof. Agassiz, at the Museum of Comparative Zoölogy at Cambridge, where he remained until 1862, pursuing closely his biological work, but also attending the lectures of Wyman, Cook, and Lowell. While with Agassiz he became more especially interested in the study of the *Brachiopoda*, a class of salt-water bivalve creatures long regarded as mollusks, and of great interest in every aspect; for, although of a low animal type, no other class exhibits such an extensive range in time, geographical distribution, and depth of water. Prof. Morse's first paper on this subject was published in the "Proceedings of the Boston Society of Natural History, 1862." In 1866 he removed to Salem, Massachusetts, where he still resides. Here he became one of the founders of the *American Naturalist*. In 1868 he was elected a Fellow of the American Academy of Arts and Sciences, and in 1871 he received the honorary title of Doctor of Philosophy from Bowdoin College, in which institution he was Professor of Zoölogy and Comparative Anatomy for three years. In 1874 he was elected to one of the university lectureships at Harvard. In 1876 he became a Fellow of the National Academy of Sciences, and the same year was elected Vice-President of the American Association for the Advancement of Science. In the prosecution of his zoölogical investigations Prof. Morse has made many excursions, visiting the Bay of Fundy several times, and also the Gulf of St. Lawrence, and Beaufort Harbor, North Carolina. Desirous of pushing his observations into regions but little examined, Prof. Morse last year went to Japan, for the purpose of dredging on the coast and searching for new specimens in his favorite lines of research. But the heathen of that remote region had the sagacity to detect the character of their visitor, and quickly secured his services, and set him at work. They said to him in effect, "We do not want the religion, nor the morality, nor the politics of your people, but we want your science." Prof. Morse was accordingly induced to accept the chair of zoölogy in the Imperial University of Tokio. He established a zoölogical station at the Bay of Yeddo, and made large collections for the museum at Tokio, besides a great number of specimens for exchange with American societies. He also discovered the traces of early man in Japan, found a large quantity of ancient pottery, and, in an address before the Asiatic Society at Tokio, he communicated the results of these researches.

Prof. Morse's most important contributions to science have been his investigations on the *Brachiopoda*, which he has pursued with indefatigable industry, going deeply into the question of their structure and affinities. By the help of embryological analysis he has thrown new and important light upon their systematic position in the scheme of invertebrate life. He maintains the view that the Brachiopods must be removed from the division of mollusks and classed with the worms. These ideas have been adopted by many leading naturalists both here and in Europe.

Prof. Morse has made all his expeditions for scientific investigation at his own private expense, and, not being a man of wealth, he has been compelled to lecture much during the winter season to get the means of carrying on his researches during the summer. He has given courses of lectures before the Lowell Institute of Boston, the Peabody Institute of Baltimore, and the Cooper Institute of New York, and has also given courses and single lectures in all the principal cities in the Northern and Western States. Of his rare qualities as a popular scientific lecturer, the thoroughness of his information, his vivid, free, and forcible style as a speaker, and his great skill of rapid delineation upon the blackboard, we have previously spoken.

Prof. Morse is a man of irrepressible activity and an inexhaustible flow of spirits, genial and hearty in manners, a fluent and fertile talker, a copious story-teller, a lover of music, and passionately fond of children. He is a patient, assiduous worker, and has contributed largely to the proceedings of scientific societies and to scientific periodicals. The following are among the most important of his publications:

1. "Description of New Species of Helix" (*Helix asteriscus*), (Proceedings of the Boston Society of Natural History, vol. vi., 1857, p. 1).

2. Description of New Species of Helix" (*Helix milium*), (Proceedings of the Boston Society of Natural History, vol. vii., 1859, p. 1).

3. "The Hæmal and Neural Regions of Brachiopoda" (Proceedings of the Boston Society of Natural History, vol. ix., 1862, pp. 3).

4. "On the Normal Position of Cephalopods" (Proceedings of the Portland Society of Natural History, vol. i., 1863).

5. "On the Occurrence of Rare Helices in Ancient Shell-Heaps" (Proceedings of the Portland Society of Natural History, vol. i., 1863).

6. "Synopsis of the Terrestrial and Fluviatile Mollusks of Maine" (published by the Author. 1864, pp. 4).

7. "Observations on the Terrestrial and Fluviatile Mollusks of Maine" (*Journal of the Portland Society of Natural History*, vol. i., 1864, 2 plates, 26 figures, pp. 63, 104 figures).

8. "Description of New Species of Pupadæ" (Annals of the New York Lyceum of Natural History, vol. viii., 1865, pp. 6, 11 figures).

9. "A Classification of Mollusca based on the Principle of Cephalization" (Proceedings of the Essex Institute, Salem, vol. vi., 1865, 1 plate, 27 figures, pp. 19).

10. "Description of a New Species of Cyclocardia" (*C. novanglaa*), (Annual Report of the Peabody Academy of Science, 2 figures, p. 1).

11. "Note on Classification of Pulmonifera" (Proceedings of the Boston Society of Natural History, vol. xii., p. 1, 1869).

12. "On the Early Stages of Brachiopods" (*American Naturalist*, Salem, vol. iii., 7 figures, pp. 2, 1869).

13. "Position of the Brachiopoda in the Animal Kingdom" (*American Naturalist*, Salem, vol. iii., 3 figures, pp. 2, 1870).

14. "The Brachiopoda a Division of Annelida" (*American Journal of Science and Arts*, vol. l., 3 figures, pp. 4, 1870).

15. "A Reply to Mr. Dall's Criticism on the Brachiopoda a Division of Annelida" (*American Journal of Science and Arts*, vol. l., pp. 4, 1870.

16. "On the Early Stages of an Ascidian" (Proceedings of the Boston Society of Natural History, vol. xiv., 1 plate, 6 figures, pp. 7, 1871).

17. "On the Tarsus and Carpus of Birds" (Annals of the New York Lyceum of Natural History, 2 plates, 48 figures, pp. 22, 1871).

18. "On the Land-slides in the Vicinity of Portland, Maine" (Proceedings of the Boston Society of Natural History, vol. xii., 1 map, 3 figures, pp. 10, 1869).

19. "Remarks on the Relations of Anomia" (Proceedings of the Boston Society of Natural History, vol. xiv., 6 figures, pp. 4, 1871).

20. "Remarks on the Adaptive Coloration of Mollusca" (Proceedings of the Boston Society of Natural History, vol. xiv., pp. 5, 1871).

21. "On the Early Stages of Terebratulina" (Memoirs of the Boston Society of Natural History, 2 steel plates, 58 figures, pp. 11, 1871).

22. "On the Oviducts and Embryology of Terebratulina" (*American Journal of Science and Arts*, vol. iv., 17 figures, pp. 3, 1872).

23. "On the Systematic Position of Brachiopoda" (Proceedings of the Boston Society of Natural History, vol. xv., 58 figures, pp. 60, 1873).

24. "Embryology of Terebratulina" (Memoirs of the Boston Society of Natural History, vol. ii., 2 plates, 108 figures, pp. 15, 1874).

25. "Apparatus for illustrating the Variations of Wave-Lengths by the Motion of its Origin" (Proceedings of the American Association for the Advance of Science, vol. xxii., 3 figures, pp. 3, 1874).

26. "Relationships of the Tunicates" (Proceedings of the Boston Society of Natural History, vol. xiv., 1874).

27. "Observations on the Spittle-Insect" (Proceedings of the Boston Society of Natural History, vol. xiv., 1874).

28. "First Book of Zoölogy" (D. Appleton & Co., publishers, 321 figures, pp. 191, 1875. Reprinted in London, and translated into Japanese).

29. "On a Diminutive Form of the Male in Buccinum Undatum" (Proceedings of the Boston Society of Natural History, vol. xviii., 4 figures, pp 3, 1876).

Prof. Morse came back from Japan to give some lectures here the past season, and returned to that country in April with his family, to continue work there a year or two longer.

CORRESPONDENCE.

NIGHT-AIR IN CITIES.

To the Editor of the Popular Science Monthly.

YOUR April correspondent, Mr. C. W. Johnson, in his critique on my brief note which appeared in your pages of February last, either has misapprehended the issue I there made with Dr. Niemeyer's article in reference to the salubrity of night as compared with day air in cities, or he has stumbled upon the unwarrantable conclusion, solely through the bias of his own cerebration, that, because I did not mention, in the short compass of a few lines, all the forms of local urban insalubrity, therefore I do not believe some of them exist.

Having imagined that I had put the issue so plainly that no reader could fail to understand it, I am at a loss to spell it out any clearer for Mr. Johnson. Let me try it in the form of an interrogatory. Is the air in which we live, move, and breathe, more likely to be charged from local sources with pollutions that produce disease when comparatively still and calm, as during the night, during the day, when stronger currents are more apt to prevail? Dr. Niemeyer says that the night-air of cities is purer than the day-air, while I, in the language of Mr. Johnson, "assume to correct" his statement by showing by a fact or two that moving air is less apt to be intensely charged by any focus of corruption than that which is almost motionless and circumjacent to the source of contamination. The issue was made on the point as to the *time* most favorable for the atmosphere to acquire impurities the most largely from local sources of pollution, not as to the nature or *forms* these impurities may assume, or as to whether they are gaseous, granular, molecular, organic, or inorganic.

Yet, upon the putting of the issue thus plainly, Mr. Johnson represents me as believing that "the insalubrity of city air depends upon the amount of non-respirable gases (!) that may be diffused into the respirable ones"—whatever this may mean—"and is wholly independent of the condensible effluvia of the vaporous kind, or of the organic germ-dust that the heat and stir of the day may keep suspended."

In candor I must say that only those whose ideas are crude and vague upon the subject of the atmosphere as a vehicle of contagia or *materies morbi* would pen such a sentence. Does Mr. Johnson suppose that the *contagium vivum* of scarlatina, or of typhoid fever, or of small-pox, is anything like the heavy dust of the streets, or that it needs the stir of day-air to keep it suspended? Does he not know that the contagia of these diseases are so subtilely diffused and attenuated that the highest magnifying power is unable to isolate or detect them? An investigator now and then has imagined that he has discovered the spores of infection, but only one as yet has made a near approach to settled verification.

To relieve the mind of Mr. Johnson as to my benighted condition on the subject of germ-dust, I beg to refer him to the *Philadelphia Medical and Surgical Reporter*, January 13, 1877, in which I take the ground that the theory of a *contagium vivum* is the only tenable one by which to account for the genesis and spread of some infectious diseases. The unlimited self-multiplication of definite forms or special phases of force, as, e. g., in small-pox, scarlatina, etc., is an attribute only of living matter. There is no more likelihood of the spores of scarlatina being converted into those of small-pox than there is of the germ of a dog being converted into that of a horse. All, in common, only reproduce after their kind.

Of course, the hypothetical spores of an infectious disease are not subject to the chemical law of gaseous diffusion; yet, as such contagia show in various ways a high degree of volatility, stillness of the air is obviously far more favorable to their large aggregation in any particular locality than rapid air-movement. Every intelligent physician is well aware that one of the very best methods of preventing the spread of an infection through a house is by good ventilation or running air. But all this is against Niemeyer's notion of the superior salubrity of still night-air, as compared with the rapid air-movements during the day. The day-air mobility is the analogue of house ventilation—the night-air stagnation the analogue of concentrated house impurity.

If Mr. Johnson desires to know, as it is presumable he does from his inquiry, how "noxious effluvia, if they obey the law of the gaseous diffusion of permanent (!) gases, hover over low marshes and putrefying cesspools," he has only to study the law in any elementary treatise on chemistry. If the effluvia be sulphuretted hydrogen, it will diffuse very rapidly; if it be carbonic acid, much more slowly—specific gravity having something to do with the process. But, in either case, the hovering is greatly promoted by the stillness of the atmosphere, as during the night. Or, let him place a speck of spoiled egg in one corner of his house: its sulphuretted hydrogen will soon be perceived throughout all the connecting rooms, but the strongest near the speck, unless it be carried out of the house by a current of air. The attenuated diffusiou of deleterious gases tends to render them harmless—their concentration to produce disease by a *de novo* process. The inspiration of concentrated or nearly pure sewage-gas has often caused instant death, a larger dilution habitually inspired often breeds fever, but an attenuated amount of it is not appreciably harmful. And what is more promotive of this dilution or attenuation than the great mobility of day-air?

J. R. Black.

EDITOR'S TABLE.

HOW NEW YORK GOT A COLLEGE.

New-Yorkers are somewhat exercised over the question what to do with their college, a problem which it ought to be easier to solve, by remembering how they came by it. What on earth New York City wanted with a college, when there were two good ones already in the town, not half full of students, might be a perplexing inquiry, did we not know that corporations, as well as individuals, often find themselves possessed of things which they don't want and never intended to have. The people did not say, "Go to, let us have a college, cost what it will, and teach Columbia and the University how to manage a higher institution of learning." The city has been drawn into running an opposition line to these establishments in a very different way, and the case is instructive as showing that education can be "managed" as well as other public interests.

What the people of New York did propose, upward of thirty years ago, was to organize a sort of polytechnic or practical high-school, connected with the school-system of the city, to give a little extra preparation to boys, who expected to devote themselves to some form of mechanical industry, and not to the learned professions. If we are not mistaken, such was the explicit object of the institution, and it was so stated upon the ballots by which the citizens voted to establish such a school. This was done by a very large popular majority, and it was set agoing under the name of the "Free Academy." But the movement was premature for New York, or its direction fell into incompetent hands, as nothing efficient was done to stamp it with the character it was designed to have, or to carry out intelligently its distinctive purpose. The plan of education wanted had to be theoretically shaped, and should have been then cautiously carried into practice, by the selection of a faculty in thorough sympathy with the idea, and as well qualified for the work as could anywhere be found. But the parties chosen failed in these respects. That they were unfit to be intrusted with the responsibility, was shown by their work, and by the fact that they were dissatisfied with the status of the concern, and wanted it turned into a "regular college." They complained that their graduates did not stand well at a distance from home, as a "Free Academy" was regarded as not amounting to much. They accordingly set to work to change it, and, by quiet, persistent effort, they at length lobbied a bill through the Legislature at Albany, abolishing the "Free Academy," and creating in its place "The College of the City of New York." How completely the original purpose of the institution was abandoned in this transformation, and the old idea of a classical college substituted, was well shown by the official and authoritative address of Judge Larremore, President of the Board of Education that voted the supplies, and also President of the Board of Trustees of the new college. He proclaimed that the "Free Academy" was dead, that he knew nothing of it, and curtly brushed aside as no longer of interest the objects for which it was founded, and the policy by which they were to be secured. He went back and expatiated on the mediæval origin and classical ideal of colleges and universities, defended the scholastic conception of culture in contrast with modern innovations, eulogized Latin and Greek, and went in for old-fogyism generally. How entirely the spirit of the original undertaking was ignored and disavowed was well illustrated by the fact that when somebody quoted, in behalf of modern scientific culture, an authority whose work upon education has been translated into a dozen languages, and has exerted an immense influence in modifying plans of study, Judge Larremore contemptuously dismissed the matter, by saying that the authority was of no weight, as the author of the book had never been through college, and was nothing but a railroad engineer. Even a railroad engineer might have counted for something, on the theory by which the "Free Academy" was established; but in the policy of the new classical institution this sort of men seemed to get but little consideration.

And thus it came about that New York finds itself the proprietor of a "regular college." The people proposed to have a high-school, free for poor boys who had attended its common schools, to get some adequate preparation for industrial avocations, and which it was supposed could be carried on for $20,000 a year; and they now find themselves cheated out of their intentions, and saddled with an ordinary college, costing $150,000 a year, more or less. Of course, the repudiation of the original school, and of the ideas which led to its establishment, was not submitted to a popular vote, and it is equally certain that, if the projected change had been thus submitted, it would have been overwhelmingly rejected. And yet, by all the reasons at present urged for the continuance of the college, the people would have been in duty bound to establish it. Indeed, the controversy which has been going on in the newspapers of late, as to whether the city of New York shall abolish its college, is chiefly significant as affording a sort of register of public sentiment on the policy of State education. The college has this use, that it forces the extreme issue in regard to the educational functions of government, and it is noteworthy that the contest has elicited strong expressions in favor of committing the whole business of education to the State. Having affirmed the voluntary principle in religion, and denied the right of the State to meddle in this most important concern—having affirmed that the individual is a better judge in this matter than the State can be—when it comes to education, we deny the voluntary principle, deny that individuals here know what is best for themselves, and that the State—that is, the politicians who happen at any time to be in office—is better than the people to be intrusted with the absolute control of the subject. The history of the New York College is merely a sample of the manœuvring by which jobs will be carried, with no reference to the popular will, just in proportion as education is given over to political management.

THE LIBERTY OF SCIENCE AND EDUCATION.

An interesting controversy has sprung up in Germany upon this subject, the most important utterances of which we have had translated and published for the benefit of American readers.[1] A part of the discussion has been made use of in England and in this

[1] *See* the addresses of Profs. Haeckel and Virchow, in the Popular Science Monthly Supplement, No. X., and Hellwald's paper in No. XI.

country in a way that makes some comment desirable.

Prof. Haeckel, of Jena, gave an address last September at Munich, before the "German Association of Naturalists and Physicians," in which he took the ground that the doctrine of evolution should be made a part of the system of general education in that country.

Prof. Virchow replied to Haeckel in a speech before the same body, on the "Liberty of Science in the Modern State," and argued eloquently against the educational project. He said that the freedom of science now enjoyed in Germany is but of recent growth, and may be imperiled if men of science do not exercise moderation. He referred to the fact that the German socialists are Darwinians, and cautioned the *savants* against so lending themselves to the purposes of this dreaded party as to make it necessary for the state to interfere. But Prof. Virchow went further, and maintained that the measure proposed would be unjustifiable, because the theory of evolution is not yet sufficiently proved. He did not reason against it, and is understood to be himself an adherent of the doctrine. But, he said, it is not yet established. As an anthropologist he declared that no progress had been made in that branch of science toward the establishment of the theory of the descent of man from the lower forms of life. He did not object to it, and considered it a desideratum of science that might be realized at any time. But the proof, he affirmed, is wanting, and the burden of his speech was that what *may be*, or is merely *probable*, must not be taken as fact, or made use of in education.

It is not to be supposed that so authoritative a statement would be neglected by those who are troubled about the adventurous spirit of modern science. Ever since his Belfast Address there have been ominous whispers that the next number of the *Quarterly Review* would contain an annihilating attack upon Prof. Tyndall; and those interested in this serious result have waited curiously for the onslaught, until they began to fear that the editors had backed out. But the German professor has come to their rescue, and in the January issue they let fly their shaft, barbed with Virchow's address. Nor are the Americans behind the English in utilizing the authority of the Berlin physiologist. Prof. Gray, of Cambridge, introduces the main parts of Virchow's argument to the pages of the New York *Independent*, with comments designed to enforce its special lessons. He prizes the address as "a timely and earnest protest against what may be called *platform science*—not peculiar to Germany, nor to advanced evolutionists—against that form of scientific dogmatism which propounds unverified and unverifiable speculations as the conclusions of science." Now, we must think that Prof. Gray has here failed to make the most telling use of his opportunity. Dogmatism and undue license of speculation are undoubtedly bad things, to be always condemned, and nothing certainly could be more proper than for Prof. Gray to warn the readers of the *Independent* against indulgence in those easily-besetting sins. But would not the point have come out a little better if Prof. Gray had said something like this: "Dogmatism—that is, arrogance of opinion, and the disposition to pronounce confidently upon matters that are incapable of being known or verified—is a universal mental habit, inveterate in proportion to people's ignorance, against which education makes but slow headway, which has ever characterized theology, and is most fostered by those powerful agencies in society—churches, Sunday-schools, and religious newspapers? All of these agencies enforce the early and passive acceptance of dogmas that are beyond the sphere of verification, and teach that repose of belief is the great end to be sought, and doubt a heinous thing not to be tolerated upon pain of eternal retribution. Science, on the contrary, begins with questioning, and, by insisting upon evidence, has restricted the sphere of speculation, and made belief more a matter of reason, and in this way it has done much to destroy the dogmatic spirit. Yet this tendency to dogmatism is so deep and strong in human nature, as at present trained, that even scientific men often yield to it, and put their baseless speculations in place of science, and here is a German *savant* of great authority who says so." This is probably what Prof. Gray meant if he had explained himself more fully, for surely one cannot suppose he intended to encourage the bad habits of one class by telling them how bad are those of another.

Let us now glance for a moment at Virchow's test of what ought to go into the schools. Prof. Gray quotes the following passage: "From the moment when we had become convinced that the evolution theory was a perfectly established doctrine—so certain that we could pledge our oath to it—from that moment we could not dare to feel any scruple about introducing it into our actual life, and not only communicating it to every educated man, but imparting it to every child, . . . and basing upon it our whole system of education." To this the reply is, first, that the standard taken is impracticable, and, if adopted, would abolish education altogether; and, second, if it is lowered, as it must be, evolution cannot be kept out of the schools.

It is important to remember here that Virchow is an evolutionist—not, perhaps, an "advanced" evolutionist, but, as Prof. Gray recognizes, a "pronounced evolutionist," like himself, we suppose. And, if so, it must be because there is a certain amount of truth in the doctrine. But, forthe purpose here contemplated, the question is not whether evolution is completely proved—it is simply whether there is sufficient truth and value in it to make its introduction into the schools an improvement upon their existing practice. Now, if evolution is true at all, as admitted by Virchow and Gray, and by the leading thinkers of the time, it must, by the very nature of the idea, be a verity in regard to the great method of things around us—how they come, and how they go, and how they are related to each other in the genetical order. Evolution must embody a truth to this extent, from the very necessity of the case, or it contains no truth at all. It is, by its definition, an unfolding in the course of Nature. That there are numerous imperfections in it, matters nothing, for no science is perfect. Astronomy, based upon physics and mathematics, has ranked as the most perfect of the sciences; but, if any one wishes to understand how imperfect it really is, let him read Prof. Newcomb's new book upon the subject. Chemistry is in a state of revolution, and physics is full of unsettled theories. What, in fact, is science but imperfect sciences getting rid of their errors and limitations?

As to evolution, it is enough that it is a mental view which answers to a great reality. Whether it is to be recognized, is not an open question; it is already in the field as a power that is modifying almost every branch of knowledge. It is guiding investigations in the pathway of successful research; it is the broadest principle of unification in Nature that the human mind has yet reached. Can so comprehensive and all-harmonizing a truth be without value as a means of mental culture? Whether Haeckel was wise or not in demanding its formal introduction into the schools, it is certain that the powers which control the German Empire cannot keep it out of the schools. Nothing would be more futile than to demand the teaching of the development theory in the schools of this country, except, perhaps, the attempt to prevent it. Already it is taught in the text-books of geology, and it will be more and more seen in the manuals of zoölogy, botany, psychology, philology, and history, when these are revised, and adapted to the advanced condition of knowledge.

With such tendencies predominant, how grotesque is the spectacle of a man like Virchow planting himself at the doors of the German schools, and flourishing his test of what is to be admitted there! As the scientific men approach with their subjects, they are stopped by the question, "Can you make oath, gentlemen, to the truth of what you offer?" And so we have a scientific man ruling out science from the schools by a standard not recognized in education, and which, if rigidly applied, would shut up every schoolhouse in Germany. For what would become of history, philology, geography, political economy, and the whole round of studies that are already pursued, if this swearing-test were to be applied to them? The question, as we have said, is whether something can be got that is better than what now exists, as this is the way all progress is secured. In an address of great power, by Prof. Du Bois-Reymond, of Berlin, on "Science and Civilization" (which we shall soon have the pleasure of publishing), the professor says of the religious instruction given in the German schools: "In the semi-official plan of studies, more than half a page of fine print is expended in setting forth the subject-matter of this instruction, while five lines suffice to dispatch the mathematical programme! On reading this half-page, and the corresponding half-page for the upper second class, one imagines he has before him the programme of a theological seminary." So there is a body of dogmatic divinity already in the schools, including, of course, a cosmogony, or theory of creation, and traditional hypotheses without number. To all this Prof. Virchow does not dream of applying his test; but, when the representatives of modern knowledge demand that the teaching shall better reflect the existing state of thought, the admonition comes: "No dogmatism! Winnow your work, gentlemen — nothing but facts are to be admitted here, with their certainties, up to the swearing-point."

Considered educationally, what else is this but the old, exploded policy of pouring facts into mental pitchers? What are facts good for if not interpreted, and what is science without explanation—that is, theory? Would Prof. Virchow swear the atomic theory out of chemistry, and the wave theory out of optics, and the nebular theory out of astronomy; and what would become of his own science of physiology if nothing could be taught of it but what he can make oath to? The highest object of education is to rouse mental activity, to set pupils to thinking, to encourage them to make their own observations and their own independent reflections; and this can in no way be done so effectually as by linking educational methods to the great movements of thought that are absorbing the world's attention, outside of the schools. To deal only in culture with demonstrated facts, and thus to reduce the process to one of bare acquisition, is a deadening and paralyzing process, not suited to prepare students to use their minds to the best advantage in the conduct of practical life.

Nothing can be clearer than that the liberty of science and the liberty of education, the progress of science and the progress of education, are indissolubly linked together. Whewell has shown us how, in the development of the human intellect, the great steps of culture have followed and resulted from the great steps of discovery that have successively enlarged the sphere of human knowledge. And it was not because certain new facts were poured in at each epoch of discovery, but because new ideas, new methods, new modes of mental activity, were introduced. These are invaluable in education, and if shorn away, so that nothing but direct results are imparted, the quickening, arousing influence of science is lost to culture. Karl Grün well observes: "Science either enjoys perfect liberty, or she is not free at all. Setting up hypotheses and tracing their ultimate consequences are part and parcel of science, and of the liberty of science;" and we may add that its use in this form is a part of the liberty of education.

It is one of the chief glories of science that it has first taught men the supreme value of truth, and the disciplines of character that the earnest pursuit of truth involves. Truth on its own account and for its own sake is its one great object, and, in proportion as it can be incorporated in education and made the incentive of mental activity, will education attain its highest and noblest object. A writer in the German periodical *Kosmos*, replying to Prof. Virchow, thus gives effective expression to this idea:

"Scientific research aims at the discovery of truth, never inquiring who is to be benefited thereby. The question, *Cui prodest?* (Who is benefited?) is fortunately of as little account in science as the other question, *Cui nocet?* (Who is hurt?) Hence whether the evolution doctrine favors the Socialists or the Ultramontanes, the high and dry Conservatives, the Moderates, the Liberals, the Radicals, or any other party, must be a matter of *entire indifference* to the earnest investigator, and must not be permitted for a moment to lead him astray in his researches. *The truth must be established for its own sake*, and for no other purpose. Any other consideration, even though it were urged by a Virchow, must be absolutely rejected. Ever since science first began there have been heard authoritative voices calling 'Halt!' to the restless spirit of speculation, and it were a grave injustice not to recognize the value of such admonitions. They who warn against danger, and they who engage in scientific speculation, are both indispensable for the development of science; but we must ever bear in mind that scientific progress always, almost without an exception, has come from the labors of those who dared to give expression to thoughts which were as a leaven to the minds of their contemporaries, and who were persecuted for heresy, and laid under a ban by the authorities. The most splendid triumphs of science are the fruit of the empiric demonstration of ingenious hypotheses. Even in cases where these hypotheses have proved untenable they have *caused men to think*, and that in itself constitutes a new advance of science. We could as little dispense with them as with the leaven in bread. All honor, then, first of all to the men to whom we are indebted for hypotheses which have given a stimulus to research; which, so to speak, constitute a landmark in the history of science; finally, in the *mastering* of which, in one sense or the other, a full generation or more has been employed! Honor, again, to those intellectual princes of whom the German proverb is true that, 'when kings build, there is work for cartmen!'"

PROFESSOR MAX MÜLLER ON "THE ORIGIN OF REASON."

And, while we happen to be on the subject of evolution in Germany, we may refer to another episode in relation to this subject. Prof. Max Müller, well known as a philologist, has written an ambitious paper on "The Origin of Reason," in which he follows Prof. Ludwig Noiré, a German philologist, and called a "rank evolutionist." Müller points out how Prof. Noiré has laid under contribution Spinoza, Descartes, Leibnitz, Kant, Locke, Schopenhauer, and Geiger, for materials to construct an evolution theory, his own contribution being that the development of mind is to be come at through the study of language. Noiré does not think much of Darwin, but prefers Cuvier, and works up his scheme out of metaphysical materials, rather than the results of modern science. This Müller indorses, saying, "Every system of philosophy which plunges into the mysteries of Nature without having solved the mysteries of the mind, the systems of natural evolution not excepted, is pre-Cartesian and mediæval." It is somewhat curious to characterize as mediæval that new spirit which arose and put an end to the mediæval period—the giving precedence to the study of Nature. The truth of the case seems to be that Noiré perceived that evolution has come to be the great basis of philosophy, and therefore accepts it and applies it in the study of the interactions of psychology and language; and yet Max Müller tells us that "Noiré's philosophy rests on a most comprehensive theory of evolution; it is the *first attempt* at tracing the growth of the whole world, not only of matter but of thought also, from the beginning of things to the present day." This is certainly a remarkable claim, and we are at once interested in the intellectual career of the party in whose behalf it is made. It turns out that Noiré's first book, "The World as an Evolution of Spirit," was published in 1874, and the last in 1877. As he subsequently repudiated that first book, the gestation of his system, involving an analysis of the "Growth of the Whole World," took less than three years. Prof. Müller says this was the "first attempt," etc., although he was perfectly aware of the fact that Herbert Spencer is the only man that has ever dealt with the subject comprehensively, and also that he published the complete prospectus of his system fifteen years before Noiré issued his first book. Mr. Spencer, in his last volume, on Sociology, has no doubt seriously damaged Müller's favorite theory of myths; but it would be more creditable to the Oxford professor, either to answer him, or acknowledge the defeat, rather then to vent his resentment by such absurd misrepresentations.

LITERARY NOTICES.

Treatise on Chemistry. By H. E. Roscoe, F. R. S., and C. Schorlemmer, F. R. S., Professors of Chemistry in Owens College, Manchester. Vol. I. The Non-Metallic Elements. New York: D. Appleton & Co. Pp. 769. Price, $4.

Chemistry undoubtedly stands among the first of the progressive sciences. Its field is so large, its applications so numerous and practical, and the number of its devotees in all countries so great, as to secure the steady and rapid advance of the science. As a consequence of this, it leaves its literary monuments behind, much as a railway-train leaves the milestones. An exposition of the subject, no matter how completely it may represent its position at a given time, quickly falls behind and becomes antiquated. The large works of Regnault and William Allen Miller, which were standards a few years ago, are now quite out of date; valuable in many respects for reference, they do not embody the results that have been attained since. There was, therefore, need of a new comprehensive treatise on chemistry to take their place in colleges and laboratories. This want has been supplied by the combined labors of Profs. Roscoe and Schorlemmer, the first volume of which is now published. The character of the work they have undertaken is thus stated by its authors: "It has been the aim of the authors, in writing the present treatise, to place before the reader a fairly complete and yet a clear and succinct statement of the facts of modern chemistry, while at the same time entering so far into a discussion of chemical theory as the size of the work and the present transition state of the science permit. Special attention has been paid to the accurate description of the more important processes in technical chemistry, and to the careful representation of the most approved forms of apparatus employed."

The work opens with an excellent historical sketch of the science on the basis of Kopp's history, and this feature is continued in dealing with the most important elements and compounds throughout the book. A marked feature of the work, and one that will be appreciated in the class-room, is the prominent attention that has been given to the representation of apparatus adapted for lecture-room experiment. The numerous new illustrations required for this purpose have all been taken from photographs of apparatus actually in use. The names of the authors are a guarantee of the accuracy and thoroughness of their work, while the proportions in which the various divisions are presented are adapted to the use of students who desire to obtain a thorough general knowledge of the science. The work is printed in large, clear type, presenting an attractive page, and its illustrations are numerous and of a superior order.

A Practical Treatise on Diseases of the Eye. By Robert Brudenell Carter, F. R. C. S. With numerous Illustrations. London: Macmillan & Co. Pp. 591. Price, $4.

This work, by one of the most prominent ophthalmic surgeons of London, has been some time published, and has an excellent character with the profession. Attention being increasingly drawn to the impairment of the health of the eye in our schools, and by various kinds of mismanagement, we were anxious to consult some modern authoritative work on the maladies of the eye, and selected this volume for the purpose. Dr. Carter is a philosophical student of his subject, and twenty-five years ago published an interesting volume on the influence of civilization in modifying diseases of the nervous system. But, although he writes as a thinker, the author has made the present work thoroughly practical. It comprises his lectures at St. George's Hospital on common forms of eye-disease which he had occasion to deal with in practice; and it is this circumstance which gives to the treatise its chief merit. It contains many illustrations of the structure of the eye, ophthalmic instruments, and modes of operation.

A History of England in the Eighteenth Century. By William Edward Hartpole Lecky. New York: D. Appleton & Co. Two volumes. Pp. 1,325. Price, $6.

Mr. Lecky has won an assured and distinguished place as a philosophical historian. We were among those who had no hesitation in saying that he fully established this character in the publication of his first considerable work, "A History of the Rise and Influence of the Spirit of Rationalism in Europe;" and his claim as an original historical thinker was confirmed by the subsequent appearance of his "History of European Morals." The direction of thought, partially opened by Macaulay, and more vigorously pursued by Buckle, which takes account of the great pacific forces that have been involved in modern civilization, is adopted by Mr. Lecky, and has been followed out by him, systematically and most ably, in his successive treatises. The old and vulgar conception of history as a mere narration and chronicle of incidents, a gossipy delineation of the great personalities that have figured in public affairs, a picture of court manners, a threading-out of diplomatic intrigues, with abundant description of battles, campaigns, wars, conquests, and the overturning of dynasties, Mr. Lecky leaves to those who can be satisfied with it. These are very much surface-effects, well fitted, indeed, to strike the imagination, but of trivial moment in comparison with those profounder agencies by which modern society has been shaped and the real work of civilization carried forward. Science has been at the bottom of a revolution in recent times, which has compelled not only a re-estimate of the importance of subjects to be dealt with in history, but a reversal of former judgments, by which subjects long neglected must henceforth have supreme regard. The influence of scientific habits of thinking has deepened the study of history, antiquated its superficial methods, and carried us down to those deeper and wider causes that have determined the amelioration of humanity. Mr. Lecky takes up the work of the historian avowedly from this point of view, and, in the two solid volumes now before us, he has applied it to an important period of the history of his own country. It is a splendid theme, for England has a central and commanding position in the movement of national development; and the times considered by Mr. Lecky were fruitful of profound changes and the most important results. The purpose and plan of his work are thus indicated in his preface:

"I have not attempted to write the history of the period I have chosen year by year, or to give a detailed account of military events, or of the minor personal and party incidents, which form so large a part of political annals. It has been my object to disengage from the great mass of facts those which relate to the permanent forces of the nation, or which indicate some of the more enduring features of national life. The growth or decline of the monarchy, the aristocracy, and the democracy, of the Church and of Dissent, of the agricultural, the manufacturing, and the commercial interests, the increasing power of Parliament and of the press, the history of political ideas, of art, of manners, and of belief; the changes that have taken place in the social and economical condition of the people, the influences that have modified national character, the relations of the mother-country to its dependencies, and the causes that have accelerated or retarded the advancement of the latter, form the main subjects of this book."

Natural Law: An Essay in Ethics. By Edith Simcox. Boston: Osgood & Co. Pp. 361. Price, $3.50.

This is a profound disquisition on the deep things of metaphysical and moral philosophy. The treatment is very didactic, and not altogether inviting; but the author is a radical thinker, and tries hard to get down to first principles. The subject is dealt with under the heads of: I., Natural Law; II., Customary and Positive Law; III., Morality; IV., Religion; V., The Natural History of Altruism; VI., The Natural Sanctions of Morality; VII., Social and Individual Perfection. The best thing in the book is an extract from Jeremy Taylor, stating the difficulties that people have in getting along in this world. The passage will bear reproducing:

"Whoever was to be born at all, was to be born a child, and to do before he could understand and be bred under laws to which he was always bound, but which could not always be exacted; and he was to choose when he could not reason, and had passions most strong when he had his understanding most weak, and was to ride a wild horse without a bridle, and, the more need he had of a curb, the less strength he had to use it; and, this being the case of all the world, what was every man's evil became all men's greater evil, and though alone it was very bad, yet when they came together it was made much worse; like ships in a storm, every one alone hath enough to do to outride it; but when they meet, besides the evils of the storm, they find the intolerable calamity of their mutual concussion, and every ship that is ready to be oppressed with the tempest is a worse tempest to every vessel against which it is violently dashed. So it is in mankind: every man hath evil enough of his own, and it is hard for a man to live soberly, temperately, and religiously; but when he hath parents and children, brothers and sisters, friends and enemies, buyers and sellers, lawyers and physicians, a family and a neighborhood, a king over him or tenants under him, a bishop to rule in matters of government spiritual, and a people to be ruled by him in the affairs of their souls, then it is that every man dashes against another, and one relation requires what another denies; and when one speaks, another will contradict him; and that which is well spoken is sometimes innocently mistaken, and that upon a good cause produces an evil effect. And by these, and ten thousand other concurrent causes, man is made more than most miserable."

A Dictionary of Music and Musicians. A. D. 1450–1878. By Eminent Writers, English and Foreign. With Illustrations and Woodcuts. Edited by George Grove, D. C. L. In Two Volumes. Number of pages in Part I., 128. A to Ballad. New York: Macmillan & Co. Price, $1.25.

Musical dictionaries have hitherto been chiefly occupied in explaining the numerous terms and technicalities which have become so prominent in the art. The present work promises to be of a much more comprehensive character, indeed to be a kind of cyclopædia of music, giving "full and accurate information in regard to the lives of eminent composers, the history of musical instruments, the origin and gradual development of musical forms (such as the symphony and the sonata), the career of great singers, and so on." Such is the object of the work of which the first installment is before us, and which is to contain twelve quarterly parts. It is an enterprise of great labor, but the execution thus far shows that it will be thoroughly done. Its main articles are contributed by eminent authorities on musical subjects, and its minor parts have evidently been prepared with assiduous care, under the editorship of Mr. Grove. The work will of course be best appreciated by those most interested in music, but it will be of value to general readers, both for reference and for study, as furnishing the materials of the history of a great and growing popular art. We might object that the type is rather too small to give most attractiveness to the page, but from the copiousness of the information to be presented this became a necessity, in order to keep the volumes within a reasonable magnitude. The work is, however, printed with great clearness; and the musical passages that are freely interspersed in the text, to illustrate the various topics, come out with admirable distinctness. When the enterprise is completed, we shall have another important reference-book in this age of cyclopedic specialties.

Proteus, or Unity in Nature. By Charles Bland Radcliff, M. D. New York: Macmillan & Co. Pp. 214. Price, $2.50.

The object of this work is to illustrate, in a somewhat full and methodical way, the great principle of oneness in Nature—the law within law, and the communion in all things. In Part I. the author traces out the law of unity in plants, in the limbs of vertebrate animals, in the appendant organs of invertebrate animals, in the skull and vertebral column, in the relations of plants and animals, and of organic and inorganic forms. In Part II. he advances to dynamical and mental phenomena, and traces the unity of physical forces, of vital and physical motion, and of the phenomena of instinct, memory, imagination, volition, and intelligence, and closes with an exemplification of it in the personal, social, and religious life of man. In his preface, the author states that it has been his object to place himself in opposition to the materialistic spirit of the age.

History of Opinions on the Scripture Doctrine of Retribution. By Edward Beecher, D. D. New York: D. Appleton & Co. Pp. 334. Price, $1.25.

This is a book, of great theological erudition, on the question of the punishment of human beings after death. The unsettled state of opinion on this subject induced Dr. Beecher to take it up and do something to bring about a better agreement among those who believe in future punishment, but differ as to its duration; and, to those who regard such an inquiry as important, the volume will prove interesting. Dr. Beecher says: "The main interest centres on the question, 'What is the doom of the wicked?' This has fixed the attention of the world upon the import of a single word, *aionios*." It seems strange that the question of the eternal doom of immortal beings should be left so uncertain for mankind as to hang upon the interpretation of a Greek word, so that we must look to the philologists to ascertain what is to be our fate through eternity.

Vital Magnetism: Its Power over Disease. By Frederick T. Parson. New York: Adams, Victor & Co. Pp. 230. Price, $1.25.

By vital magnetism the author of this book, of course, means animal magnetism, and this term has been applied to a class of obscure and irregular effects exhibited by, or induced in, the nervous system, and also to an art of treating certain diseases. The author of the work claims that this country is very much behind Europe in the cultivation of this branch of the healing art, and his work is offered to supply a want to the medical profession arising from this backwardness of the subject, and to furnish evidence of the extent of its European development. The book has been compiled with excellent judgment, and gives account of a large number of cases, chiefly European, which are full of medical interest. It is due to the author to say that (though a Magnetic Physician) he is more modest than the standard ethics of the profession requires, for he neither parades his own cases, nor does he announce the street and number, or even the city, where he is to be found.

What there is in animal magnetism, or vital magnetism, that deserves attention as a method of treating disease, we cannot pretend to say; but those interested will find this book very suitable, as a presentation of its claims, and the evidences of its utility. There is, probably, something in it, and there may be much in it that the medical profession will yet have to recognize; but we advise the cultivators of the method to get rid of the term *magnetism* as quickly as possible, for it is both fanciful and misleading. The fact is, the thing referred to is not magnetism. It is claimed that there are certain effects produced by movements upon the human body, in certain directions, which effects are reversible by reversing the movements. This very naturally suggests analogies to magnets, which are charged and discharged in similar ways, but it no more proves the body to be a magnet than his method of grinding food proves man to be a grist-mill. The danger of such analogies is, that they are always apt to be carried too far. The author quotes approvingly the words of Dr. Ashburner as follows: "Man is a magnet. He has, like all other magnets, poles and equators. But, being a magnetic machine of very complex structure, his magnetic apparatus is divided into many parts. The brain is the chief magnet, and the trunk and extremities are separate magnets, having intimate relations with the chief source of magnetism. We infer from these facts, what is the truth, that the normal currents take a normal course from the brain to the caudal extremities."

Myths and Marvels of Astronomy. By Richard A. Proctor. New York: G. P. Putnam's Sons. Pp. 363. Price, $4.

This volume contains an excellent selection of some of the most readable of Mr. Proctor's popular essays. While not systematic studies in strict science, they contain a great deal of scientific information, and are, moreover, enriched by an erudition of side considerations which come from extensive reading, and the assiduous collection of the historic curiosities of the various subjects treated. The subjects of the present volume are—1. "Astronomy;" 2. "The Religion of the Great Pyramid;" 3. "The Mystery of the Pyramids;" 4. "Swedenborg's Vision of other Worlds;" 5. "Other Worlds and other Universes;" 6. "Suns in Flames;" 7. "The Rings of Saturn;" 8. "Comets as Portents;" 9. "The Lunar Hoax;" 10. "On some Astronomical Paradoxes;" 11. "On some Astronomical Myths;" 12. "The Origin of the Constellation Figures."

The Creed of Christendom; Its Foundations contrasted with its Superstructure. By William Rathbone Greg. With a New Introduction. In Two Volumes. Boston: J. R. Osgood & Co. Pp. 549. Price, $7.

This work has been before the public some thirty years, and is now announced as in the fifth edition. It has been extensively read, and ranks among the leading books of modern criticism upon the history and character of the Christian Scriptures. The new introduction, made to the third edition, is dated 1873, and contains 94 pages. It is interesting, as a comprehensive review of the contributions of Colenso, Renan, the author of "Ecce Homo," and Matthew Arnold, to the same general subject, and all made after the original publication of Mr. Greg's book. The main idea of the work is that Christianity has undergone the most profound changes since its first promulgation; and this idea is very impressively reiterated in the closing passages to the author's last introduction, of which the following is a part:

"I have but one word more to say—and that is an expression of unfeigned Amazement—so strong as almost to throw into the shade every other sentiment, and increasing with every year of reflection, and every renewed perusal of the genuine words and life of Jesus—that, out of anything so simple, so beautiful, so just, so loving, and so grand, *could* have grown up or been extracted anything so marvelously unlike its original as the current creeds of Christendom; that so turbid a torrent *could* have flowed from so pure a fountain, and yet persist in claiming that fountain as its source; that any combination of human passion, perversity, and misconception *could* have reared such a superstructure upon such foundations. Out of the teaching of perhaps the most sternly anti-sacerdotal prophet who ever inaugurated a new religion, has been built up (among the Catholics and their imitators here) about the most pretentious and oppressive priesthood that ever weighed down the enterprise and the energy of the human mind. Out of the life and words of a Master, whose every act and accent breathed love and mercy and confiding hope to the whole race of man, has been distilled (among Calvinists and their cognates) a creed of general damnation and of black despair. Christ set at naught 'observances,' and trampled upon those prescribed with a rudeness that bordered on contempt—Christian worship, in its most prevailing form, has been made to *consist* in rites and ceremonies, in sacraments and feasts, and fasts and periodic prayers. Christ preached personal righteousness, with its roots going deep into the inner nature, as the one thing needful—his accredited messengers and professed followers say: No! purity and virtue are filthy rags; salvation is to be purchased only through vicarious merits and 'imputed' holiness," etc.

The Aneroid Barometer: Its Construction and Use. New York: D. Van Nostrand. Pp. 106. Price, 50 cents.

It is generally understood that the aneroid barometer is a little instrument, the size of a watch, which depends for its action upon the changes in form of a thin metallic box, partially exhausted of air. As the pressure of the atmosphere varies, the thin walls of the vacuum-chamber move, and the motion is taken up by a suitable mechanism and indicated by a hand on a dial-plate. Captain Fawcett, who has had much experience with the instrument, says the value of the aneroid, as a handy and portable instrument for rapidly obtaining relative heights in surveys, has been underrated. The point chiefly valuable in an aneroid is its portability, as in the pocket it takes up no more room than a watch. Its calculations can be done quickly, and its indications may be generally relied upon within ten or twenty feet. In traveling and making geographical observations, especially in hilly or mountainous regions, it is extremely convenient. Van Nostrand's little pocket-book gives all the information necessary to make the best use of the aneroid barometer, and it contains copious tables to facilitate calculations.

The Princeton Review, March. Pp. 398. 37 Park Row, New York. Price, 35 cts.

Having floated down the tranquil stream of time for fifty-four years, this stanch old orthodox review begins to find that the waters are growing rough, and that the navigation must be closely attended to. So the first thing is to move out of Jersey, and plant itself down in the metropolis, and respectfully announce that it "is not the organ of any theological seminary." It has altered its backing, and it is now understood that instead of a theological establishment it has a big heap of money behind it. This is made probable by such a swelling out of its proportions as would not be justified by any considerations of legitimate business. It will be issued six times a year, at a subscription of two dollars, and, if each number is to contain as much reading-matter as the one before us, it will be dirt cheap, though we are afraid the proprietors will have to draw on their pile to hire their subscribers to read it. This we say entirely with reference to the unconceivable bulk of matter furnished. It seems to be forgotten life is short, and that people generally have much else to do besides reading. However, the scope of the review is broad, as it is to consist entirely of original articles on theology, philosophy, politics, science, literature, and art, and, if it had a good serial novel in it, we do not see why it might not claim to answer all the wants of the reading public. A glance at the articles of the present number shows that they are solid, if not brilliant, while the names Chadbourne, Hodge, Hopkins, Hall, Spear, Atwater, Bowen, West, Alexander, Bishop Cox, Hickok, and McCosh, all of whom have articles in this March issue, are a guarantee that the periodical will maintain its character for theological conservatism.

Creed and Deed. A Series of Discourses. By Felix Adler, Ph. D. New York: G. P. Putnam's Sons. Pp. 243. Price, $1.50.

The author of this work combines the erudition of the scholar with the independence of the radical thinker. The topics he deals with in this volume are religious and ethical in their character, and the essays are keen in criticism and of marked literary merit. Our readers have had an illustration of these qualities, as the essay in the volume on "The Evolution of Hebrew Religion" first appeared in the pages of The Popular Science Monthly. The papers were delivered as lectures before the Society for Ethical Culture and are published by request of those who listened to them.

Tables for the Determination of Minerals. By Persifor Frazer, Jr. Philadelphia: Lippincott. Pp. 119. Price, $2.

Prof. Frazer adopts, as the basis of his work, the tables prepared by Weisbach, which he has enlarged and completed. The work provides for the student a method of determining minerals from an examination of those physical properties which may be ascertained by the aid of the simplest instruments. In the author's plan, all minerals are divided into three classes: those having a metallic lustre; those of non-metallic lustre, but giving a colored streak; and those of non-metallic lustre, with colorless streak. The tables correspond to this threefold classification, and by a reference to them most minerals can be determined without difficulty. In short, the student has only first to ascertain to which of the three great classes a specimen belongs. He then ascertains first the character of the lustre—if any it has—then its color, the color of the streak, the relative hardness and tenacity, the crystal system, and the cleavage. A glance at the tables will give him the name of the mineral in which all these characters exist in the proportions found in his specimen.

Mound-Making Ants of the Alleghanies. By the Rev. Henry C. McCook. With Plates. Philadelphia: J. A. Black, 1334 Chestnut Street. Pp. 43. Price, 75 cents.

We have had frequent occasion to recount the ingenious researches of Mr. McCook into the life-histories of insects. The present essay is the most voluminous one we have ever seen from his pen, and perhaps also the most interesting. The subject is the wood or fallow ant (*Formica rufa*), whose hills are familiar to all visitors among the mountains of Pennsylvania. These hills are cones of more or less regularity, commonly of ten or twelve feet in circumference at the base, and from two and a half to three feet in height, though in some instances they have dimensions twice or thrice as great. The author has studied the principles of architecture which guide this ant in the construction of its mounds; also its system of engineering, whereby it overcomes natural obstacles in the construction of its works. Further, he has observed in these ants a curious mode of feeding—a troop of foragers going out, and coming back with abdomens swollen with honey-dew, which they give up to the workers on their return to the mound. The whole memoir gives evidence of very patient and conscientious research.

Mechanics of Ventilation. By G. W. Rafter, C. E. New York: Van Nostrand. Pp. 96. Price, 50 cents.

Mr. Rafter lays no claim to originality of ideas in this little treatise, his object being rather to reduce to systematic form the existing fund of knowledge with respect to the important problem of warming and ventilation. His essay is in every way worthy of the attention of civil engineers and architects.

Engineering Construction. By J. E. Shields, C. E. New York: Van Nostrand. Pp. 138. Price, $1.50.

The four general heads under which the author of this work distributes his subject-matter are: "Foundations," "Masonry," "Tunnels," and "Engineering Geodesy." His aim is to expound the true principles of construction, as ascertained by the highest authorities in that branch of science; but no theory, he assures us, is here set forth which has not received confirmation from practical test.

Foundations. By Jules Gaudard. Translated from the French by Vernon Harcourt. New York: D. Van Nostrand. Pp. 104. Price, 50 cents.

This is another valuable monograph of Van Nostrand's "Science Series." It is a study in the art of civil engineering, and gives a compendious account of the construction of foundation-works for bridges, piers, viaducts, and all buildings where the weight of the superstructure is so great that the question of foundations is fundamental.

PUBLICATIONS RECEIVED.

The Epoch of the Mammoth. By J. C. Southall. Philadelphia: Lippincott. Pp. 445. $2.50.

Chemical Experimentation. By S. P. Sadtler. Louisville: Morton. Pp. 225.

Browne's Phonographic Monthly. Vol. II. New York: D. L. Scott-Browne. $2 per year.

The House Sparrow. By T. G. Gentry. Philadelphia: Claxton, Remsen & Haffelfinger. Pp. 129. $2.

Putnam's Library Companion. Vol. I. New York: Putnams. Pp. 90. 50 cents.

The Kirografik Teecher. By J. B. Smith. Amherst, Mass.: J. B. & E. G. Smith. Pp. 99.

Mineralogy. By J. H. Collins. New York: Putnams. Pp. 206. $1.50.

Matter and Motion. By J. C. Maxwell. New York: Van Nostrand. Pp. 224. 50 cents.

Planetary Meteorology. By R. Mansill. New York: American News Company. Pp. 60. 50 cents.

Report of the Director of the Central Park Menagerie (1877). Pp. 50.

The Metric System of Weights and Measures. By P. Frazer, Jr. Reprint from the *Polytechnic Review*. Pp. 24.

Adamites and Preadamites. By A. Winchell. Syracuse, N. Y.: Roberts. Pp. 52. 15 cents.

Foul Air and Consumption. By Dr. R. B. Davy. Cincinnati: Reprint from the *Lancet and Observer*. Pp. 13.

Life Insurance, and how to find out what a Company owes You. By G. W. Smith. New York: Van Nostrand. Pp. 28. 25 cents.

The Forces of Nature (illustrated). By A. Guillemin. Parts 2, 3, 4, 5. New York: Macmillan. 40 cents each.

Intercultural Tillage. By Dr. E. L. Sturtevant. From the Report of the Connecticut State Board of Agriculture. Pp. 42.

Report of the Cincinnati Zoölogical Society (1877). Cincinnati *Times* print. Pp. 40.

Meteorological Method. Pp. 15.—Causes of the Huron Disaster. Pp. 4. By William Blasius. Philadelphia: The Author.

Our Public School System. By C. W. Bardeen. Pp. 32.

Ventilation. By Dr. W. C. Van Bibber. Annapolis Md.: Colton print. Pp. 36.

Economic Tree-Planting. By B. G. Northrop. From Report of Connecticut Board of Agriculture. Pp. 29.

European and American Climatic Resorts. By Dr. G. E. Walton. Pp. 12.

Report of the Connecticut Agricultural Experiment Station (1877). New Haven: Tuttle, Morehouse & Taylor print. Pp. 104.

The New Rocky Mountain Tourist (illustrated). By J. G. Pangborn. Chicago: Knight & Leonard. Pp. 64.

Primitive Property. By E. de Laveleye. New York: Macmillan. Pp. 356. $4.50.

Star-Gazing, Past and Present. By J. N. Lockyer (with Plates). Same publisher. Pp. 496. $7.50.

Proceedings of the American Chemical Society. Vol. I., No. 5. New York: Baker & Godwin print. Pp. 104.

The Sugar-Beet in North Carolina. By A. Ledoux. Raleigh: *Farmer and Mechanic* print. Pp. 50.

The Salt-eating Habit. By R. T. Coburn. Dansville, N. Y.: Austin, Jackson & Co. print. Pp. 29.

The Star-Finder, or Planisphere, with Movable Horizon. New York: Van Nostrand.

POPULAR MISCELLANY.

The Growth of Photography.—At one of the public lectures recently given under the auspices of the New York Academy of Sciences, Prof. Charles F. Chandler sketched the progress of photography during the last hundred years. The first authentic record of pictures made by solar agency he finds in Cooper's "Rational Recreations," published in 1774, where an account is given of the marking of bottles by silver salts. Next came Scheele's experiments on the effect of exposing to light paper sensitized by the same salts. The first genuine sun-pictures were probably produced by Bolton and Watt, who were followed by Humphry Davy and Wedgwood. Still, down to the beginning of the second quarter of the nineteenth century, photography had not advanced beyond the stage of producing images of plant-leaves laid on sensitized paper, and exposed to light. These images, crude as they were, soon disappeared on continued exposure of the paper to the light, for as yet no means of fixing the photograph image had been discovered. Niepcé studied the subject experimentally for nearly fifteen years, without any very encouraging results, but in 1824 he associated with himself Daguerre, who in 1839 announced to the world his discovery of a method of producing permanent sun-pictures. Dr. Draper, of New York, added sundry important improvements to Daguerre's method. Fox-Talbot produced the first silvered-paper photograph, which was the germ of the modern sun-picture. The great development came in 1841, when Schönbein discovered gun-cotton. Cotton, he found, when exposed to nitric acid, becomes explosive, and soluble in a mixture of alcohol and ether. The discovery of this latter property was the foundation of the common photographic process, where a film of collodion, sensitized by silver iodide, produces the "negative" image, from which thousands of pictures may be struck off. It was stated by Prof. Chandler that Albert, a photographer of Munich, and Edward Bierstadt, of New York, are engaged in perfecting a process for printing photographs in colors.

The Development of Botanical Science.—The progressive development of botanical science is forcibly exhibited by the *Belgique Horticole*, in a numerical statement of the different species of plants named in sundry ancient documents, and now ascertained by botanists. Thus, in the Bible, we are told, about fifty plants are clearly determined, while about as many more are mentioned in more general terms. Hippocrates mentions 234 species, Theophrastus about 500, Dioscorides over 600, and Pliny 800. In the sixteenth century Conrad Gerner names 800, Charles de l'Escluse 1,400, Dalechamps 2,731, and Gaspard Bauhin 6,000. In 1694 Tournefort describes 10,146 species. He was the first to class the species of plants into genera, of which he reckoned 694. In the eighteenth century Linné defined 7,294 plants, distributed in 1,239 genera. In 1805 Persoon's "Synopsis Plantarum" included nearly 26,000 species, and in P. de Candolle's "Elementary Theory of Botany" 30,000 species are said to be known scientifically. Stendel's "Nomenclator Botanicus" (published in 1824) contains 78,000 names of plants. Loudon's "Hortus Britannicus" (1839) enumerates 31,731 species in 3,732 genera. According to Endlicher (1840), there were 6,895 known genera in the vegetal kingdom, which number is increased to 8,931 by Lindley in the year 1853. In 1863 Bentley estimated the known species at 125,000. The *Belgique Horticole* thus classes the species now known:

60,000 dicotyledons,
20,000 monocotyledons,
40,000 cryptogams,

or, in all, about 120,000 species distributed among 8,000 genera. The species actually cultivated number 40,000, and these are true botanical species, not simply races or varieties.

Facts about the So-called "Rain-Tree."—For some months there has been circulating in the newspapers a notice of a tree found in Northern Peru, the "rain-tree of Moyobamba," from the trunk of which, as the story runs, "water may frequently be seen to ooze, falling in rain from the branches in such quantity that the ground beneath is converted into a perfect swamp." The facts with regard to this "rain-tree" are stated as follows by Mr. Spence, the traveler, in a letter to Mr. Thiselton Dyer, which the latter has communicated to *Nature*. The tree is not a myth, but a fact, though the current story is not quite exact. Mr. Spence first witnessed the phenomenon in question in September, 1855. On a certain day, about seven o'clock in the morning, while in latitude 6° 30′ south, longitude 76° 20′ west, he found a "lowish, spreading tree, from which, with a perfectly clear sky overhead, a smart rain was falling. A glance upward showed a multitude of cicadas sucking the juices of the tender young branches and leaves, and squirting forth slender streams of limpid fluid." The tree belonged to the acacia tribe, but Mr. Spence was informed by his native attendants that almost any tree, when in a state to afford food to the nearly omnivorous cicada, might become, *pro tempore*, a *Tamia-caspi*, or rain-tree. Afterward, he himself verified this fact more than once. "As to the drip from the tree causing a little bog to form underneath and around it," writes Mr. Spence, "that is a very common circumstance in various parts of the Amazon Valley, in flats and hollows, wherever there is a thin covering of humus, or a non-absorbent subsoil, and the crown of foliage is so dense as to greatly impede evaporation beneath it."

Clearing Land with Dynamite.—A severe storm of wind having blown down a number of large trees on the estates of the Earl of Stamford and Warrington, recourse was had to the use of dynamite for the purpose of breaking up the roots, that being esteemed the most expeditious mode of removing those incumbrances. The first experiment was made on four very large elm-roots. An auger-hole, one and a half inch in diameter was bored in each, and charged with eight dynamite cartridges, which, on being exploded, shivered the roots into fragments suitable for firewood. The second experiment was on two huge oak-roots. These were simply charged by placing a few cartridges of dynamite in natural crevices of the roots, without any auger-hole. The charges were exploded, and the roots blown to pieces of manageable size. Next, an auger-hole was bored in each of seven oak-roots, and charged with two cartridges each, the result being that all were broken up. The fourth experiment was on an extraordinarily large ash-root, the great fangs of which were lying undisturbed in the ground. Underneath this a number of crowbar-holes were made and charged with dynamite. The fuses were all cut the same length and fired simultaneously, blowing the whole mass out of the ground.

Color-Blindness.—In an article on "Defective Vision considered in its Relations to Railroad Management," published in the *Chicago Railway Review*, Mr. Thomas F. Nelson, optician, remarks as follows on the phenomenon of color-blindness: "This defect but rarely assumes the form that would be termed *absolute* color-blindness, or want of *any* sensation of color. Where this form is perfectly developed there is generally a sharp, well-defined appreciation of differences between light and shade, or even between the finest grades of apparent brightness or intensity; but recognition of color is entirely wanting, there being no distinction whatever between different colors having the same degree of intensity. A curious fact might be noticed in this connection, that these defects are but rarely found in women.

"The more common form is that caused by the absence of perception of one of the three fundamental colors. These are mentioned in the order of their comparative frequency, viz., where the elementary sensation corresponding to *red* is wanting; next, the absence or imperfect perception of *green*, and third of *blue*. It will be noticed as a remarkable fact that the first two mentioned are now used to make up the entire code of railway-signals, and that this defect for *red* occurs more frequently than for any other color. This is an item of the greatest importance in railway and vessel management, since *red* is almost always used for the danger-signal. To add still further to the deceptive and dangerous character of the defects, I have, in the course of my experiments, found a number of persons who were unable to distinguish between the primary colors at night, while their perception or sensation of color by daylight was apparently perfect. Again, I have found another anomaly which, until it has been more thoroughly investigated, and the real causes that produce it are understood, I shall designate as a form of color-blindness, although I am in doubt myself as to its dependence upon any of the principles that enter into that defect; this is an inability to distinguish between or to recognize the primary colors at certain distances, varying more or less in individuals. This was found to be the most difficult of all defects to detect in the various cases I have examined, amounting to some nine or ten, in the regular course of my business as optician during the past three years. I have found no two of them at all alike except in general results.

"I have kept records of various accidents that have occurred, both upon land and water, during the past few years, and I have gathered such information about some of them as I could get outside of official sources—often I was unable to get any of any value, but I am convinced beyond a doubt that a large proportion of them could have been traced to this defect for a correct solution as to the primary causes of the accident. The query has been made, that if these defects in their various forms are as numerous and of such a dangerous character as has been shown, how can we account for such a comparatively small number of accidents occurring which might be charged to them? I have attributed it to the high average intelligence and acquired cautiousness of engineers and pilots as a class. They have become so accustomed to be on the lookout for danger that their suspicions are easily aroused, which creates a sort of instinct that governs their actions, and they do not recognize but that their perceptions are correct."

Sewer-building.—The general principles of sewer-building are, says the *Polytechnic Journal*, that each day's influx should be promptly passed out by natural flow or flushing, and not allowed to deposit sediment. The alignment should be good, especially at the bottom; the descent should be uniform, and the interior surface smooth, so as to reduce friction and not to cause clogging; the walls should be absolutely impervious, and the suction such as will cause the most rapid possible flow, with a minimum of sewage. Rapid flow being essential, smooth interior walls should be provided; mortar projecting from the joints of a brick sewer markedly impedes the flow and arrests putrefiable matter. A flat-bottomed sewer is the worst form as regards the velocity of the flow; a circular bottom is better; an egged-shaped section, with the point downward, permits of a minimum current flushing and cleansing the bottom. In brick sewers the mortar, constantly moist, must sooner of later succumb to the disintegrating action of the matters passed through it, and the whole line gradually passes into the condition of a sieve, allowing the liquid portions of the sewage to pass through it and to saturate the subsoil, but retaining the solids. From the consequent saturation of the soil result contagious fevers. Hence vitrified clay pipes are now almost universally employed. The "slip" glazing applied to these pipes resists the severest chemical action of sewage-water. The "slip" glaze is produced by dipping the unbaked clay into a mixture of "slip-clay" or Albany-earth and water, which, under a white heat continued from twelve to thirty hours, produces a vitreous and very durable silicious surface upon the wares.

Remarkable Land-Slides.—Bear-Tooth Mountain is one of the most prominent landmarks in Northern Montana; it is plainly visible from Helena, thirty miles distant. It presents, or rather used to present, the appearance of two great tusks rising hundreds of feet above the general contour of the mountains. One of these tusks, the smaller one, which was fully five hundred feet high, three hundred feet in circumference at the base, and one hundred and fifty feet at the top, was recently dislodged from its place and precipitated into the valley below. A few weeks since, according to the Helena *Independent*, a party of hunters chasing game several miles north of the Bear Tooth heard a rumbling sound and felt a quaking of the earth, which they took to be a veritable earthquake. But, as the sound was not repeated, they soon forgot the occurrence, and continued their chase till they came to the vicinity of the Bear Tooth. What was their surprise to find that the stupendous mass of the eastern tusk had been dislodged, sweeping for a quarter of a mile through a forest of heavy timber, and overwhelming with its *débris* the ground round about! Virginia City, in the same State, is gradually slipping down the mountain-side on which it is built. The movement is gradual, and imperceptible at the surface. A water-main recently uncovered was found telescoped for the space of one foot, and otherwise injured. A fissure has been traced in the ground on the western side of the town; on one side of this the ground is three feet higher than on the other.

The Death of a Generation.—A writer in an English magazine studies from birth to death the march of an English generation through life, basing his remarks on the annual report of the registrar-general. The author singles out, in imagination, a generation of one million souls, and finds that of these more than one-fourth die before they reach five years of age. During the next five years the deaths number less than one-seventh of those in the first quinquennium. From ten to fifteen, the average mortality is lower than at any other period. From fifteen to twenty the number of deaths increases again, especially among women. At this period, the influence of dangerous occupations begins to be seen in the death-rate. Fully eight times as many men as women die violent deaths. The number of such deaths continues to rise from twenty to twenty-five, and keeps high for at least twenty years. Consumption is prevalent and fatal from twenty to forty-five, and is responsible for nearly half the deaths. From thirty-five to forty-five the effects of wear and tear begin to appear, and many persons succumb to diseases of the important internal organs. By fifty-five the imagined million has dwindled down to less than one-half, or 421,115. After this, the death-rate increases more rapidly. At seventy-five, there remain 161,124, and at eighty-five, 38,565. Only 202 reach the age of one hundred. At fifty-three, the number of men and women surviving is about equal, but from fifty-five onward the women exceed the men.

Setting Tires with Hot Water.—The use of hot water in place of fire for expanding tires may not be new, but it is less common than it ought to be, if we are to accept as accurate the results said to be obtained in the workshops of the Moscow-Nizhni Railroad, in Russia. There an iron tank, one-fourth filled with water, is fixed near a stationary boiler, from which a steam-pipe is led through it, capable of heating the water to 212° Fahr. Into this the tire is plunged by means of a portable crane, and, after an immersion of from ten to fifteen minutes, is taken out and immediately placed on the wheel. The allowance for shrinking—in other words, the difference between the diameter of the skeleton and that of the tire—is 0.75 millimetre to a metre. This is ascertained by gauges of great accuracy; and, if it be deviated from, the tire will either be loose after cooling, or too small to get on the wheel. When fire is used, the tire can never be heated equally or cooled equally in all parts, and, in consequence, is sure to be more or less oval in form, which is not the case when hot water is employed. The officials of the railroad named above made a comparison of the two methods, from which it appears that, during a six years' trial of fire-shrunken tires, 37 per cent. ran loose, and 5 per cent. were broken; while, during a three years' trial of water-shrunken tires, less than one per cent. ran loose, and only a single tire was broken.

Distribution of Prairie and Forest.—Many are the theories which have been offered to explain the distribution of prairie and forest. The continued existence of the prairies of the West has been attributed to the annual fires; to the nature of the soil and its underlying rock; to deficiency of rainfall; finally, to deficiency of winter rains and snow. The contrary conditions would, according to these theories, favor the production of forests. Prof. J. E. Todd, who, in the *American Naturalist*, discusses this problem with special reference to Southwestern Iowa, offers a very ingenious theory, and one that certainly appears to account for the phenomena observed by him in the above-mentioned region. He finds that—1. In the hill-regions where the slopes are inclined from 5° to 10°, timber occurs mostly on the northern slopes, just south of creeks flowing east or west; it occurs a little less frequently on western slopes, east of creeks flowing north or south; 2. In the bluff-region, where the slopes are from 10° to 45°, just east of the bottom-lands of the Missouri, timber is found over most of the surface. This belt of timber-land is usually bounded on the west by the crest of the most western ridge of the bluffs, leaving the slopes facing the bottom-land bare, except when a lake, slough, or stream, comes close to the base of the bluffs, or where the bluff-side is deeply furrowed by ravines; 3. In the low alluvial valleys, timber is found along the streams, usually in narrow strips, and generally wider on the east and north banks; the rest of the bottom-land is destitute of trees and bushes. According to the author, *constancy of moisture* is the condition *sine qua non* of forest-growth; and, 1. This constancy of moisture must be in one or both the media in which the trees are to exist—the soil or the air; 2. It is plain that moisture of soil will be more constant on northern slopes than southern, the former being less exposed to the sun's heat. In the spring, and after showers, the northern slopes dry up more slowly, and, at certain degrees of humidity of the air, the moisture given off by the southern slope of a hill may be condensed by the northern. These and other like considerations may perhaps account for the timber occurring on northern slopes, while it is nearly absent from southern; 3. The fact that the prevailing winds of Southwestern Iowa in spring and summer are westerly may perhaps explain the preponderance of timber-areas on the east banks of the streams flowing south; and this, combined with the increased roughness of the surface, may also go far toward explaining the timber-belt of the bluff-region; 4. It remains to explain the distribution of timber and prairie in the alluvial valleys. Here layers of clay prevent the ready drainage of many parts; these conditions render much of the surface too wet (for trees) at all times, while other places are too wet in spring and too dry in summer. On the other hand, the occurrence of trees along the streams and on ridges along old channels may be explained partly by the inequality of surface, making the drainage of surplus water possible, so that moisture around the roots is more constant than elsewhere on the bottoms.

More about the Agricultural Ant.—While visiting Texas last summer, the Rev. H. C. McCook attentively studied the habits of the agricultural ant (*Myrmica molefaciens*). His observations are, for the most part, strongly confirmatory of the statements made by the late Dr. Lincecum; but he also adds to our knowledge of these interesting insects a number of new and interesting facts. Mr. McCook has published, in the "Proceedings of the Academy of Natural Sciences of Philadelphia," a general preliminary statement of his results, intending soon to treat the subject more fully. He carried on his observations in the vicinity of the city of Austin, where the soil is black and sticky, varying in depth from three feet to a few inches. The formicaries of the agricultural ants are commonly flat, circular clearings, hard and measurably smooth, aptly called "pavements" by Lincecum. A few of them had in the centre low mounds, a few inches in height, and two or three in diameter. The formicaries vary in width from twelve feet to two or three feet. They are invariably located in open sunlight. The process of making a clearing strongly suggested the modes of pioneers in a forest—spires of grass taking the place of trees. The chain of evidence that determines these ants to be true harvesters in as follows: 1. Workers were seen gathering seeds and carrying them into the formicaries through the central gates; 2. The same seeds were found in granaries within the opened formicaries; 3. The seeds, with outer shell removed, were found in other granaries; 4. The ants were found carrying out shells to the refuse-heaps. The author's opinion is, that these ants do not plant seeds on purpose, but that they carefully preserve on the outer margin of the clean space the growths which arise from seeds dropped accidentally. To the question whether there is anything like a systematic direction of the labors of the ants by the queen or the major-workers, Mr. McCook replies that the queen seems to have nothing to do but to replenish the population of the community; her life is spent mostly underground. No "officers" could be seen, and each ant acts independently. The worker-majors act constantly as sentinels, and once or twice was observed what appeared to be, on their part, an effort to aid the harvesters in gathering seeds. The entrances to the interior of the formicary are circular openings or gates at the surface, connecting with tubular galleries which lead to the granaries. These granaries consist of rooms of a more or less oval shape, one above another, after the manner of floors in a house. The rooms are about half an inch in height, with hard and smooth roofs and floors. Similar rooms are employed for nurseries of the young. The rooms of each story, as also the different stories, are connected together by galleries. The author gave examples showing strong intelligence in separating white meal from arsenic, with which it had been mixed, and of the refusal of poisoned molasses.

Birds' Eggs and Birds' Nests.—There exists a curious relation between a bird's *mode of nesting* and the *color of its eggs*. The circumstance is noted in the *Bulletin of the Nuttall Ornithological Club* by Mr. J. A. Allen, who observes that nearly all birds that nest in holes, either in the ground or in trees, lay *white* eggs. As instances of this fact may be cited, the woodpeckers, kingfishers, bee-eaters, rollers, hornbills, barbets, puff-birds, trogons, toucans, parrots, paroquets, and swifts; while only occasionally are the eggs white in species which build open nests. A few exceptions are noted by the author to the rule, according to which only *white* eggs are laid in open nests; these are owls, humming-birds, and pigeons. On the other hand, in only two or three small groups of species that nidificate in holes are the eggs speckled or in any way colored. Wallace, it will be remembered, has endeavored to show that the form of nest is, as a rule, correlated to the color of the female bird: if the color is brilliant or in any way striking, the nest is concealed; and *vice versa*, if the female is inconspicuous in color, the nest is open. Mr. Allen, in the paper from which we are quoting, calls attention to the many weak points of Wallace's theory, and asserts that a more uniform correlation exists between color of eggs and style of nest than between the two members of Wallace's correlation. Mr. Allen, however, does not care to formulate a "law" upon the basis of the facts stated above, the exceptions being, as he says, too numerous to consist with the relation of cause and effect.

Subterranean Water-Courses.—It often happens, in years of great drought, that the waters of the Danube, near its source, nearly altogether disappear in the fissures and holes in the bed of the river. The proprietors of works situated farther down-stream have frequently closed these subterranean passages, to avoid losses of water. But other manufacturers, owning works on the Aach, a tributary of Lake Constance, a few miles distant from the Danube, and at an elevation some 150 metres less, contended that these holes and fissures in the bed of the Danube open into water-passages connecting with the source of the Aach; hence they applied to the courts for an injunction to prevent the stopping of these outlets. To test the truth of this theory of the Aach water-supply, 10,000 kilogrammes of common salt was thrown into the Danube at the point where it gets lost. This salt reappeared in the water of the source of the Aach. Another experiment consisted in mixing fluoresceine with the Danube-water at the same point. On October 9th, at 5 P. M., about fifty litres of this dyestuff was poured into one of the openings in the river-bed. On the morning of October 12th, the observers stationed at the source of the Aach perceived the coloration of the water, which was of an intense green. The color grew more and more intense till the evening of October 12th, and disappeared about 3 P. M. of the 13th.

A Bird-eating Trout.—A correspondent of *Land and Water* tells a well-accredited story of a trout caught in the act of swallowing a sparrow which it had seized. The trout had been kept for some time in an open shallow well or spring, and had become very tame. In the well was a flat stone, one end of which projected above the water. On this small birds would alight to drink, and the villagers suspected that more than one of them had fallen victims to the trout's rapacity. This surmise proved to be correct, for, one day while the owner of the well was passing with some friends, a splashing in the water caused them to turn and look. There was the trout struggling hard to gulp his prey. One of the spectators fearing that the fish would be choked by the wing-feathers, thrust his hand into the water, and caught hold of them. But the trout, unwilling to surrender any part of his prize, held on resolutely, and the feathers had to be taken from him by force.

Meteorological.—In the eighth of Prof. Loomis's papers on Meteorological Phenomena, published in the *American Journal of Science* for January, with a view to determine the circumstances under which storms originate, the author takes all the instances in which the barometer fell below 29.25 inches at any station, Mount Washington and Virginia City excepted, during a period of twenty months from September, 1872, to May, 1874. The number of instances was 148, and corresponds to 44 different storms. Two-thirds of these storms had their origin north of latitude 36°, and one-half upon or very near the Rocky Mountains. Two of them came from the Pacific Ocean, three from the Gulf of Mexico, one from near Cuba; others were widely distributed in Wyoming, Dakota, Colorado, and elsewhere. The first stage in each of these storms was the development of an area several hundred miles in diameter, over which the barometer was about thirty inches, with areas of high barometer on both the east and west sides, a thousand miles distant. These areas of high barometer are one of the most important causes of the storm which succeeds. From this cause there arises a movement of air toward the central area which is relatively one of low barometer. The air thus in motion is deflected to the right by the earth's rotation, giving rise to the well-known rotary motion of air during a storm's progress; there also occurs a diminished pressure in the central portion, and an upward movement of the air. The upward-rushing air carries with it large amounts of aqueous vapor which is condensed into rain. By the condensation of the vapor, heat is liberated, causing expansion of the air, and more violent inward movement of the wind. The rainfall thus tends to increase the force and violence of the storm, and invariably occurs when the storm is at its height. Heavy rains usually occur eastward of the storm-centre—that is, eastward of the area of lowest barometer—and usually diminish when the centre has passed. The author says, "I have found no instance of violent storms which was not attended by considerable rainfall, but the rainfall is to be considered as a result, not the cause of the first movement of the wind."

It was shown, in a former article, that storms have a forward motion, which is usually a little north of east. No sooner is a storm-centre formed than it begins to change its position. The storm's movement seems, with few exceptions, to correspond with that of the atmosphere, the average annual progress of which is from west to east. Prof. Loomis says that on the west side of a storm a pressure occurs, resulting from the cause which determines the general circulation of the atmosphere, and which exists whether a storm occurs or not. A storm disturbs the atmosphere chiefly in its lower portion; in the upper portions the general atmospheric movement goes on. The depressions of the atmosphere on the west side of a storm are from these conditions filled up, so that the barometer is continually rising closely in the rear of a storm, but as continually falling as before explained, just eastward of the storm-centre. It is a matter of common observation that, when a storm-centre is passed, high barometer and clear air are close at hand. Other conditions of a storm's progress are presented, and the interesting fact developed that high barometer, east and west of a storm-area, remains unaffected by the tempest that is raging between those areas—whence Prof. Loomis infers that the air inflowing in the storm and rising at or near its centre flows outward at a considerable elevation to the areas of high barometer, having been deprived of its aqueous vapor. It thus appears that a vertical circulation is going on during a storm's progress.

Snake-Affection.—Most people will prefer knowledge at second hand of the playfulness and affection of snakes, to personal tests of the existence of such qualities. Not so a correspondent of *Land and Water*, who, having got possession of a harmless snake of the species *Natrix torquata* about twenty-eight inches in length, adopted it as a pet. This snake took great pleasure in passing in and out again and again between the fingers of its master. It was only necessary to hold the hand in the open box, when he would at once commence to glide between the fingers, always turning round sharply the instant its tail was free, and resuming its journey in the contrary direction. The process of shedding the skin is worthy of observation. The snake lies in a sluggish state for several days. The bright eyes become dull and fishy, and the skin loses its glossy smoothness. In time a slight break appears to run in the line of demarkation between the mucous membrane of the mouth and the outer skin, along the edge of the lips. In a few hours the crack appears to widen, and the skin to dry and curl over at the edges. Soon after this, in the present instance, the snake passed through a wisp of straw provided for this purpose in his box, and the skin was stripped off in one piece. The animal was now as active as a kitten, and as hungry. He quickly swallowed a fog, whose cries were heard after it had passed into the snake's stomach.

A Magnetized Spider.—In a communication to the Academy of Natural Sciences of Philadelphia, Dr. John Vansant treats of the influence of magnetism on living organisms, and describes at length one experiment with a spider, which was killed by the magnetic emanation. The magnet employed was a small steel one, of the U-shape, the legs of which were about two and one-half inches long by one-half inch wide and one-sixth inch thick, the distance between the poles being about one-quarter inch. Having noticed a small spider actively running along the arm of his chair, he brushed it off upon the carpet, where it began to run, but was somewhat impeded by the roughness of the fabric. He now slid the magnet along the carpet, following after the spider, till it was between the poles. The animal almost instantly stopped, and in a few seconds was motionless; but, at the end of two or three minutes, it began slowly to move its legs and elevate and depress its head. At the end of five minutes the spider was quite still. After the lapse of ten minutes Dr. Vansant covered both spider and magnet with a tumbler. On the expiration of two hours, he removed the glass and observed the spider with a magnifying-lens. It was apparently dead. The author states that he has killed spiders and other small animals, as worms and insects, as well as some plants, by magnetism, at various times during the past eight years, but never before succeeded in destroying the life of a spider so quickly, and without touching it frequently, though lightly, with the magnet. In the present instance he did not touch the animal at all.

Waste of the Locomotive-Whistle.—Persons residing in the country near any of the great railway lines will heartily approve any effort made toward suppressing the nuisance of locomotive-whistles. A writer in the *Railroad Gazette* remarks as follows on the *wastefulness* of this practice: "A simple toot or two," he writes, "in cases of emergency, to warn some one from the track, or as a signal for brakes, would seem to be the only legitimate use of steam in the way of whistles. And yet, of the twenty or more trains which daily pass my residence, I notice that nearly one-half make a regular practice of blowing their whistles some twenty rods at a time, and some half a dozen times within as many miles; and their safety-valves also seem to be at work most of the time. It would be interesting to know exactly what percentage of the fuel is wasted in this way. If the coal-bunks upon their tenders were made so as to let a bushel of coal drop on the track every ten miles of their progress, the waste would then become so manifest, no doubt, that it would be attended to at once. If one train can be run without the use of the safety-valve or whistle, another can be so run, with the exercise of an equal care and vigilance on the part of the engineer and fireman. This matter of waste at the safety-valve and whistle seems to rest entirely with the men upon the foot-board of the engine; and, as they prize their good standing as engineers and firemen, they should attend to it."

NOTES.

The Department of Agriculture has received from General Charles P. Stone, now in the military service of the Khedive of Egypt, a lot of red-date seed, with which it is designed to make the experiment of growing the date-palm in the United States. General Stone, from what he has seen of the date-producing regions of Northeastern Africa, and from his observations in the Desert of the Colorado, between Carissa Creek and Fort Yuma, is inclined to believe that the greater portion of the latter region can be made productive and very valuable by the culture of this tree. The date-palm, he writes, not only does not require much water, but much water is prejudicial to it, and the climate of the Colorado Desert is strikingly similar to that of some of the best date-producing districts of Egypt.

In a tower of the Temple of Ularo, in Kioto, Japan, is suspended the largest bell in the world. The date of its casting is unknown. It measures 24 feet in height and is 16 inches thick at the rim. It is sounded by a suspended lever of wood, used like a battering-ram, striking the bell on the outside. The Bolshoi (Giant) in Moscow, cast in the sixteenth century, and recast in 1654, was 21 feet high and 18 feet in diameter; its weight was estimated at 288,000 pounds. The metal of this bell was used in casting the present "great bell of Moscow," the *Tsar Kolokol*, 19 feet 3 inches high, and about 19 feet in diameter; estimated weight, 443,772 pounds.

The Central Railroad of New Jersey have, at their Communipaw shops, a small gas-works for converting into illuminating gas, oil-waste and other combustible material collected along the line of road. The fuel used in the gas-furnace is the screenings from the locomotives—a material previously used only for road-ballast. The gas costs the company only 35 cents per thousand feet, and enough is produced to supply 225 burners. Its illuminating power is said to be very high.

In the opinion of the *Lancet*, California will, before long, be supplying Europe with wines that will bear comparison with the finest vintages of the Rhine and the Moselle. A few years ago there was an exhibition at Kensington, of the wines of many countries, at which the wines from California took a very high rank. An analysis of these wines, recently published in the *Pharmaceutical Journal*, makes a very favorable exhibit for our Pacific slope vintages.

The fourth annual report of the Buffalo Society of Natural Sciences gives evidence of a highly-creditable degree of scientific activity on the part of the members of the society; but we regret to notice that the publication of the *Bulletin* has been for the present suspended, from the want of funds to continue it. During the year 1877 the society's collections were used by the scholars of the public schools of Buffalo as a means of instruction in natural history. The number of books in the library has been considerably increased. The zoölogical specimens added to the collections during the year were numerous. The original scientific work of members of the society has afforded material for 33 memoirs, published by the Department of the Interior, and in various scientific journals. To the society is due the credit of having inaugurated a course of cheap winter evening lectures, at an admission-fee of ten cents.

The use of "toughened" glass is not without its dangers, as we learn from the experience of a certain Prof. Ricard. He bought a child's cup of toughened glass, which was exposed to hard usage for some months, without suffering from the rough treatment. But one evening it was left, with a spoon in it, on a table, and the room was shut. Shortly afterward a noise as of a pistol-shot alarmed the whole household. On entering the room, fragments of glass were found scattered all around—the cup had exploded after the manner of a Prince Rupert drop.

A process of engraving on glass and crystal by means of electricity has been discovered by M. Gaston Planté. The process consists in covering the plate to be engraved with a concentrated solution of nitrate of potash, put in connection with one of the poles of a battery, and in tracing the design with a fine platinum point connected with the other pole. M. Planté employs a battery composed of 50 or 60 secondary elements.

In an establishment at Oakland, California, the entrails of sheep are used for making very serviceable belting for machinery. First the entrails are cleaned and soaked for a few days in brine. The prepared material is then wound on bobbins, when it is ready for working up either into ropes or flat belts. A three-quarters-inch rope of this material is capable of bearing a strain of seven tons. The material, furthermore, is very durable—more than twice as durable as hemp.

The directors of the Paris Exposition of 1878 intend to repeat, on a large scale, Foucault's famous pendulum-experiment, showing the rotation of the earth. The pendulum to be suspended in the Champ de Mars will be about 660 pounds in weight and 220 feet long, and will be so hung that the points of suspension can freely move, thus permitting the pendulum to swing in one plane or nearly so. The spectator will notice that the pendulum changes its line of oscillation as regards the floor beneath, but if he understands the questions to be answered, he will know that it is the floor, and himself with it, that is carried round, while the pendulum continues to oscillate in one plane, or nearly so.

It has been observed by a French physician, De Renzi, that the paroxysms of those suffering from lockjaw are always more frequent and more violent by day than by night, and he has noticed the same fact in frogs poisoned with strychnine. He has further observed that the paroxysms are more intense when the animals are freely exposed to light than when they are kept in darkness, and that frogs poisoned by weak doses of strychnine die on being roughly shaken, but live when left in a state of complete repose. On these results M. de Renzi bases a new system of treatment for cases of lockjaw; it is as follows: The patient is shut in a perfectly dark room, and the door is opened very gently every four hours to give food and drink. The external auditory meatus are sealed with wax. Every hour (?) soup or an egg, with two spoonfuls of sherry, is given from a cup with a spout to it. A little powder of belladonna and ergot is given to appease the paroxysm. The floor should be covered with a carpet.

Books taken from circulating libraries for the use of convalescents may easily become the vehicles of contagious diseases, and it is much to be desired that some effectual method could be devised of disinfecting volumes which have been so used. Until this is done, circulating libraries would do well to caution their patrons against the danger, and to request that the books be not used where such diseases exist. In these days of cheap publications it is easy to obviate this peril by procuring for the use of the sick low-priced volumes, to be destroyed after they have been perused.

M. Schiaparelli, during the last opposition of Mars, made observations of the position of the south-polar spot, as was also done by Prof. Hall. The method adopted by the latter was to measure the angle of position of the spot from the centre of the disk. M. Schiaparelli made his measures by placing the wire of his micrometer tangent to the limb of the planet at the middle of the spot. The latitude and longitude (areographic) of the spot are:

$$\theta = 29.47^\circ,\ \lambda = 6.15^\circ \text{ (S.)} \qquad \theta = 20.66^\circ,\ \lambda = 5.18^\circ \text{ (E.)}$$

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The planting of trees in the streets of towns is condemned as unsanitary by a writer in the *Lancet*, on the ground that fresh air, Nature's great deodorizer, is checked in its movements by the foliage. In the narrow, tortuous lanes and pent-up courts, where the poorer part of the population live, anything that interferes with the freest possible circulation of the air must be injurious to health.

Dr. J. A. Campbell, writing in the *British Medical Journal*, favors recourse to summary proceedings in the treatment of "fasting girls," i. e., young females who, under the influence of hysteria, believe themselves to possess the miraculous power of living without food or drink. The hysterical manifestations, he says, can be overcome by the stomach-pump, "and with our present knowledge no more fasting girls should be *permitted to occur*."

In Texas camels are raised as easily as horses and cattle. The colts of the first three or four days are rather tender, and require close attention, but afterward they are hardy enough. They feed on cactus and brush, refusing all grasses. The females, with proper care, give a colt every year.

It is commonly supposed that the softer a bar of steel is, the better is it able to endure strains and shocks causing vibration. But experiments made by Mr. W. Metcalf, of Pittsburg, show in fact that hard steel suffers less from vibration than soft. Mr. Metcalf's attention was first drawn to this subject by the constant breaking of steam-hammer piston-rods. Those made of ordinary steel lasted only six months. Then lower and lower steels were tried, and broke in about five months. Once it happened that a rod of comparatively high steel was employed, which held out for over two years. This totally unexpected result led to systematic experiment which confirmed the conclusion stated above.

Of "trials of endurance" now so much in vogue, the latest is that undertaken by a Mr. Murphy, of Kern, California, who talked incessantly for twenty-four hours, with a rest of five seconds in each hour for the purpose of taking a drink of whiskey. At the conclusion of his task, Murphy fell from his chair, but whether this was the result of exhaustion or of intoxication could not be determined.

Experiments have lately been made in Germany to determine the value of the common nettle as a textile fibre. The weed having been treated in the same way as hemp, yielded a fibre as fine as silk and as strong as hemp-fibre. A considerable area of ground is now planted with the nettle in the Prussian province of Nassau.

CHARLES FREDERIC HARTT.

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THE AGE OF GYMNASTICS.

By F. L. OSWALD, M. D.

"WHAT can we learn from the ancient Greeks?" was the theme which the Florentine Art-School proposed to the competitors for the De Rossi prize last year: the most suggestive theme, perhaps, that could be recommended to the consideration of the nineteenth century.

"Neither in delicacy of execution nor in grandeur of conception can we measure ourselves with the Greeks of the ante-Alexandrian era," says *L'Abbate Pintore*, "The Painter Priest," as the successful competitor signs himself, "nor would it be easy to say in what they were *not* our superiors."

The latter question would, indeed, be difficult to answer, even if we should extend its application, which the Painter Priest probably restricts to art-matters; and the theory which ascribes our progress in secular as well as in spiritual insight to the "revealed light" of our religion can hardly be reconciled with the fact that, in the very branches of knowledge which refer to the conduct of human life, our latest and best ideas were anticipated by those Nature-taught heathens, while even in the objective sciences our fancied superiority would be sadly reduced, if we should subtract the chance discoveries and technical details which are the cumulative bequest of all preceding generations.

It does really suggest a general revision of our physical and metaphysical standards, if we consider in how many senses of the word the proudest progress of our latter-day civilization is but a return to the standpoints which the pagan inhabitants of a Mediterranean peninsula occupied twenty-four centuries ago. After an infinitude of political experiments with absolute and most puissant monarchs, elective monarchs, constitutional monarchs, and figure-head monarchs, the most advanced nations of our century have come to the conclusion that the old Hellenic form of government by representatives of the people was the most sensible, after all; that armed citizens can fight as well as, if not better than, standing armies, and that the ancient method of appointing and removing public functionaries by a majority of votes was far superior to the *par ordre du mufti* system of Mohammedan and Christian sultans. Religious toleration, which the fearful experience of the middle ages has made the watchword of all liberals and reformers, was practised among the Greeks and republican Romans to an extent which we are as far yet from having reattained as their freedom of speech, of commercial affairs, and of domestic life. Popular education, the national stage, and all the fine arts, have to be emancipated from innumerable prejudices and paralyzing restrictions before they can be restored to their pristine prime, not to speak of the science of health nor of the science of happiness, which will, perhaps, never recover from their long neglect.

But, of all the national institutions of ancient Greece which we have abolished or altered to our disadvantage, there is none whose reintroduction would be attended with greater benefits than that system of physical education which so influenced the national spirit and reacted upon the character of the representative Grecian heroes, statesmen, and philosophers, that it may be considered as the distinguishing feature of their age. At a very early period the Greeks of Southern Europe and Asia Minor had recognized the truth that, with the advance of civilization and civilized modes of life, a regular system of bodily training must be substituted for the lost opportunities of physical exercise which Nature affords so abundantly to her children in the daily functions of their wild life. "It is impossible to repress luxury by legislation," says Solon, in Lucian's "Dialogues of Anacharsis," "but its influence may be counteracted by athletic games, which invigorate the body and give a martial character to the amusements of our young men."

The nature of ancient weapons and the use of heavy defensive armor made the development of physical force a subject of national importance, but military efficiency was by no means the exclusive object of gymnastic exercises. The law of Lycurgus provides free training-schools for the thorough physical education of both sexes, and cautions parents against giving their daughters in marriage before they had attained the prescribed degree of proficiency in certain exercises, which were less ornamental and probably less popular than what we call callisthenics. Greek physicians, too, prescribed a course of athletic sports against various complaints, and had invented a special curriculum of gymnastics, which, as Ælian assures us, never failed to cure obesity. When the increase of wealth and culture threatened to affect the manly spirit of the Hellenic race, physical education was taken in hand by the public authorities in almost every Grecian city; and the ablest statesmen at Athens, Thebes, and Corinth, emulated the Spartan legislator in founding palæstræ, gymnasia, and international race-courses, and devising measures for popularizing these institutions. Four different localities—Olympia, Corinth, Nemea, and the Dionysian race-course near Athens—were consecrated to the "Panhellenic games," at which the athletes of all the Grecian tribes of Europe and Asia met for a trial of strength at intervals varying from six months to four years, the latter being the period of the great Olympic games which formed the basis of ancient chronology. The honor of being crowned in the presence of an assembled nation would alone have sufficed to enlist the competition of all able-bodied men of a glory-loving race, but many additional inducements made the Olympic championship the day-dream of youth and manhood, and served to increase the ardor of gymnastic emulation. The victors of the Isthmian and Nemean games were exempt from taxation, became the idols of their native towns, were secured against the vicissitudes of fortune and the wants of old age, by a liberally-endowed annuity fund, and enjoyed all the advantages and immunities of the privileged classes.

Egenetus, a humble citizen of Agrigentum, won three out of the five prizes of the ninety-second Olympiad, and was at once raised from poverty to opulence by the magnificent presents which the enthusiasm of the spectators forced upon him before he had left the arena. His return to his native city was attended by a procession of three hundred chariots, each drawn, like his own, by two white horses, and all belonging to the citizens of the town. All international quarrels and family feuds were suspended when the preparatory interval of forty-eight months approached its close, and even prisoners of war and political culprits were released on parole if they wished to contest the laurel wreath of any championship, for to deprive them of the chance of winning such a distinction was thought a penalty too severe for a merely political offense. The ecstatic power of an Olympian triumph is well illustrated by the story of Diagoras, the Rhodian, who had been a famous champion in his younger days, and was present when his two sons won the entire *pentathlon*, i. e., carried off the five prizes for which the athletes of all Greece had been training during the four years preceding the sixty-first Olympiad. When the boys lifted their father up and carried him through the arena, the shouts of the assembled multitude were heard in the harbor of Patræ, at a distance of seven leagues, but Diagoras himself had heard nothing on earth after the herald's voice had proclaimed the names of the victors; "the gods," as Pindar says, "had granted that the happiest moment of his life should be his last." Would Diagoras have exchanged that moment for a week of those "beatific visions" which rewarded St. Dominic for his seven years' penance?

If any athlete received more than one prize of the same Olympiad, his victory was commemorated by a statue executed by the best contemporary sculptor of his native state. What a terrestrial Walhalla it must have been, that sacred mountain-grove of Elis, where these statues were erected in the shade of majestic trees, while the summit of the hill and the open meadows were adorned by such masterpieces of Grecian architecture as the temple of Jupiter Olympius and the Pantheon of Callicrates! Besides the military drill-grounds and the public gymnasia, of which every hamlet had one or two, and where the complete apparatus for all possible sports was often combined with free baths and lecture-halls, the larger cities had associations for the promotion of special favorite exercises, the brag-accomplishments of the rival towns. Wrestling, javelin-throwing, running, leaping, pitching the quoit, riding, driving, climbing ropes, shooting the arrow, were all practised by as many amateur clubs, which commonly owned a race-course or a private hall.

How many of the most admirable character-traits of the ancient Greeks, and how much of their success in the arena of life may be distinctly traced to these sources of mental and physical health! Health in the widest sense of the word was, indeed, the primary characteristic of their age, for health and vigor are synonyms. The same process of adaptation that qualifies the body for the performance of athletic feats disqualifies it for the development of any morbid elements, and accelerates the elimination of effete matter from the organism. We accordingly see that, among the creatures of the wilderness whose normal condition is one of muscular vigor, disease is wholly abnormal, and premature death only the consequence of wounds or protracted famine. "The immunity of hard-working people from the consequences of wrong or over-feeding," says Dr. Boerhaave, "is a proof that nine-tenths of your fashionable diseases might be cured *mechanically* instead of *chemically*, by climbing a tree, or chopping it down, if you prefer, instead of swallowing castor-oil and sulphur-water." Physical exercise, by accelerating the circulation of the blood, stimulates the activity of all those internal organs whose functions conjointly constitute the phenomenon of life, and counteracts innumerable functional disorders, any one of which is sure to react on the nervous system and the organ of the soul.

Mental pathology, if rightly understood, is a physiological science which must recognize the intimate connection and interaction of soul and body, and the influence of every physical derangement on the most subtile functions of the brain.

The physical superiority of the ante-Alexandrian Greeks to the hardiest and most robust nations of modern times is perhaps best illustrated by the military statistics of Xenophon. According to the author of the "Anabasis," the complete accoutrements of a Spartan soldier, in what we would call heavy marching order, weighed seventy-five pounds, exclusive of the camp, mining, and bridge-building tools, and the rations of bread and dried fruit which were issued in weekly installments, and increased the burden of the infantry soldier to ninety, ninety-five, or even to a full hundred pounds. This load was often carried at the rate of four English miles an hour for twelve hours *per diem*, day after day; and only in the burning deserts of Southern Syria the commander of the Grecian auxiliaries thought it prudent to shorten the usual length of a day's march by one-fourth. The gymnastic tests applied by the *systarchus*, or recruiting-officer of a picked corps, would appear even more preposterous to the uniformed exquisites of a modern "crack regiment." Even tall and well-shaped men of the soundest constitution could not pass the preliminary examination unless they were able to jump their own height vertically, and thrice their own length horizontally, and two-thirds of those distances in full armor; pitch a weight equal to one-third of their own to a distance of twenty yards, and throw a javelin with such dexterity that they would not miss a mark of the size of a man's head more than four out of ten times at a distance of fifty yards, besides other tests referring to their expertness in the use of the bow and the broadsword.

Where the average physical standard was so far superior to our own, it need not surprise us that the achievements of the national champions surpassed the feats of our professional athletes in the same proportion. Polydamus, the victor of the ninety-seventh Olympiad, was able to fracture the skull of a steer with a single blow of his fist, and tamed a wild horse by catching it by the hoofs of the hind-legs, which he twisted inward till the joints of the fetlocks creaked whenever the animal attempted the least rebellious movement. Milo of Crotona, the same athlete who carried a young bull around the race-course, could not be moved from his position by a four-horse team, if he planted his left foot on the level ground, and braced his right against a slightly-projecting rock; and once saved an assembly of Pythagorean philosophers when the roof of a dilapidated temple threatened to fall, by supporting the keystone of the porch with his uplifted arms till all had escaped, after which he saved himself by two rapid leaps. A Theban gladiator, whose renown had reached the court of Persia, was invited to Sardis, the summer resort of King Darius, and on the day after his arrival entered the list against three picked men of the "Immortal Band," as the Persian body-guard was called. A savage combat followed, in which the three Persians began to lose ground, and would have been driven beyond the lists if the fight had not been stopped by command of the king. But his order came too late; in the few minutes which the contest had lasted the three "immortals" had received their death-wounds.

Deerfoot, a Cherokee Indian, who was brought to England in 1758, was able to outrun the swiftest horses, if the length of the race-course did not exceed two-thirds of a mile; and during the administration of Niccolo Marcello, the inhabitants of Ravenna witnessed the feats of a young Savoyard, who repeatedly distanced the favorite racer of the doge, and offered to run against any horse in the world and for any distance, provided the direction of the race was to be more or less up-hill, not down-hill or over a sandy level. But the amateur runners of the Grecian and Roman armies frequently engaged in contests with race-horses and trained hounds without any such reservations; and Pindar sung the praises of a Rhodian athlete who could keep pace with a relay of four trotting horses, and tire them out successively.

The *hemerodromes*, or foot-couriers of ancient Greece, made from eighty to ninety miles a day, and the volunteer messenger who arrived in Athens with the news of the victory of Marathon on the night after the battle, must have run at the rate of fourteen miles an hour. Dion Chrysostomus speaks of a Thessalian patriarch who had followed the trade of a hemerodrome for upward of ninety years, having made his first trip on his twentieth birthday, and his last after the completion of his hundred and tenth year. During this long career, as his life might well be called, he had never been known to betray a trust, never was behind time, and never had been sick for a single hour.

Longevity was not the least of the benefits which the ancients derived from their health-giving exercises. The second census of Trajan furnishes some curious statistics on this subject, and shows that among the 28,000,000 inhabitants of Northern Italy, Greece, and *Magna Græcia* (Southern Italy and Sicily), there were 11,000 centenarians, 750 of whom had passed sixscore years, eighty-two their one hundred and fiftieth, and twenty their one hundred and seventy-fifth year of life, while three were double centenarians and respectively two hundred and six, two hundred and eight, and two hundred and eighteen years of age. Four brothers of an Albanian family had all passed their hundred and tenth year. The same census shows that, among the indolent races of Asia Minor, Egypt, and Palestine, the proportion of centenarians to every 1,000,000 of inhabitants was considerably lower and not much above the present average.

That the Hebrew Psalmist's threescore and ten was not our original term of life will not be denied by orthodox readers of the Mosaic genealogies, and the ablest biologists agree that it would be far below the normal average even now, if our manner of life itself was not wholly abnormal. It would explain the most vexing contradictions and enigmas of our existence if we could be sure that by strict observance of the health-laws of Nature the Psalmist's maximum might be increased by thirty or forty years: it would amount to a satisfactory solution of the whole problem of life. Under the present condition of things our lives are mostly half-told tales, dramas ending in the middle of the first act; our season terminates before the tree of life has had time to ripen its fruits. That "hunger after immortality" which is often alleged as a proof of a future existence, arises most likely from an instinctive perception of the truth that our present spans of life are too short for reaching the goal of our destination; for those vague yearnings were unknown to the Semitic and Grecian patriarchs. They died in peace, "full of years," and satisfied, as any reasonable man might be who had witnessed one hundred and fifty rotations of the four seasons, and enjoyed all their blessings in perfect health.

There is no doubt that the military triumphs of the ancient Greeks were the natural result of their physical education. "A nation," says Jean Jacques Rousseau, "which can boast of 20,000 *men*, is not vincible." Virility as well as virtue was originally derived from a word which means simply strength, just as our Anglo-Saxon ancestors used to speak of the *best man* of a parish, without special reference to the most regular church-goer. Strength is the parent of valor and self-confidence, and confidence in the valor and strength of armed companions begets that national heroism which enabled the republican Greeks, the Swiss, the Circassians, and the Montenegrins, to defy the most powerful and numerically superior of their would-be conquerors.

Not to their political but to their physical constitutions these nations owed their long independence. The historical records of the last three thousand years demonstrate the strange fact that international wars, almost without a single exception, ended by *the victory of northern nations over their southern rivals*. The Carthaginians, originally natives of Phœnicia, conquered the Numidian principalities, but were in turn conquered by their Roman neighbors ; Rome, victorious against all her southern, southeastern, and southwestern rivals, was herself struck down by the iron arm of the Visigoth, the north-Spanish Christians overcoming the south-Spanish Moors, the northern Turks wresting the sceptre from their southern fellow-Mohammedans, the north-Mongol Tartars oppressing the south-Mongol Chinese, the North-German Prussians bullying the southern members of the Confederation, the Northmen of Scandinavia conquering Normandy, Brittany, and Great Britain, the house of Hapsburg eclipsed by the house of Hohenzollern, a North-Italian kingdom absorbing the southern states of the peninsula—the same phenomenon, in hundred variations, repeating itself from China to Peru, from the Trojan War to the civil war of the North American States.

What does all this mean, but that the fortune of war is biased by bodily strength ? Rome was not vanquished by the intellectual superiority of the Visigoths, nor Maria Theresa by the moral merits of Frederick's cause, but we may safely assume that in all international contests the physical advantage was on the side of the northern champion. The climate and the comparative sterility of a cold country necessitate a continual struggle with the adverse powers of Nature, and beget that hardy and robust constitution which is the basis of all military efficiency. But, this incidental advantage which northern races derive from the inclemency of their latitude, any nation might secure in a more direct and much more agreeable way, by introducing a thorough and popular system of physical education.

The fallen races, as the nations of Southern Europe and South America have been called, are not wholly blind to the causes of their degeneracy. "How dare you appeal to the God of battles?" says Simon Bolivar, in that famous protest against the endowment of convents, "if you devote all your worship to a score of sickly saints?" and in still plainer language honest Boileau denounces the effeminacy of his countrymen: "What has become of the image of God!" he exclaims in his second epistle; "want of physical exercise and vicious indulgences, what have they left of that form that once furnished the model for Grecian statues? We are a generation of cripples!"

Open-air exercise also bestows that beauty and that native grace in which a New Zealand warrior is the superior of a cockney dandy. Not only the North American red-skins but also those semi-barbarians whose noble forms induced us to make them the representatives of the "Caucasian" tribes, the natives of Circassia and Daghestan, belong to the Mongol or Turanian race, which originally was far inferior to our Aryan ancestors. Under the influence of an effete civilization that same race has begot those Chinese caricatures of the Creator which are justly despised even by Sambo Africanus, whose dark skin covers at least a vigorous body. Old Montaigne already remarks that "the handsomest man was a hunter and not a hair-dresser," and was by no means astonished to find brighter eyes and more faultless noses among the woodchoppers of the Pyrenees than among the exquisites of a Parisian ballroom.

There was at least a theoretical consistency in the dogma of the mediæval monks who pretended to despise the pagan culture of the manly powers and extolled self-torture, maceration, and abasement of the body, as so many Christian virtues. We cannot doubt that they reasoned from false premises; but are there not still millions of their spiritual progeny who persist in the belief that the Creator approves the marring of his image, and that "a sickly, whining wretch, who fears to walk upright or raise his eyes, lest the Deity might be offended at his want of humble contrition"—is a more pleasing sight in the eyes of God than a man like Milo, who walked earth *incessu invicti*, "with the gait of one who has not known defeat," and did not think it necessary to ruin his body in order to save his soul? "A good creed to die by," that monstrous belief is often called, just as if the sun had been created for the sake of the twilight; but it is a curious circumstance that on the eve of the long night the eyes of many of these world-despising ascetics have been opened to the significance of their mistake, and the consciousness of having wasted an irretrievable day can hardly have made its close more cheerful.

"I have sinned against my brother, the ass" (referring to his abused body), were the last words of St. Francis of Assisi, when his self-inflicted martyrdom at last brought on a hæmorrhage from the lungs, which his physician told him would prove fatal.

Baron Oxenstiern, the Swedish chancellor, who was a stanch Protestant, but a gloomy ascetic nevertheless, passed the last week of his life on the mountain-farm of his brother, an honest farmer, who had never left the paternal manse. One evening, two days before the chancellor's death, his biographer tells us, the brothers were sitting on a rustic bench, on the edge of a mountain-lawn, where the boys of the farmer were disporting themselves, running races, shouting in the joy of exuberant health, or resting arm-in-arm at the foot of an old beech-tree, in the interacts of their play. While the chancellor watched their sports, a vision was haunting his inner eye: the dreary college of Upsala, and two pale-faced students, whose features resembled or had resembled his own. Staggering suddenly to his feet he drew a dagger from its sheath and handed it to his brother, with the words, "Cut my throat, Hendrick—I cannot stand that any longer!" "What's the matter?" said the old farmer, smiling; "are you in such a hurry to go to h—? If Dr. Hochstratten" (a Catholic controversialist) "is right, you will get there soon enough!" "Better be there," said the chancellor, grimly, "than in the other place, where I might meet my sons. How can I answer for the earthly paradise they have lost through my fault? What have I robbed them of!"

Open-air labor is the most effective cosmetic, an almost infallible panacea against all kinds of bodily deformity. But the remedial virtue of labor, i. e., sound bodily exercise, is greater than that of open-air life *per se*, for among the rustic population of Scandinavia, Scotland, and Northern Germany, who perform a large portion of their hard work in-doors, we frequently find models of health and vigor; far more frequently than among the inhabitants of Italy, Spain, etc., who pass the greater part of their indolent lives in open air.

But, besides all this, athletic exercises have a moral value, which our social reformers have strangely failed to recognize; they afford a diversion and a vent to those animal energies which otherwise are sure to explode in debauch and all kind of vicious excesses. The sympathetic thrill by which the mind accompanies a daring gymnastic feat and the enthusiasm of athletic contests form the most salutary and perhaps the only normal gratification of that love of excitement which is either the legitimate manifestation of a healthy instinct, or else a wholly irremediable disease of our nature. The soul needs emotions as the body needs exercise, and the exciting sports of the palæstra met both wants at once. We try to suppress these instincts, but their motives remain, and if thwarted in their normal manifestations they assert themselves in some abnormal way, chemically instead of mechanically, as Dr. Boerhaave would say; by convulsing the organs of digestion, since the organs of motion are kept in unbearable inactivity. In times of scarcity the paupers of China and Siam silence the clamors of their hungry children by dosing them with opium; and for analogous reasons millions of our fellow-citizens seek relief in alcohol: they want to benumb a feeling which they cannot satisfy in a healthier way.

After finishing his day's work the Grecian mechanic went to the gymnasium, the Roman to the amphitheatre, and the modern European and American goes to the next "saloon," to satisfy by different methods the same instinct—a longing for a diversion from the dull sameness of business-routine. There is no question which method was the best—the only question is which of the two bad substitutes may be the worse: the brutalizing, i. e., soul-hardening spectacles of bloodshed of the Roman arena, or the soul and body destroying poisons of the liquor-shop?

Not a few of the victims of alcohol have contracted their fatal passions with their eyes open to all its consequences—but what should they do? After masticating the dry bread of drudgery for six days, we cannot expect them to content themselves on the seventh with sleeping under a tree, or in church; and the very classes whose want of mental culture incapacitates them for purely intellectual recreations also lack the material resources by which the rich can more easily forego the advantage of public and free opportunities of healthy amusements. The cruel sports to which our bull-fighting ancestors devoted their holidays have perhaps been justly suppressed, but what have we substituted for them? Sunday-schools, revivals, and reading-rooms of the Young Men's Christian Association? Alas!—*Deflebilis manet hiatus*—a deplorable void remains; man is a compound of body and soul, and the unmixed joys of the New Jerusalem will be found insufficient for terrestrial wants, till the spiritualists have invented the art of dematerializing bodies as well as of materializing ghosts.

The pagan Greeks had discovered and divulged a secret which seems not to have been rediscovered yet by our philanthropists, viz., that the highest well-being of the body and of the soul cannot be attained separately, but must go hand-in-hand like thought and action, or will and force. They also had found out that it is the safest plan to improve each day as it comes, they celebrated life as a festival, and their poor as well as their rich enjoyed heaven on this side of the grave. In going along, they found time to do what we postpone to the end of the journey, which too often is never reached. The joyous love of life, of men to whom existence itself was a luxury, has therefore given way to very different moods—sad misgivings and doubts, provoked by ever-present but never-satisfied longings. "He who has done his duty can die in peace," we are told; but is it a duty to work for such rewards?

"So much labor for a winding-sheet?"

It may be said that we, too, have our national sports, trials of skill if not of strength, such as base-ball, cricket, target-shooting, and the like, or trials of strength *by proxy:* horse-races, cock-fighting, etc., on which a man may bestow all the time and stake all the money he has to spare. Well, we cannot afford to despise these things—they are the best we have; but can any man seriously compare the dreary fun of the cockpit with the enthusiasm of the palæstra, or the rapture of a Derby-day or even of a base-ball match with that of the Olympic race, and the moment when the *νικηφορία*—the shout of victory—was echoed by a million voices, and an assembled nation rose to hail the victor in the presence of his relations and friends! Men whose hearts were stirred by such scenes had no need of buying inspiration at the gin-shop. The *Turnverein* is yet but in its egg, and competitive gymnastics has yet to take rank again as the noblest, the happiest, and the most popular, of all our national pursuits.

We have emerged from the *aphanasia* of the middle ages, that fearful eclipse of reason and happiness that followed like an unnatural night upon the bright sunrise of Grecian civilization, and the spiritual lethargy of that night has been shaken off by all that deserve the name of men; how is it, then, that so much of its physical torpor still remains behind? Have we really forgotten that God is the creator of our bodies as well as of our souls? Our limbs seem to have been paralyzed by long disuse; the gates of our hierarchical Bastile have been forced, but the great majority of the prisoners seem in no hurry to leave their cells. Though freed from Jesuitical control, our educational system is still not only unnatural but anti-natural to such a degree that we think it our duty to suppress the healthiest instincts of our children and keep them in the beaten track which has led us deeper and deeper into the labyrinth of dogmatism, till we have almost forgotten that there is a brighter light and purer air outside.

Yet there is hope. The spirit of our Nature-loving ancestors will assert itself before long, and the inhabitants of *Greater Britain* will return from the languid repose of the Hebrew heaven to the healthier pastimes of the Anglo-Saxon Walhalla. The Germans, too, are seeing the dawn of a long hoped-for morning, and the prophetic words of their philosophical Messiah are beginning to be fulfilled. "The spiritual juggler-guild," says Gotthold Lessing, "who derive their revenues from the supernatural dogmas of the three Semitic religions, have found it to their advantage to divert our attention from the natural laws of God, but those laws cannot be outraged with impunity. I foresee a physical reformation, and its advent-sermons will be preached before long."

THE GIGANTIC EXTINCT ARMADILLOS AND THEIR PECULIARITIES, WITH A RESTORATION.[1]

By JOHN A. RYDER.

THE general principle that, with increased size, there is an increase in the thickness and strength of the skin and its protective appendages, is in no instance better illustrated than in the extinct and living armadillos; in the former the thickness attained by the bony armor

[1] It is but just to refer to Prof. H. Burmeister's magnificent monograph on these animals in the "Anales del Museo Público" of Buenos Ayres, for 1866–'73, from which

sometimes exceeds an inch, in the latter it is usually less than one-eighth of that thickness. Note, also, the corresponding contrast in size. The smallest living species is less than a foot in length, whereas the largest known fossil form measured between twelve and thirteen feet in length; or quite as much as the largest rhinoceros. In structure or make-up these giants were sufficiently different from their living relatives to characterize a distinct family, appropriately named by Huxley the *Hoplophoridæ*, or armor-bearers. Unlike the living armadillos, the back and sides of the body were covered with an inflexible carapace, or coat-of-mail, which, like the same in living forms, was made up of numerous more or less nearly hexagonal *tesseræ* or plates. In recent forms the armor is divided into two parts: a forward part, covering the scapular or region of the shoulder-blades, and a posterior, covering the pelvic or region of the hips and flanks; between the two a series of mobile bands or zones of plates are interposed transversely, so as to enable the animal to bend its covering upon itself, and thus envelop all the soft parts, and thereby protect itself from enemies almost as effectually as the hedgehog can with its spines.[1] The *Hoplophoridæ* were provided with an additional rigid, pear-shaped armor-plate or buckler upon the under side of the body, hence they have also been called *Biloricata*, or two-shielded, in contradistinction to the living *Loricata* (armadillos), which are shielded only on the back. Head-shields covering the upper part of the head are characters common to both living and fossil forms. The extinct species, with their carapace and plastron, or belly-shield, resembled the snapping turtles in not having the belly-shield to cover more than one-half of the area of the lower side of the body left uncovered by the carapace of the back. The reason why this belly-shield was smaller than the area it partially covered was to allow free and unimpeded movement of the limbs. All that remains of this rigid belly-shield in even the best-armored living species are numerous separated plates, which do not interfere with that flexibility of the walls of the abdomen which is necessary in bending the body when the animal covers itself with its dorsal armor or carapace.

Living species are mostly burrowing in habit. Whether the *Hoplophoridæ* were burrowers cannot be affirmed, but it is extremely doubtful; though, from the great resemblance of the fore-limbs and claws to those of living species, it is likely that they were able, upon occasion, to dig with great rapidity and dexterity.

I have seen the tongue protruded nearly two inches with great quickness by a young six-banded armadillo; it is tapering and very flexible, and is no doubt used to advantage in capturing insects which

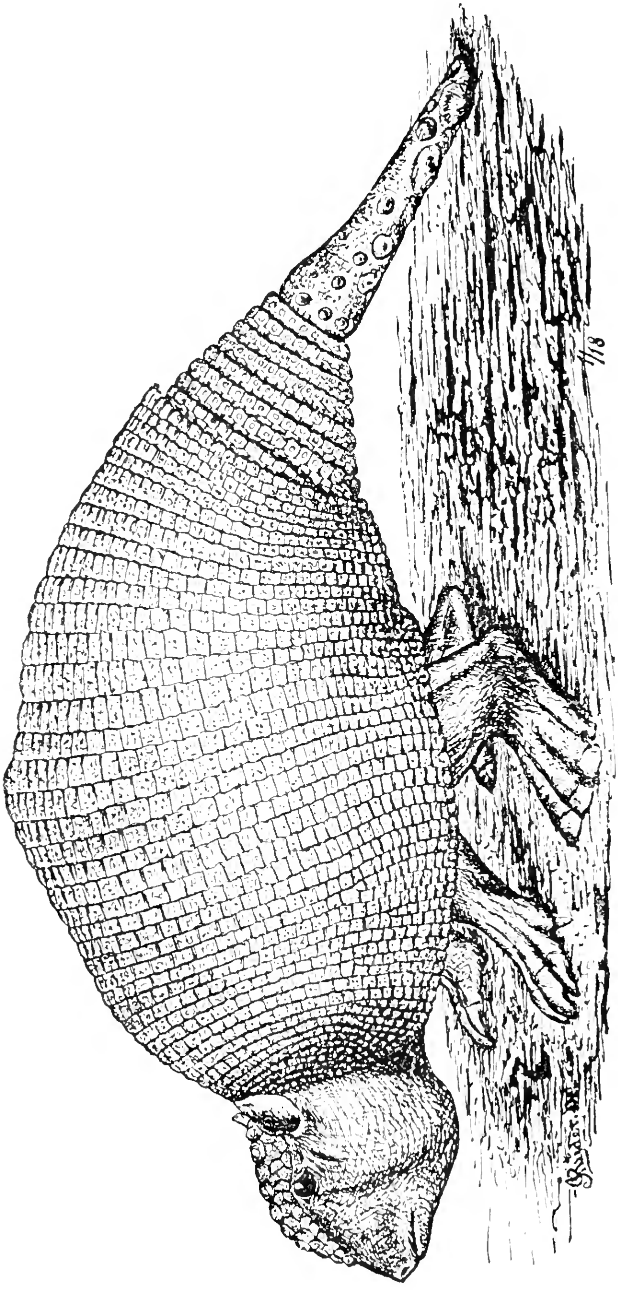
most of the materials which I have used in my studies and comparisons have been drawn. From the wealth of materials at his command he has been enabled to present a fuller account of the osteology of these creatures than any other hitherto published. The memoirs of Owen, Lund, Nodot, Huxley and others, have also been consulted.

[1] *See* Brehm's "Thier-leben," vol. ii., p. 508, for an interesting account of this habit.

fall in its way, as well as to convey other food to the mouth with more readiness. The elongated, protrusible tongue of recent species, as well as of the remaining representatives of the order, gives a clew to the nature of the tongue of the extinct giant armadillos, which was probably used as a herbage-grasping organ, as in the giraffe, and as Prof. Owen finds reason to believe must have been the case with the great extinct sloths, *Megatherium*, and its allies. It is highly probable, nay, almost certain, that the prehensile powers of the tongues of the *Edentata*[1] are intimately associated with their want of incisors, or cutting-teeth. Similar disappearance or loss of function of the incisors by ruminants, proboscidians, and rhinoceroses, is similarly correlated with a grasping tongue, trunk, or lips.

In living armadillos the grinding-teeth vary in number from twenty-six to thirty-eight, and are in the form of cylindrical or oval columns. All the *Hoplophoridæ* have thirty-two grinders, sixteen above and the same number below, without enamel, as in recent forms. Two deep grooves run vertically up and down on both the inside and outside of each tooth, causing the appearance of two deep bays on each side in transverse section, which is not quite twice as long as wide. Unlike living allied forms, these giants had strong descending processes directed downward from the zygomatic arches (cheekbones), similar to those of the great extinct and small modern sloths; and, like the first of the last mentioned, the bones of the pelvis, hind-limbs, and tail, were relatively more massive than in their existing representatives, showing in these features strong resemblances to the sloth-like division of the order. From the deep implantation of the grinding-teeth in the giant armadillos, one cannot resist the inference that, like the great sloths, they were herbivorous. This idea is further countenanced by their size, which, in terrestrial mammals, is usually an accompaniment of herbivorous habits. The features, however, which unmistakably ally them to living armadillos, are the presence of a third trochanter on the femur, and the union of the tibia and fibula and the annular and tubular armor covering the tail. The animal of our figure has the basal part of the tail surrounded and covered with eight slightly mobile rings of armor-plates; each one of these rings is supported on the inside by five strong processes of bone which arise radially or like the spokes of a wheel from each of the first seven caudal vertebræ. The first caudal vertebra supports two of the armor-rings. The last fourteen joints of the tail are inclosed by rigid armor, much the same as the end of the finger is covered by a thimble. These terminal joints, confined within this inflexible bony case, become united into a continuous bony rod. Other species have been described which have the tail covered throughout with rings of armor-plates, within which each joint of the tail is separate, as usual in the tails of other vertebrates. In one living species the tail is almost

[1] The total length of the tongue in the ant-bear (*Myrmecophaga*), from its origin at the xiphoid end of the breastbone, is three feet.

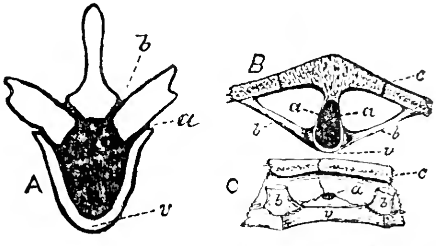


Panochthus tuberculatus.—(Burmeister.)

naked, whence its name, *Dasypus gymnurus.* The little three-banded species has the upper face of the tail covered with relatively thick plates. In living specimens I have also noticed that the ears, though very thin, were covered with thin and minute (usually polygonal) scales, both inside and out.

Studies of the feet of the *Hoplophoridæ* show that they can be divided into two well-defined groups: the first, to which the animal represented in the figure belongs, has four claw-bearing toes on the fore-legs, and four hoof-bearing toes on the hind-legs; the second group has four claw-bearing toes on the fore-legs, and five hoof-bearing toes on the hind ones. As the figure shows, and which is fully supported by the osteology, the hinder extremities are proportionally more massive and longer than the fore ones, which fact, together with the enormously expanded pelvic bones, shows that the creature perhaps raised the fore-part of the body into a more or less nearly vertical position with the help of its tail to reach the leaves of plants upon which it fed, as did its huge congeners, the extinct sloths. This view is favored by the flattened condition of the tail-case or armor toward its extremity, perhaps from the pressure to which it was often subjected from below while in the bipedal position. This also explains the use of the belly-shield to have been to afford protection against enemies from below while in such an attitude, as the animal, because so well protected otherwise, was probably less favored in respect to sight and hearing.

The carapace was supported for nearly half its length upon the haunch-bones (ilia and ischia), as well as by the strong, longitudinal, median, bony crest rising from the lumbar and sacral vertebræ, consisting of their united neural or spinous processes. The carapace rested directly on these bones, and was joined to them by suture, as the roughened and expanded surfaces for such juncture clearly show. The



A, transverse section of the "dorsal tube" of *Panochthus tuberculatus*: *a* and *b*, toramina for spinal nerves; *v*, vertebral centrum. One-sixth natural size. (After Burmeister.)
B, transverse section through a portion of the carapace and middle of one of the vertebræ (dorsal tube) of a salt-water terrapin: *c*, carapace; *b*, proximal extremity of ribs; *a a*, situation of foramina for the exit of spinal nerves; *v*, vertebral centrum. Central dark spaces in *A* and *B* show the forms of the neural or spinal canals in section. (Original.)
C, side-view of a dorsal vertebra of a European tortoise: *a* indicates the position of lateral foramina *a a* in *B*. Other references same as in *B*. (After Bojanus.)

entire union of the lumbar and sacral vertebræ into a hollow bony bar, and the union of this to the lateral elements of the pelvic arch, together with the union of both by suture with carapace, rendered any lateral bending of the trunk impossible, so that an almost universal union of the trunk or body segments ensued, owing to this structurally enforced loss of mobility between the vertebral elements. As a consequence, the centra or bodies of the segments disappeared, or were atrophied, leaving only their trough-like plates about one-fourth of an inch thick, formed of the degenerate and united central bodies. This trough, with the united rib-bearing arches that arose from its edges, formed a tube for the lodgment and protection of the spinal or nervous cord. Unlike all vertebrates, except turtles, this tube in that portion over the lungs is perforated at intervals on each side at points about midway of the length of each one of the several united segments to give egress to the spinal nerves.[1] The points of egress for the spinal nerves are usually between the spinous processes in other orders of vertebrates.

In living armadillos the centra of the trunk vertebræ still remain as more or less depressed cylinders of bone, or at least they are distinguishable *as* centra, from which arise the rib-bearing arches, which do not completely unite, leaving lateral inter-spinous openings so as not to entirely close over the nervous cord, as happens in fossil forms. The reason why the vertebræ remained separated in recent species is undoubtedly because of the mechanical conditions to which these parts of their skeleton were subjected. Here the carapace was jointed and flexible; hence the need of flexibility in the spinal column. In the extinct species, as in turtles, the degeneration of the centra into mere conduits for the nervous cord is one of the many contrivances the origin and teleological significance of which can only be explained by a mechanical theory. The vertebral column in both was similarly conditioned with respect to strains, mostly transverse—hence the similarity of structure; which it must be borne in mind is, however, no indication of zoölogical affinity.

Beginning with the homogeneous notochord or continuous rod-like axis of some such form as *Amphioxus*, Mr. Spencer points out how, as this axis became bony with the assumption of the characters of the higher fishes, the alternate pressure and tension incident to the flexures of this axis during locomotive acts would tend to differentiate the vertebral segments; for it is obvious that, in order to be flexible and at the same time bony, the vertebral axis must become segmented. The mechanical conditions under which vertebral axes are placed would indicate that the segmentation took place from within outward, which is in accordance with observed facts. It is also obvious, in view of the premises, that, in the absence of flexures or bendings of the vertebral axis, we should have a return to the homogeneous structure, such as we actually find to result in the two cases under consideration, and as happens in a few of the posterior trunk-segments (sacral) of birds and mammals. Embryology and phylogeny both bear out these

[1] In birds, as, e. g., the common fowl, the first segments of the sacrum, the centra of which are similarly atrophied, are perforated laterally in the same situation.

conclusions ; not only do the vertebral centra become more rudimentary as the young condition is departed from in the life-history of the individual tortoise, but the centra also become successively more rudimentary as we pass from the less completely armored genera *Sphargis* and *Trionyx*, to the more completely armored *Testudo* and *Cistudo*.

Like the tortoises, our huge animal had an arrangement of the neck vertebræ whereby he could withdraw his head slightly backward in case of an attack, so as to bring his head-shield to fit closely against his carapace. The atlas or first joint of the neck was separate, the next four were united, the sixth was separate, and a "trivertebral bone," which seems to have taken a share in the neck as well as in the thorax, followed next, and probably was the bone which enabled the creature to retract its head somewhat; next followed ten united rib-bearing trunk-vertebræ, which Prof. Burmeister has aptly called the "dorsal tube" (*see* cross-section, Fig. *A*). Succeeding the "dorsal tube" are eight lumbar and probably eight sacral vertebræ firmly united together and to the ilia ; following these, come twenty-one caudal or tail bones, footing up a total of fifty-six segments in the entire spinal column, which is not far from the number found in living species, though only about one-fourth as many are united together in them as in our fossils. The plates of the carapace were united by suture in the fossil species, rendering the armor as rigid as the carapaces of land-tortoises. In living forms, the plates, in some species at least, are slightly separated by intervening integument, rendering the armor more or less flexible throughout.

The remains of the *Hoplophoridæ*—better known by Prof. Owen's older name as the *Glyptodons*—have been found mostly in the bone-caves of Brazil, and in the alluvium and pampean Pliocene of Eastern and temperate South America. The finest collection of their remains in existence is in the Public Museum of Buenos Ayres. They were probably contemporaneous with some of the great *Carnivora*, whose remains have also been found in the caves. One of these, the sabre-toothed tiger (*Machairodus*), would, no doubt, have frequently rendered the almost invulnerable armor of the giant (but perhaps harmless) armadillo of great service, within which he could feel himself secure from the attacks of such a well-armed foe.

The restoration is one-eighteenth of the natural size, and is based on the figures in Burmeister's work. It is believed to be approximately correct, since nothing was needed to make the originals assume the appearance of life except to clothe the skull and neck with flesh, and furnish the extremities with claws and hoofs, muscles and tendons. The animal was between nine and ten feet in total length, and stood about four and a half feet high at the highest part of the back. Prof. Burmeister has christened the species *Panochthus tuberculatus*.

EVOLUTION OF CEREMONIAL GOVERNMENT.

By HERBERT SPENCER.

V. OBEISANCES.

SPEAKING of a party of Shoshones surprised by them, Lewis and Clarke say: "The other two, an elderly woman and a little girl, seeing we were too near for them to escape, sat on the ground, and, holding down their heads, seemed as if reconciled to the death which they supposed awaited them. The same habit of holding down the head and inviting the enemy to strike, when all chance of escape is gone, is preserved in Egypt to this day." Here we are shown an effort to propitiate by absolute submission; and from acts so prompted originate obeisances.

When, at the outset, in illustration of the truth that ceremony precedes not only social evolution but even human evolution, I named the behavior of a small dog which throws itself on its back in presence of an alarming great dog, probably many readers thought I was putting on this behavior a somewhat forced construction. They would not have thought so had they known that a parallel mode of behavior occurs among human beings. Describing the Batoka salutation, Livingstone says, "They throw themselves on their backs on the ground, and, rolling from side to side, slap the outside of their thighs as expressions of thankfulness and welcome." Whether or not consciously adopted for this reason, the assumption of this attitude, which implies, "You need not subdue me, I am subdued already," is the best means of obtaining safety. Resistance generates antagonism and arouses the destructive instincts. The stronger animal or the stronger man becomes less dangerous when the weaker animal or man passively submits; because nothing occurs to excite the passion for victory. Hence, then, the natural genesis of this obeisance by prostration on the back, which, perhaps, more than any other position, makes self-defense impracticable. I say perhaps, because another attitude may be instanced as equally helpless, which more elaborately displays complete subjugation. "At Tonga Tabu . . . . the common people show their great chief . . . . the greatest respect imaginable by prostrating themselves before him, and by putting his foot on their necks." The like occurs in Africa. Laird says the messengers from the King of Fundah "each bent down and put my foot on their heads, and threw dust over themselves." And among ancient historic peoples this position, originated by defeat in battle, became the position assumed in acknowledgment of submission.

From these primary obeisances thus representing, as literally as may be, the attitudes of the conquered beneath the conqueror, there come obeisances which express in various ways the subjection of the slave to the master: this last being the sequence of the first. Of old in the East such subjection was expressed when "Ben-hadad's servants girded sackcloth on their loins, and put ropes on their heads, and came to the King of Israel." In Peru, where the militant type of organization was pushed to so great an excess, Garcilasso tells us that a sign of humility was to have the hands tied and a rope round the neck; that is, there was an assumption of those bonds which originally marked captives brought from the battle-field. Along with this mode of simulating slavery, another mode was employed when approaching the Ynca: servitude had to be indicated by carrying a burden; and "this taking up a load to enter the presence of Atahuallpa is a ceremony which was performed by all the lords who have reigned in that land."

These few extreme instances I give at the outset by way of showing the natural genesis of the obeisance as a means of obtaining mercy; first from a victor and then from a ruler. An adequate conception of the obeisance, however, includes another element. In the introductory chapter it was pointed out that sundry signs of pleasure, having a physio-psychological origin, which occur in presence of those for whom there is affection, pass into complimentary observances; because men are pleased by supposing themselves liked, and are therefore pleased by demonstrations of liking. Hence, while aiming to propitiate a superior by expressing submission to him, there is generally an endeavor further to propitiate him by exhibiting joy at his presence. Keeping in view, then, both these elements of the obeisance, let us now consider its varieties; with their political, religious, and social uses.

Though the loss of power to resist which prostration on the face implies does not reach the utter defenselessness implied by prostration on the back, yet it is sufficiently great to make it a sign of profound submission; and hence it occurs as an obeisance wherever despotism is unmitigated and subordination slavish. It was found in ancient America, where, before a Chibcha cazique, "people had to appear prostrate and with their faces touching the ground." We find it in Africa, where, "when he addresses the king, a Borghoo man stretches himself on the earth as flat as a flounder, in which attitude he lies, kissing the dust, till his business with his sovereign is at an end." Asia furnishes many cases of it: "When preferring a complaint, a Khond or Panoo will throw himself on his face, with hands joined, and a bunch of straw or grass in his mouth;" and while, in Siam, "before the nobles all subordinates are in a state of reverent prostration, the nobles themselves, in the presence of the sovereign, exhibit the same crawling obeisance." Similarly in Polynesia. Falling on the face is a mark of submission among the Sandwich-Islanders: the king did so to Cook when he first met him. And in the records of ancient historic peoples plenty of kindred illustrations are given: as when Mephibosheth fell on his face and did reverence before David; or when the King of Bithynia fell on his face before the Roman Senate. In some cases this attitude of the conquered before the conqueror, thus used to signify entire subjection, has its meaning emphasized by repetition. Bootan supplies an instance: "They . . . . made before the rajah nine prostrations, which is the obeisance paid to him by his subjects whenever they are permitted to approach."

Every kind of ceremony is apt to have its primitive character obscured by abridgment; and by abridgment this profoundest of obeisances is rendered a less profound one. In the assumption of a full-length prostration there is, almost of necessity, the passage through an attitude in which the body is on the knees with the head on the ground; and still more on rising, a drawing up of the knees is a needful preliminary to raising the head and getting on the feet. Hence this attitude may be considered as an incomplete prostration. It is a very general one. Among the Coast negroes, if a native "goes to visit his superior, or meets him by chance, he immediately falls on his knees, and thrice successively kisses the earth, claps his hands, wishes the superior a good day or night, and congratulates him." Laird tells us that, in acknowledgment of his inferiority, the king of the Brass people never spoke to the king of the Ibos "without going down on his knees, and touching the ground with his head." At Embomma, on the Congo, "the mode of salutation is by gently clapping the hands, and an inferior at the same time goes on his knees and kisses the bracelet on the superior's ankle."

Often the humility of this obeisance is increased by emphasizing the contact of the head with the earth. On the Lower Niger, "as a mark of great respect, men prostrate themselves, and strike their heads against the ground." When, in past times, the Emperor of Russia was crowned, the nobility did homage by "bending down their heads, and knocking them at his feet to the very ground." In China, at the present time, among the eight obeisances, increasing in humility, the fifth is kneeling and striking the head on the ground; the sixth, kneeling and thrice knocking the head, which again doubled makes the seventh, and trebled, the eighth: this last being due to the emperor and to Heaven. Of old, among the Hebrews, repetition had a kindred meaning. Remembering that this obeisance is variously exemplified, as when Nathan "bowed himself before the king with his face to the ground," and as when Abigail did the like to David, and Ruth to Boaz, we have the additional fact that "Jacob bowed himself to the ground seven times, until he came near to his brother."

From what has gone before it will be anticipated that this attitude of the conquered man, used by the slave before his master and the subject before his ruler, becomes that of the worshiper before his deity. The East, past and present, yields sufficient examples. That complete prostration is made, whether the being to be propitiated is visible or invisible, is shown us in Hebrew records by the statement that "Abraham fell upon his face" before God when he covenanted with him; by the fact that "Nebuchadnezzar fell upon his face, and worshiped Daniel;" and by the fact that when Nebuchadnezzar set up a golden image there was a threat of death on "whoso falleth not down and worshipeth." Similarly, the incomplete prostration in presence of kings recurs in presence of deities. When making obeisances to their idols, the Mongols touch the ground with the forehead thrice, the Calmucks only once. So, too, the Japanese in their temples "fall down upon their knees, bow their head quite to the ground, slowly and with great humility." And sketches of Mohammedans at their devotions familiarize us with a like attitude.

While preserving in common the trait that the inferiors assuming them keep at a lower level than their superiors, these groveling obeisances admit of considerable variety. From the positions of prostration on back or face, and of semi-prostration on knees, we pass to sundry others, which, however, continue to imply relative inability to resist. In some cases it is permissible to vary the attitude, as in Dahomey, where "the highest officers lie before the king in the position of Romans upon the *triclinium*. At times they roll over upon their bellies, or relieve themselves by standing 'on all-fours.'" Duran states that "cowering . . . . was, with the Mexicans, the posture of respect, as with us in genuflection." Crouching is a sign of respect among the New Caledonians; as it is also in Feejee, and as it is also in Tahiti.

Other changes in attitudes of this class are entailed by the necessities of locomotion. In Dahomey, "when approaching royalty they either crawl like snakes or shuffle forward on their knees." When changing their places before a superior, the Siamese "drag themselves on their hands and knees." It is so, too, in Cambodia: "If any one had to approach the royal person, to give him anything or to obey a call, however far the distance, Cambodian etiquette prescribed a crawling progressive motion on knees and elbows." In Java an inferior must "walk with his hands upon his heels until he is out of his superior's sight." Similarly with the subjects of a Zulu king—even with his wives: Dingarn's wives said that "while he was present in the house they were never permitted to stand up, but always moved about" on their hands and knees. And, in Loango, extension of this attitude to the household appears not to be limited to the court: wives in general "dare not speak to them" (their husbands) "but upon their bare knees, and in meeting them must creep upon their hands." A neighboring state furnishes an instance of gradation in these forms of partial prostration, and a recognized meaning in the gradation. Burton tells us that the "Dakro," a woman who bears messages from the Dahoman king to the Meu, goes on all-fours before the king. Also, "as a rule, she goes on all-fours to the Meu, and only kneels to smaller men, who become quadrupeds to her."

Here we come incidentally upon a further abridgment of the original prostration; whence results one of the most widely-spread obeisances. As from the entirely prone posture we pass to the posture of the Mohammedan worshiper with forehead on the ground, so from this we pass to the posture on all-fours, and from this, by raising the body, to simple kneeling. That kneeling is, and has been in countless places and times, a form of political homage, a form of domestic homage, and a form of religious homage, needs no showing. We will note only that it is, and has been everywhere, associated with coercive government; as in Africa, where "by thus constantly practising genuflection upon the hard ground, their" (the Dahomas') "knees in time become almost as hard as their heels;" as in Japan, where "on leaving the presence of the emperor, officers walk backward on their knees;" as in China, where "the viceroy's children . . . . as they passed by their father's tent, fell on their knees and bowed three times, with their faces toward the ground;" and as in mediæval Europe, where serfs knelt to their masters, feudal vassals to their suzerains, and, in 1444, the Duchess Isabella de Bourbon, visiting the queen, went on her knees thrice during her approach.

Not dwelling on the transition from descent on both knees to descent on one knee, which, less abject, comes a stage nearer the erect attitude, it will suffice to note the transition from kneeling on one knee to bending the knee. That this form of obeisance is an abridgment is well shown us by the Japanese:

> "On meeting, they show respect by bending the knee; and when they wish to do unusual honor to an individual they place themselves on the knee and bow down to the gronnd. But this is never done in the streets, where they merely make a motion as if they were going to kneel. When they salute a person of rank, they bend the knee in such a manner as to touch the ground with their fingers."

We are shown the same thing equally well, or better, in China, where, among the specified gradations of obeisance, the third is defined as bending the knee, and the fourth as actually kneeling. Without accumulating evidence it will be manifest that what still survives among ourselves as the courtesy with the one sex, and what until recently survived with the other sex as the scrape (made by a backward sweep of the right foot), are both of them vanishing forms of the going down on one knee.

There remains only the accompanying bend of the body. This, while on the one hand the first motion passed through in making a complete prostration, is, on the other hand, the last motion that survives as the prostration becomes stage by stage abridged. In various places we meet indications of this transition. "Among the Soosoos, even the wives of a great man, when speaking to him, bend their bodies, and place one hand upon each knee; this is done also when passing by." In Samoa, "in passing through a room where a chief is sitting, it is disrespectful to walk erect; the person must pass along with his body bent downward." Of the ancient Mexicans who, during an assembly, crouched before their chief, we read that "when they retired, it was done with the head lowered." And then, in the Chinese ritual of ceremony above cited, we find that obeisance number two, less humble than bending the knee, is bowing low with the hands joined. Having such facts before us, and bearing in mind that there are insensible transitions between the humble salaam of the Hindoo, the profound bow which in Europe shows great respect, and the moderate bend of the head expressive of consideration, we cannot doubt that the familiar and sometimes scarcely perceptible nod is the last trace of the aboriginal prostration.

These several abridgments of the prostration which we see occur in doing political homage and social homage occur also in doing religious homage. Of the Congoese, Bastian says that when they have to speak to a superior—

> "They kneel, turn the face half aside, and stretch out the hands toward the person addressed, which they strike together at every address. They might have sat as models to the Egyptian priests when making the representations on the temple-walls, so striking is the resemblance between what is represented there and what actually takes place here."

And we may note kindred parallelisms in European religious observances. There is the going on both knees and the going on one knee; and there are the bowings and courtesyings on certain occasions at the name of Christ.

As already explained, along with the act expressing humility, the complete obeisance includes some act expressing gratification. To propitiate the superior most effectually it is needful at once to imply, "I am your slave," and "I love you."

Certain of the instances cited above have exemplified the union of these two factors. Along with the attitude of abject submission assumed by the Batoka, we saw that there go rhythmic blows of the hands against the thighs. In others of the cases named, clapping of the hands, also indicating joy, was described as being in Africa an accompaniment of movements showing submission; and many others may be added. Of the nobility who approach the King of Loango, Astley says, "They clap their hands two or three times, and then cast themselves at his majesty's feet into the sand, rolling over and over into it in token of subjection;" and Speke says of certain attendants of the King of Uganda, that they "threw themselves in line upon their bellies, and, wriggling like fish . . . . while they continued floundering, kicking about their legs, rubbing their faces, and patting their hands upon the ground." Going on their knees to superiors, the Balonda "continue the salutation of clapping the hands until the great ones have passed;" and a like use of the hands occurs in Dahomey. A further rhythmical movement having like meaning must be added. Already we have seen that jumping as a natural sign of delight is a friendly salute among the Fuegians, and that it recurs in Loango as a mark of respect to the king. Africa furnishes another instance. Grant narrates that the King of Karague "sat concealed, all but his head, in the doorway of his chief hut, and received the salutations of his people, who, one by one, shrieked and sprang in front of him, swearing allegiance." Let such saltatory movements be gradually methodized, as they are likely to be in the course of development, and they will constitute the dancing with which a ruler is sometimes saluted; as in the before-named case of the King of Bogotá, and as in the case Williams gives in his account of Feejee, where an inferior chief and his suite, entering the royal presence, "performed a dance, which they finished by presenting their clubs and upper dresses to the Somo-somo king."

Of the other simulated signs of pleasurable emotion commonly forming part of the obeisance, kissing is the most conspicuous. This, of course, has to take such form as consists with the humility of the prostration or kindred attitude. As shown in some foregoing instances, we have kissing the earth where the superior cannot be, or may not be, approached close enough for kissing the feet or the garment. Others may be added. "It is the custom at Eboe, when the king is out, and indeed in-doors as well, for the principal people to kneel on the ground and kiss it three times when he passes;" and the ancient Mexican embassadors, on coming to Cortez, "first touched the ground with their hands and then kissed it." This, in the ancient East, expressed submission of conquered to conqueror; and is said to have gone as far as kissing the footmarks of a conqueror's horse. Abyssinia, where the despotism is extreme and the obeisances are servile, supplies us with a modification. In Shoa kissing the nearest inanimate object belonging to a superior or a benefactor is a sign of respect and thanks. From this we pass to licking the feet and kissing the feet. Drury tells us that licking the knee is a sign of respect among the Malagasy, but does not indicate such deep abasement as licking the feet; and, describing the return of a Malagasy chief from war, he says: "He had scarcely seated himself at his door, when his wife came out crawling on her hands and knees till she came to him, and then licked his feet; when she had done, his mother did the same; and all the women in the town saluted their husbands in the same manner." Slaves, etc., did the like to their masters. So in ancient Peru, where subordination was unqualified, "when the chiefs came before" (Atahuallpa), "they made great obeisances, kissing his feet and hands." And that this extreme homage was, and is now, the practice in the East we have clear proof. In Assyrian records Sennacherib mentions that Menahem of Samaria came up to bring presents and to kiss his feet. "Kissing his feet" was part of the reverence shown to Christ by the woman with the box of ointment; and that the "catching hold of him by the feet" on the part of Mary Magdalene, doubtless accompanied by kissing, was not exceptional, we are shown by the description of a like act on the part of the Shunamite woman to Elisha. At the present day among the Arabs inferiors kiss the feet, the knees, or the garments, of their superiors. Kissing the shah's and the sultan's feet is now a form of homage in Persia and in Turkey; and Sir R. K. Porter narrates that, in acknowledgment of a present, a Persian "threw himself on the ground, kissed my knees and my feet, and wept with a joy that stifled his expression of thanks."

Kissing the hand is a less humiliating observance than kissing the feet, because it goes along with a less complete prostration. To kiss the feet implies bringing the head close to the ground; while there cannot be kissing of the hand without more or less raising of the body. This difference of implication is recognized in regions remote from one another. In Tonga, "when a person salutes a superior relation, he kisses the hand of the party; if a very superior relation, he kisses the foot." And D'Arvieux states that the women who wait on the Arabian princesses kiss their hands when they do them the favor not to suffer them to kiss their feet or the border of their robe. The prevalence of this obeisance, as expressing loving submission, is so great as to render illustration superfluous.

What is implied where, instead of kissing another's hand, the person making the obeisance kisses his own hand? Is the one symbolic of the other, and meant to be the nearest approach to it possible under the circumstances? This appears a hazardous inference; but there is evidence justifying it. According to D'Arvieux, as quoted by Prof. Paxton—

> "An Oriental pays his respects to a person of superior station by kissing his hand and putting it to his forehead; but, if the superior be of a condescending temper, he will snatch away his hand as soon as the other has touched it; then the inferior puts his own fingers to his lips and afterward to his forehead."

This, I think, makes it clear that the common custom of kissing the hand to another originally expressed the wish, or the willingness, to kiss his hand.

Here, as before, the observance, beginning as a spontaneous propitiation of conqueror by conquered, of master by slave, of ruler by ruled, and which we have just seen becomes, by extension under a modified form, a social propitiation, early passes also into a religious propitiation: to the ghost, and to the deity developed from the ghost, these actions of love and liking are used. That embracing of the feet, associated with kissing them, which we have seen occurred among the Hebrews as an obeisance to the living person, Egyptian wall-paintings represent as an obeisance made to the mummy inclosed in its case; and then, in pursuance of this action, we have kissing the feet of statues of gods among the Romans and of holy images among Christians. Ancient Mexico furnished an instance of the transition from kissing the ground as a political obeisance to a modified kissing the ground as a religious obeisance. Describing the Mexican ceremony of taking an oath, Clavigero says, "Then naming the principal god, or any other they particularly reverenced, they kissed their hand, after having touched the earth with it." In Peru the observance was further abridged by dispensing with any object kissed. D'Acosta says, "The manner of worship was to open the hands, to make some noise with the lips as of kissing, and to ask what they wished, at the same time offering the sacrifice;" and Garcilasso, describing the libation of a drop of liquor to the sun, made before drinking at an ordinary meal, adds: "At the same time they kissed the air two or three times, which . . . . was a token of adoration among these Indians." Nor have European races failed to furnish kindred facts: kissing the hand to the statue of a god was a Roman form of adoration.

Once more, saltatory movements, which, as we have seen, being natural expressions of delight, become complimentary acts before a visible ruler, also become acts of worship before an invisible ruler. In illustration there is the dancing of David before the ark; and there is the dancing which was originally a religious ceremony among the Greeks: from the earliest times the "worship of Apollo was connected with a religious dance called Hyporchema." We have the fact that King Pepin, "like King David, forgetful of the regal purple, in his joy bedewed his costly robes with tears, and danced before the relics of the blessed martyr." And we have the fact that in the middle ages there were religious dances in churches.

To interpret another series of associated observances we must go back to the prostration in its original form. I refer to those expressions of submission which are made by putting dust or ashes on some part of the body.

Men cannot roll over in the sand in front of their king, or repeatedly knock their heads against the ground, or crawl before him, without soiling themselves. Hence the adhering dust or earth is recognized as a concomitant mark of subjection; and comes to be gratuitously assumed, and artificially increased, in the anxiety to propitiate. Already the association between this act and the act of prostration has been incidentally exemplified by cases from Africa; and Africa furnishes other cases which exemplify more fully this self-defiling as a definitely-elaborated form. "In the Congo regions," says Burton, "prostration is made, the earth is kissed, and dust is strewed over the forehead and arms, before every Banza or village chief; and he tells us that the Dahoman salutation consists of two actions—prostration and pouring sand or earth upon the head. Similarly we read that "in saluting a stranger they" (the Kakanda people on the Niger) "stoop almost to the earth, throwing dust on their foreheads severalt imes." And, describing "the punctiliousness of manners shown by the Balonda," Livingstone says:

"The inferiors, on meeting their superiors in the street, at once drop on their knees and rub dust on their arms and chest. . . . During an oration to a person commanding respect, the speaker every two or three seconds 'picked up a little sand, and rubbed it on the upper part of his arms and chest. . . . When they wish to be excessively polite, they bring a quantity of ashes or pipe-clay in a piece of skin, and, taking up handfuls, rub it on the chest and upper front part of each arm.'"

Moreover, we are shown how in this case, as in all other cases, the ceremony undergoes abridgment. Of these same Balonda Livingstone says, "The chiefs go through the manœuvre of rubbing the sand on the arms, but only make a feint of picking up some." And, on the Lower Niger, the people when making prostrations "cover them" (their heads) "repeatedly with sand; or at all events they go through the motions of doing so. Women, on perceiving their friends, kneel immediately, and pretend to pour sand alternately over each arm." That in Asia this ceremony was, and still is, performed with like meaning, is also clear. As expressing political humiliation it was adopted by the priests who, when going to implore Florus to spare the Jews, appeared "with dust sprinkled in great plenty upon their heads, with bosoms deprived of any covering but what was rent." And at the present time in Turkey abridgments of the obeisance may be witnessed. At a review, even officers on horseback, saluting their superiors, "go through the form of throwing dust over their heads;" and common people, on seeing a caravan of pilgrims start, "went through the pantomime of throwing dirt over their heads."

Hebrew records prove that this sign of submission made before visible persons was made before invisible persons also. Along with those bloodlettings and markings of the flesh and cuttings of the hair, which, at funerals, were used to propitiate the ghost, there went the putting of ashes on the head. The like was done to propitiate the deity; as when "Joshua rent his clothes, and fell to the earth upon his face before the ark of the Lord until the eventide, he and the elders of Israel, and put dust upon their heads." Even still this usage occurs among Catholics on occasions of special humiliation.

Again we must return to that original obeisance which first actually is, and then which simulates, the attitude of the conquered before the conqueror, to find the clew to a further series of these bodily movements signifying submission. I refer to the joining of the hands. As described in a foregoing paragraph, the supplicating Khond "throws himself on his face with hands joined." Whence this attitude of the hands?

From the usages of a people among whom submission and all the marks of submission were carried to great extremes, an instance has already been given indicating the natural genesis of this action. A sign of humility in ancient Peru was to have the hands bound and a rope round the neck; that is, the condition of captives was simulated. Proof that it has been a common practice to make prisoners of war defenseless by tying their hands is superfluous; and, indeed, the fact that, among ourselves, men charged with crimes are handcuffed by the police when taken, sufficiently shows how obviously suggested is this method of rendering prisoners impotent. If there needs further reason for concluding that bound hands, at first distinguishing the conquered man, hence came to be an adopted mark of subjection, we have it in two strange customs found in Africa and China respectively. When the King cf Uganda returned the visit of Captains Speke and Grant, "his brothers, a mob of little ragamuffins, several in handcuffs, sat behind him. . . . It was said that the king, before coming to the throne, always went about in irons, as his small brothers now do." And then, of the Chinese, Doolittle tells us that "on the third day after the birth of a child . . . . the ceremony of binding its wrists is observed. . . . These things are worn until the child is fourteen days old . . . . sometimes . . . . for several months, or even for a year. . . . It is thought that such a tying of the wrists will tend to keep the child from being troublesome in after-life."

Such indications of its origin, joined with such examples of derived practices, force on us the inference that raising the joined hands as part of that primitive obeisance signifying absolute submission was in reality offering of the hands to be bound. The above-described attitude of the Khond exhibits the act in its original form; and on reading in Huc that "the Mongol hunter saluted us, with his clasped hands raised to his forehead," or in Drury that when the Malagasy approach a great man they hold the hands up in a supplicatory form, we cannot doubt that this position of the hands now expresses reverence because it originally implied subjugation. Of the Siamese, so abject in their political condition and so servile in their usages, La Loubere says, "If you extend your hand to a Siamese, to place it in his, he carries both his hands to yours as if to place himself entirely in your power." And that the presentation of the joined hands has the meaning here suggested is otherwise shown us. In Unyanyembe, "when two of them meet, the Wezee puts both his palms together, these are gently clasped by the Watusi" (a man of a more powerful race); and in Sumatra the salutation "consists in bending the body, and the inferior's putting his joined hands between those of the superior, and then lifting them to his forehead." By these cases we are reminded that a kindred act was once a form of submission in Europe. When doing homage, the vassal, on his knees, placed his joined hands between the hands of his suzerain.

That here, again, an attitude signifying political subordination becomes an attitude of religious devotion, scarcely needs pointing out.

We have in the East, by the Mohammedan worshiper, that same clasping of the hands above the head which we see expresses reverence for a living superior. Among the Greeks, "the Olympian gods were prayed to in an upright position with raised hands; the marine gods with hands held horizontally; the gods of Tartarus with hands held down." And the presentation of the hands joined palm to palm, once throughout Europe required from an inferior when professing obedience to a superior, is still taught to children as the attitude of prayer.

Nor should we omit to note that a kindred use of the hands descends into social intercourse. The filiation continues to be clear in the far East. "When the Siamese salute one another, they join the hands, raising them before the face or above the head." Of the eight gradations of obeisance in China, the first and least profound is that of joining the hands and raising them before the breast. Even among ourselves a remnant of this action is traceable. An obsequious shopman or fussy innkeeper may be seen to join and loosely move the slightly-raised hands one over another, in a way suggestive of derivation from this primitive sign of obedience.

A group of obeisances having a different, though adjacent root, come next to be dealt with. Those which we have thus far considered do not directly affect the subject person's dress; but from modifications of dress, either in position, state, or kind, a series of ceremonial observances result.

The conquered man, prostrate before his conqueror, and becoming himself a possession, simultaneously loses possession of whatever things he has about him. The minor loss of his property is included in the major loss of himself; and so, while he surrenders his weapons, he also yields up, if the victor demands it, whatever part of his dress is worth taking: the motive for taking it being, in many cases, akin to the motive for taking his weapons; since, being often the hide of a formidable animal, or a robe decorated with trophies, the dress, like the weapons, becomes an addition to the victor's proofs of prowess. At any rate, it is clear that, whatever be the particular way in which the taking of clothing from a conquered man originates, the nakedness, partial or complete, of the captive, becomes additional evidence of his subjugation. That it was so regarded of old in the East, we have clear proof. In Isaiah xx. 2-4, we read: "And the Lord said, Like as my servant Isaiah hath walked naked and barefoot three years for a sign . . . so shall the King of Assyria lead away the Egyptians prisoners, and the Ethiopians captives, young and old, naked and barefoot." Nor are we without evidence, furnished by other races, that the taking off and yielding up of clothing hence become a mark of political submission, and in some cases even a complimentary observance. In Feejee, on the day for paying tribute—

"The chief of Somo-Somo, who had previously stripped off his robes, then sat down, and removed even the train or covering, which was of immense length, from his waist. He gave it to the speaker," who gave him "in return a piece large enough only for the purposes of decency. The rest of the Somo-Somo chiefs, each of whom, on coming on the ground, had a train of several yards in length, stripped themselves entirely, left their trains, and walked away . . . . thus leaving all the Somo-Somo people naked."

Further we read that, during Cook's stay at Tahiti, two men of superior rank "came on board, and each singled out his friend . . . . this ceremony consisted in taking off great part of their clothes and putting them upon us." And then in another Polynesian island, Samoa, we find this complimentary act greatly abridged: only the girdle is taken off and presented.

With such facts to give us the clew, we can scarcely doubt that this surrendering of clothing originates those obeisances which are made by uncovering the body, more or less extensively. We meet with all degrees of uncovering having this meaning. From Ibn Batula's account of his journey into the Soudan in the fourteenth century, Mr. Tylor cites the statement that "women may only come unclothed into the presence of the Sultan of Melli, and even the sultan's own daughters must conform to the custom;" and what doubt we might reasonably feel as to the existence of an obeisance thus carried to its original extreme, is removed on reading in Speke that at the present time, at the court of Uganda, "stark-naked, full-grown women are the valets." Other parts of Africa show us an incomplete, though still considerable, unclothing as an obeisance. In Abyssinia inferiors must bare their bodies down to the girdle in presence of superiors; "but to equals the corner of the cloth is removed only for a time." The like occurs in Polynesia. The Tahitians uncover "the body as low as the waist, in the presence of the king;" and Forster states that in the Society Isles generally "the lower ranks of the people, by way of respect, strip off their upper garment in the presence of their" principal chiefs. How this obeisance becomes further abridged, and also how it becomes extended to other persons than rulers, we are well shown by the natives of the Gold Coast. Cruickshank writes:

"They also salute Europeans, and sometimes each other, by slightly removing their robe from their left shoulder with the right hand, gracefully bowing at the same time. When they wish to be very respectful, they uncover the shoulder altogether, and support the robe under the arm, the whole of the person, from the breast upward, being left exposed."

And of these same people, Burton remarks that, "throughout Yoruba and the Gold Coast, to bare the shoulders is like unhatting in England."

That uncovering the head, thus suggestively compared with uncovering the upper part of the body, has the same original meaning, can hardly be questioned. Even in certain European usages the relation between the two has been recognized, as by Ford, who remarks that "uncloaking in Spain is . . . . equivalent to our taking off the hat." It is recognized in Africa itself, where, as in Dahomey, the two are joined; "the men bared their shoulders, doffing their caps and large umbrella hats," says Burton, speaking of his reception. It is recognized in Polynesia, where, as in Tahiti, along with the stripping down to the waist before the king, there goes the uncovering of the head. Hence it seems that the familiar taking off of the hat among European peoples, often reduced among ourselves to touching the hat, is a remnant of that process of unclothing himself by which, in early times, the captive expressed the yielding up of all he had.

That baring the feet is an observance having the same origin, is well shown by these same Gold Coast natives; for while, as we have seen, they partially bare the upper part of the body in signification of their reverence, they also remove the sandals from their feet "as a mark of respect," says Cruickshank: they begin to strip the body at both ends. Throughout ancient America uncovering of the feet had a like meaning. In Peru, "no lord, however great he might be, entered the presence of the Ynca in rich clothing, but in humble attire and barefooted;" and in Mexico, "the kings who were vassals of Montezuma were obliged to take off their shoes when they came into his presence:" the significance of this act being so great that as "Michoacan was independent of Mexico, the sovereign took the title of cazonzi—that is, 'shod.'" Kindred accounts of Asiatics have made the usage familiar to us. In Burmah, "even in the streets and highways, a European, if he meets with the king, or joins his party, is obliged to take off his shoes." And similarly in Persia, every person who approaches the royal presence is obliged to bare his feet.

Verification of these several interpretations is yielded by the more obvious interpretations of certain usages which we similarly meet with in societies where extreme expressions of subjection are insisted upon. I refer to the appearing in presence of rulers, dressed in coarse clothing—the clothing of slaves. In ancient Mexico, whenever, to serve him, Montezuma's attendants "entered his apartments, they had first to take off their rich costumes and put on meaner garments . . . . and were only allowed to enter into his presence barefooted, with eyes cast down." So was it, too, in Peru: along with the rule that a subject, however great, should appear before the Ynca with a burden on his back, simulating servitude, and along with the rule that he should be barefooted, further simulating servitude, there went, as we have seen, the rule that "no lord, however great he might be, entered the presence of the Ynca in rich clothing, but in humble attire," again simulating servitude. The kindred though less extreme usage exists in Dahomey, where also autocracy is rigorous and subjection unqualified: the highest subjects, the king's ministers, may "ride on horseback, be carried in hammocks, wear silk, maintain a numerous retinue, with large umbrellas of their own order, flags, trumpets, and other musical instruments. But, on their entrance at the royal gate, all these insignia are laid aside." Even in mediæval Europe, submission to a conqueror or superior was expressed by this laying aside of such parts of the dress and appendages as were associated with dignity, and the consequent appearance in such relatively-impoverished state as consisted with servitude. Thus, in France, in 1467, the headmen of a conquered town, surrendering to a victorious duke, "brought to his camp with them three hundred of the best citizens in their shirts, bareheaded, and bare-legged, who presented the keies of the citie to him, and yielded themselves to his mercy." And the doing of feudal homage included observances of kindred meaning. Saint Simon, describing one of the latest instances, and naming among other ceremonies gone through the giving up of sword, gloves, and hat, says that this was done "to strip the vassal of his marks of dignity in presence of his lord." So that, whether it be the putting on of coarse clothing or the putting off of fine clothing and its appendages, the meaning is the same.

Acts of propitiation of this kind, like those of other kinds, extend themselves from the feared being who is visible to the feared being who is no longer visible—the ghost and the god. On remembering that among the Hebrews the putting on sackcloth and ashes went along with cutting off the hair, self-bleeding, and making marks on their bodies—all to pacify the ghost; on reading that the habit continues in the East, so that a mourning lady described by Mr. Salt was covered with sackcloth and sprinkled over with ashes, and so that Buckhardt "saw the female relations of a deceased chief running through all the principal streets, their bodies half naked, and the little clothing they had on being rags, while the head, face, and breast," were "almost entirely covered with ashes"—it becomes clear that the semi-nakedness, the torn garments, and the coarse garments, expressing submission to a living superior, serve also to express submission to one who, dying and becoming a ghost, has so acquired a power that is feared.[1] The inference that this is the meaning of the act is verified

[1] Tracing the natural genesis of ceremonies leads us to interpretations of what otherwise seem arbitrary differences of custom; as instance the use of white for mourning in China, and of black farther west. A mourning dress must have coarseness as its essential primitive character: this is implied by the foregoing argument; and for this there is direct as well as inferential evidence. By the Romans, mourning habits were made of a cheap and coarse stuff; and the like was the case with the mourning habits of the Greeks. Now, the sackcloth named in the Bible as used to signify mourning and humiliation was made of hair, which, among pastoral peoples, was the most available material for textile fabrics; and the hair used being ordinarily more or less dark in color, the darkness of color incidentally became the most conspicuous character of these coarse fabrics, as distinguished from fabrics made of other materials, lighter, and admitting of being dyed. Relative darkness coming thus to be distinctive of a mourning dress, the contrast was naturally intensified; and eventually the color became black. Contrariwise in China. Here, with a swarming agricultural population, not rear-

on observing that it becomes also an act of religious subordination; as is shown when Isaiah, himself setting the example, exhorts the rebellious Israelites to make their peace with Jahveh in the words—"Strip you, and make you bare, and gird sackcloth upon your loins;" and as, when the fourscore men who came from Shechem, Shiloh, and Samaria, to propitiate Jahveh, besides cutting their hair and gashing themselves, also tore their clothes. Nor does the parallelism fail with baring the feet. This, which we have seen is one of those unclothings signifying humiliation before a ruler, was one among the signs of mourning among the Hebrews; as is shown by the command in Ezekiel (xxiv. 17), "Forbear to cry, make no mourning for the dead, bind the tire of thine head upon thee, and put on thy shoes upon thy feet," and among the Hebrews putting off the shoes was also an act of worship. Elsewhere, too, it occurred as in common a mark of political subordination and of religious subordination. Of the Peruvians, who went barefoot into the presence of the Ynca, we read that "all took off their shoes, except the king, at two hundred paces before reaching the doors" (of the temple of the Sun); "but the king remained with his shoes on until he came to the doors." Once more the like holds with the uncovering of the head. Used along with other ceremonial acts to propitiate the living superior, it is used also to propitiate the spirit of the ordinary dead, and also the spirit of the extraordinary dead, which, becoming apotheosized, is permanently worshiped. We have the uncovering round the grave which continues even among ourselves; and we have, on the Continent, the uncovering by those who meet a funeral-procession. We have the taking off the hat to images of Christ and the Madonna, out-of-doors and in-doors, as enjoined in old books of manners; the unhatting on the knees when the host is carried by in Catholic countries; and the baring the head on entering places of worship everywhere.

Nor must we omit the fact that obeisances of this class, too, made first to supreme persons most feared and presently to less powerful persons, extend gradually until they become general. Quotations above given have shown incidentally that in Africa partial uncovering of the shoulder is used as a salute between equals, and that a kindred removal of the cloak in Spain serves a like purpose. So, too, the going barefoot into a king's presence, and into a temple, originates an ordinary civility: the Damaras take off their sandals before entering a stranger's house; a Japanese leaves his shoes at the door even when he enters a shop; "upon entering a Turkish house, it is the invariable rule to leave the outer slipper or galosh at the foot of the stairs." And then in Europe, from having been a ceremony of feudal homage and of religious worship,

ing animals to any considerable extent, textile fabrics of hair are relatively expensive; and of the textile fabrics made of silk and cotton, those of cotton must obviously be much the cheaper. Hence, for mourning dresses cotton sackcloth is used: and the unbleached cotton being of a dirty white, this has by association established itself as the mourning color.

uncovering the head has become an expression of respect due even to a laborer on entering his cottage.

These last facts suggest a needful addition to the argument. Something more must be said respecting the way in which all kinds of obeisances between equals have thus resulted by diffusion from obeisances which originally expressed surrender to a conqueror and submission to a ruler.

Proof has been given that rhythmical muscular movements, naturally signifying joy, such as jumping, clapping the hands, and even drumming the ribs with the elbows, become simulated signs of joy used to propitiate a king, when joined with attitudes expressing subjection. These simulated signs of joy become civilities where there is no difference of rank. According to Grant, "when a birth took place in the Toorkee camp . . . . women assembled to rejoice at the door of the mother, by clapping their hands, dancing, and shouting. Their dance consisted in jumping in the air, throwing out their legs in the most uncouth manner, and flapping their sides with their elbows." And then, where circumstances permit, such marks of consideration become mutual. Bosman tells us that on the Slave Coast, "when two persons of equal condition meet each other, they fall both down on their knees together, clap hands, and mutually salute, by wishing each other a good-day." And cases occur where, between friends, there is reciprocity of compliment even by prostration. Among the Mosquitos, says Bancroft, "one will throw himself at the feet of another, who helps him up, embraces him, and falls down in his turn to be assisted up and comforted with a pressure." Such extreme instances yield verifications, if there need any, of the conclusion that the mutual bows, and courtesies, and unhattings, among ourselves, are remnants of the original prostrations and strippings of the captive.

But I give these instances chiefly as introducing the interpretation of a still more familiar observance. Already I have named the fact that between polite Arabs the offer of an inferior to kiss a superior's hand is resisted by the superior if he is condescending, and that the conflict ends by the inferior kissing his own hand to the other; and here, from Niebuhr, is an account of a nearly-allied usage:

> "Two Arabs of the desert meeting, shake hands more than ten times. Each kisses his own hand, and still repeats the question, 'How art thou?' . . . . In Yemen, each does as if he wished the other's hand, and draws back his own to avoid receiving the same honor. At length, to end the contest, the eldest of the two suffers the other to kiss his fingers."

Have we not here, then, the origin of shaking hands? If of two persons each wishes to make an obeisance to the other by kissing his hand, and each refuses out of compliment to have his own hand kissed, what will happen? Just as when leaving a room, each of two persons, proposing to give the other precedence, will refuse to go first, and there will result at the doorway some conflict of movements, preventing either from advancing; so, if each of two tries to kiss the other's hand, and refuses to have his own kissed, there will result a raising of the hand of each by the other toward his own lips, and by the other a drawing of it down again, and so on alternately. Though at first such an action will be irregular, yet as fast as the usage spreads, and the failure of either to kiss the other's hand becomes a recognized issue, the motions may be expected to grow regular and rhythmical. Clearly the difference between the simple squeeze, to which this salute is now often abridged, and the old-fashioned hearty shake, exceeds the difference between the hearty shake and the movement that would result from the effort of each to kiss the hand of the other.

Even in the absence of this clew yielded by the Arab observance, we should be obliged to infer some such genesis. After all that has been shown, no one can suppose that hand-shaking was ever deliberately fixed upon as a salute; and if it had a natural origin in some act which, like the rest, expressed subjection, the act of kissing the hand must be assumed as alone capable of leading to it.

Whatever its kind, then, the obeisance has the same root with the trophy and the mutilation. At the mercy of his conqueror, who, cutting off part of his body as a memorial of victory, kills him, or else, taking some less important part, marks him as a subject person, the conquered enemy lies prone before him now on his back, or now with neck under his foot, smeared with dust or dirt, weaponless, and with torn clothes, or, it may be, stripped of the trophy-trimmed robe he prized. Thus, the prostration, the coating of dust, and the loss of covering, incidental on subjugation, become, like the mutilation, recognized proofs of it: whence result, first of all, the enforced signs of submission of slaves to masters, and subjects to rulers; then the voluntary assumptions of humble attitudes before superiors; and, finally, those complimentary movements expressive of inferiority, made by each to the other between equals.

That all obeisances originate in militancy is a conclusion harmonizing with the fact that they develop along with development of the militant type of society. Attitudes and motions signifying subjection do not characterize headless tribes and tribes having unsettled chieftainships, like the Fuegians, the Andamanese, the Australians, the Tasmanians, the Esquimaux; and accounts of etiquette among the wandering and almost unorganized communities of North America make little, if any, mention of actions expressing servitude or subordination. There are indeed, in India, certain simple societies politically unorganized and peaceful, in which there occur humble obeisances; as instance the Todas. At marriage, a Toda bride puts her head under the foot of the bridegroom. But, since exceptions of this kind, and less marked kinds, occur in settled cattle-keeping or agricultural tribes, whose ancestors passed through those stages between the wandering and the stationary, during which militant activities were general, we may reasonably suspect that these are surviving ceremonies that have lost their meanings: the more so as, in the case named, there exists neither that social subordination nor that domestic subordination which they express. On the other hand, in societies compounded and consolidated by militancy which have acquired the militant type of structure, we find political and social life conspicuously characterized by servile obeisances. If we ask in what slightly-developed societies occur the groveling prostrations and creepings and crawlings before superiors, the answer is clear. We find them in warlike, cannibal Feejee, where the power of rulers over subjects and their property is unlimited, and where, in some slave districts, the people regard themselves as brought up to be eaten; we find them in Uganda, where war is chronic, where the revenue is derived from plunder, both of neighboring tribes and of subjects, and where it is said of the king out shooting that, "as his highness could not get any game to shoot at, he shot down many people;" we find them in sanguinary Dahomey, where adjacent societies are attacked to get more heads for decorating the king's palace, and where everybody, up to the chief minister, is the king's slave. Among states more advanced they occur in Burmah and Siam, where the militant type, bequeathed from the past, has left a monarchical power equally without restraint; in Japan, where, with a despotism evolved and fixed during the wars of early times, there have ever gone these groveling obeisances of each rank to the rank above it; and in China, where, with a kindred form of government similarly derived, there still continue semi-prostrations and knockings of the head upon the ground before the supreme ruler. So is it again with kissing the feet as an obeisance. This was the usage in ancient Peru, where the entire nation was under a regimental organization and discipline. It prevails in Madagascar, where the militant structure and activity are decided. And among sundry Eastern peoples, living still, as they have ever done, under autocratic rule, this obeisance exists at present as it existed in the remote past. Nor is it otherwise with complete or partial removals of the dress. The extreme forms of this we saw occurred in Feejee and in Uganda; while the less extreme form of baring the body down to the waist was exemplified from Abyssinia and Tahiti, where the kingly power, though great, is less recklessly exercised. So, likewise, with the baring of the feet. This was an obeisance to the king in ancient Peru and ancient Mexico, as it is now in Burmah and in Persia—all of them having the despotic governments evolved by militancy. And the like relation will be found to hold with the other extreme obeisances: the putting dust on the head, the assumption of mean clothing, the taking up of a burden to carry, the binding of the hands.

The same truth is shown us on comparing the usages of European peoples in early ages, when war was the business of life, with the usages which obtain now that war has ceased to be the business of life. In feudal days homage was shown by kissing the feet, by going on the knees, by joining the hands, by laying aside sundry parts of the dress; but in our days the more humble of these obeisances have, some quite and others almost, disappeared: leaving only the bow, the courtesy, and the raising of the hat, as their representatives. Moreover, it is observable that, between the more militant nations of Europe and the less militant, kindred differences are traceable: on the Continent obeisances are fuller, and more studiously attended to, than they are here. Even from within our own society evidence is forthcoming; for by the upper classes, forming that regulative part of the social structure which here, as everywhere, has been developed by militancy, there is not only at court, but in private intercourse, greater attention paid to these forms than by the classes forming the industrial structures, among the members of which little more than the bow and the nod are now to be seen. And I may add the significant fact that, in the distinctively militant parts of our society—the army and navy—not only is there a more regular and peremptory performance of prescribed obeisances than in any other of its parts, but, further, that in one of them, the navy, specially characterized by the absolutism of its chief officers, there survives a usage analogous to usages in barbarous societies: in Burmah, it is requisite to make "prostrations in advancing to the palace;" the Dahomans prostrate themselves in front of the palace-gate; in Feejee, stooping is enjoined as "a mark of respect to a chief or his premises, or a chief's settlement;" and, on going on board an English man-of-war, it is the custom to take off the hat to the quarter-deck.

Nor are we without evidence of kindred contrasts among the obeisances made to the supernatural being, whether spirit or deity. The wearing sackcloth to propitiate the ghost, as now in China, and as of old among the Hebrews, the partial baring of the body and putting dust on the head, still occuring in the East as funeral-rites, are not found in advanced societies having types of structure more profoundly modified by industrialism. Among ourselves, most characterized by the degree of this change, obeisances to the dead have wholly disappeared, save in the uncovering at the grave. Similarly with the obeisances used in worship. The baring of the feet when approaching a temple, as in ancient Peru, and the taking off the shoes on entering it, as in the East, are acts finding no parallels here on any occasion, or on the Continent, save on occasion of penance. Neither the prostrations and repeated knockings of the head upon the ground by the Chinese worshiper, nor the kindred attitude of the Mohammedan at prayers, occurs where freer forms of social institutions, proper to the industrial type, have much qualified the militant type. Even going on the knees as a form of religious homage has, among ourselves, fallen greatly into disuse; and the most unmilitant of our sects, the Quakers, make no religious obeisances whatever.

The connections thus traced, parallel to connections already traced, are at once seen to be natural on remembering that militant activities, intrinsically coercive, neccessitate command and obedience, and that therefore, where they predominate, signs of submission are insisted upon; while, conversely, industrial activities, whether exemplified in the relations of employer and employed or of buyer and seller, being carried on under agreement, are intrinsically non-coercive, and therefore, where they predominate, only fulfillment of contract is insisted upon: whence results decreasing use of the signs of submission.

WATER-WAVES AND SOUND-WAVES.[1]

BY J. NORMAN LOCKYER, F. R. S.

LET us find a piece of tranquil water and drop a stone into it. What happens?—a most beautiful thing, full of the most precious teachings. The place where the stone fell in is immediately surrounded by what we all recognize as a wave of water traveling outward, and

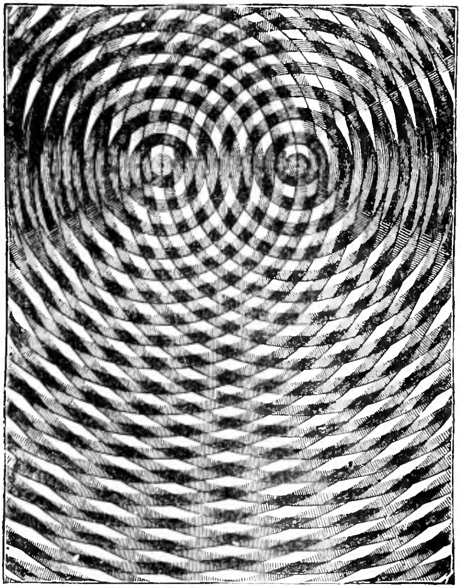


FIG. 1.—SUPERPOSITION OF TWO WAVE-SYSTEMS.

then another is generated, and then another, until at length an exquisite series of concentric waves is seen, all apparently traveling outward

[1] From advance sheets of "Studies in Spectrum Analysis" ("International Scientific Series," No. XXIII.).

—not with uncertain speed, but so regularly that all the waves all round are all parts of circles and of concentric circles.

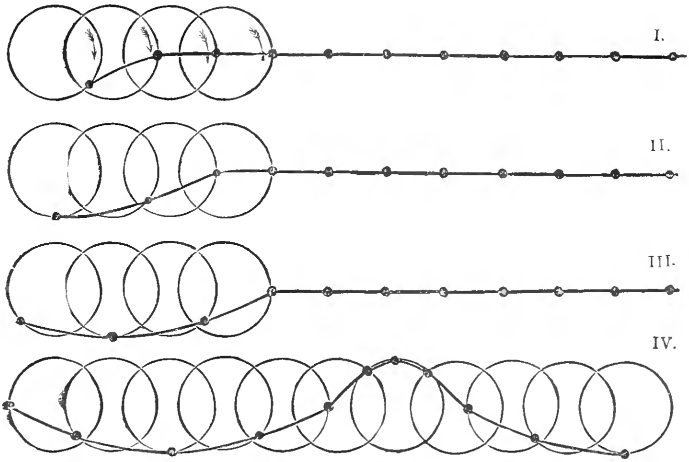


FIG. 2.—SHOWING THE FORMATION OF WAVES BY THE CIRCULAR MOTION OF EACH PARTICLE OF WATER IN A VERTICAL PLANE. Eight positions in each revolution are shown.—I. One Particle in Motion.—II. Two Particles in Motion.—III. Three Particles in Motion.—IV. Complete Wave and Motion of its Elements.

Let us drop two stones in at some little distance apart. What happens then? We have two similar systems each working its way outward, to all appearance independently of the other. We get what is represented in Fig. 1.

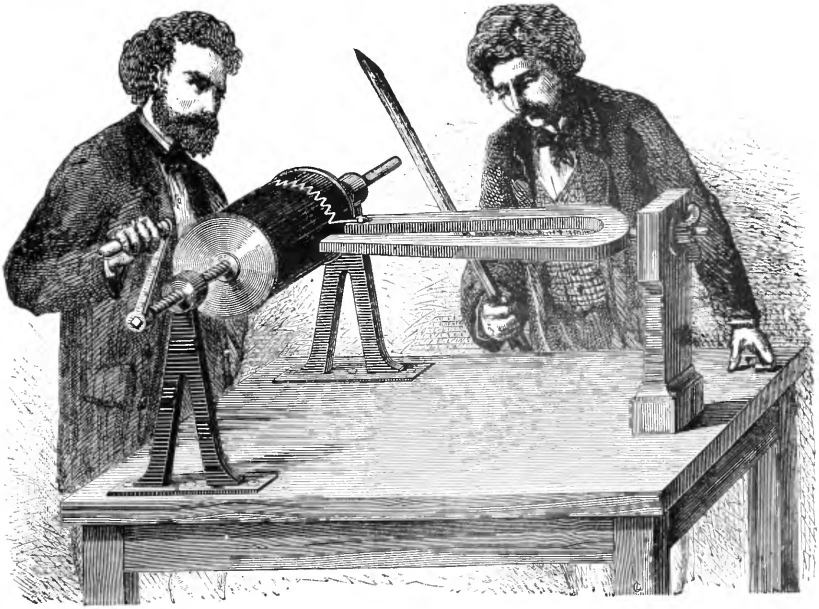


FIG. 3.—GRAPHICAL METHOD OF OBSERVING THE MODE OF VIBRATION OF A TUNING-FORK.

Now, these appearances are as if there were an actual outpouring of water from the cavity made by the stone; but if we strew small pieces of paper or other light material on the water-surface before we drop the stone, we find that it is not the water which moves outward, but only the state of things—the wave. Each particle of water moves in a circular or elliptic path in a vertical plane lying along the direction of the wave, and so comes again to its original place. Hence it is that only the *phase* goes on—*how* it goes on will easily be gathered from Fig. 2.

Let us now pass to a disturbance of another kind, from two dimensions to three, from the surface of water to air.

We hear the report of a gun or the screech of a railway-whistle, or any other noise which strikes the ear. How comes it that the ear is struck? Certainly no one will imagine that the sound comes from the cannon or from the railway-whistle like a mighty rush of air. If it came like a wind we should feel it as a wind, but as a matter of fact

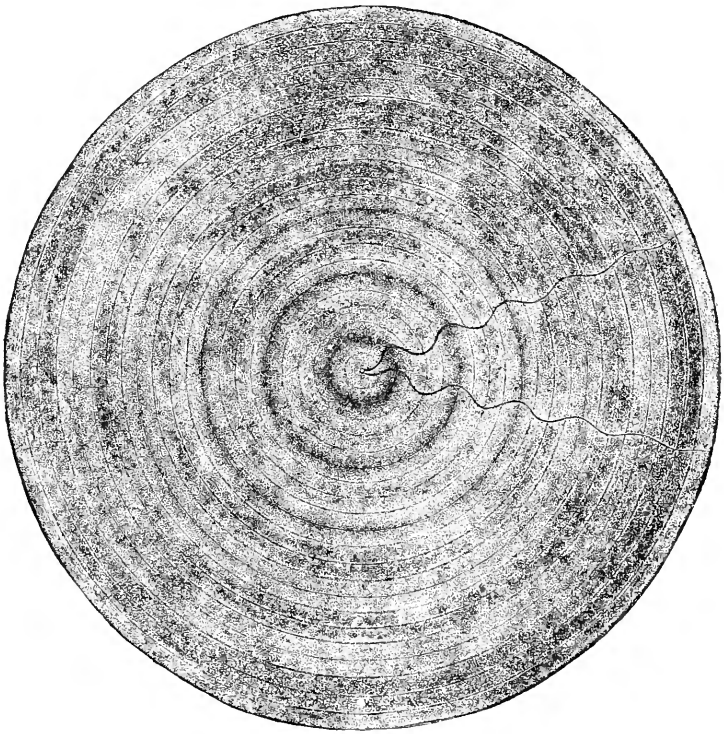


Fig. 4.—Shells of Compressed and Rarefied Air produced by a Source of Sound.

no rush of this kind is felt. It is clear, therefore, that we do not get a bodily transmission, so to speak, as we get it in the case of the ball thrown from one boy to the other. We have a *state of things* passing from the sender of the sound to the receiver; the medium through which the sound passes being the air. A sounding body in the middle of a room, for instance, must send out shells of sound as it were, in all directions, because people above, below, and all round it, would hear the sound. Replace the stone by a tuning-fork. To one prong of this fasten a mirror, and on this mirror throw a powerful beam of light. When this tuning-fork is bowed, and a sound is heard, the light thrown by the attached mirror shows the fork to be vibrating, and when the tuning-fork is moved we get an appearance on the screen which reminds us of the rope; or we may use the fork as shown in Fig. 3, and obtain a wavy record on a blackened cylinder.

Experiment shows that we have at one time a sphere of compression—that is to say, the air is packed closely together; and, again, a sphere

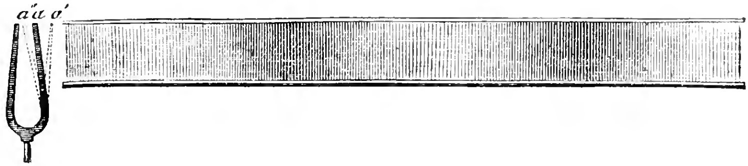


FIG. 5.—PROPAGATION OF SOUND-WAVES ALONG A CYLINDER.

of rarefaction, when the particles of air are torn farther apart than they are in the other position. The *state of things*, then, that travels in the case of sound, is a state of compression and rarefaction of the air. Hence, the particle of air travels differently from the particle of water; it moves backward and forward in a straight line in the direction in which the sound is propagated.

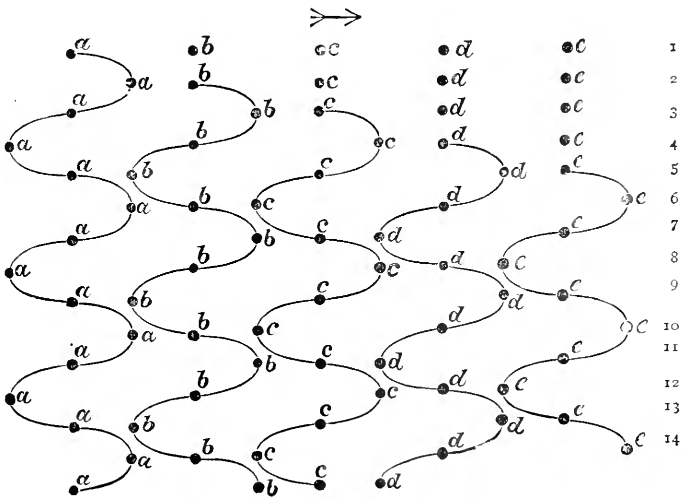


FIG. 6.—SOUND-WAVES. Particles of air, *a*, *b*, *c*, *d*, *e*, are in position 1 at rest. The remaining positions show how they are situated at successive instants, when a continuous series of impulses reaches them from the left. In position 2, e. g., only one particle has begun its oscillation; in position 3, only two; while, in position 6, all are in motion.

The preceding figure (Fig. 6) will show how this backward-and-forward movement results in the compressions and rarefactions to which reference has been made, in consequence of the impulse having been imparted to one molecule after the other. Owing to the pendulum-like motion of the molecules, their relative positions vary at each instant of time.

Prof. Weinhold has given, in his "Experimental Physics," a good method of obtaining on a plane a mental image of what goes on in a so-called sound-wave, and by the courtesy of Messrs. Longmans I am enabled to give here the illustrations which he employs. After all the particles have been put into motion as shown in Fig. 6, if we graphically represent the backward-and-forward oscillation of a particle by such a wavy line as in Fig. 7, we shall, when we put a large number of such waves side by side, introducing the change of phase, have such an arrangement of wavy lines as is represented in Fig. 8.

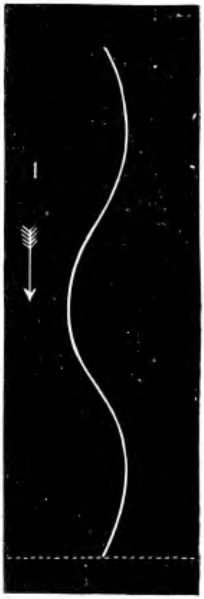


Fig. 7.

Now, the beauty of Weinhold's illustration consists in this: he almost makes each element of each line—each element representing, of course, a particle of air—appear to be actually in motion by treating the above figures in the following way: He cuts a narrow slit, *SS*, in a piece of stiff paper, either black or of a dark color, as shown in Fig. 9. He then holds this on the dotted line at the bottom of Fig. 7. "The book is now slowly drawn along in the direction of the arrow, the piece of paper being held in the same position. At first the lower extremity of the curved line in *A* is seen through the slit; but, as the book is drawn along, the portions to the right and those to the left come successively in view; the small white dot, which is the only visible portion of the curved line, appears as a point which moves first to the right and then to the left, and imitates closely the motion of a vibrating particle of air, the rate of motion being, however, much slower. If, now, the slit be placed over the dotted line" (at the bottom of Fig. 8), "and the book drawn along underneath it in the direction of the arrow, a representation is obtained of the motion of a series of particles of air which are acted on by a number of successive equal undulations or waves. Each particle merely moves a little right and left, and always comes back again to its starting-point; but the condensations and rarefactions, represented by the lines being respectively closer together or farther apart, are gradually transmitted through the whole series of air-particles from one end to the other."[1]

In dwelling upon sound-phenomena, we have the advantage of deal-

[1] "Experimental Physics," p. 332.

ing with phenomena about which Science says she does know something: from a consideration of these known facts we shall be able, slowly but surely, to grasp some of the much less familiar phenomena with which spectrum analysis is especially concerned.

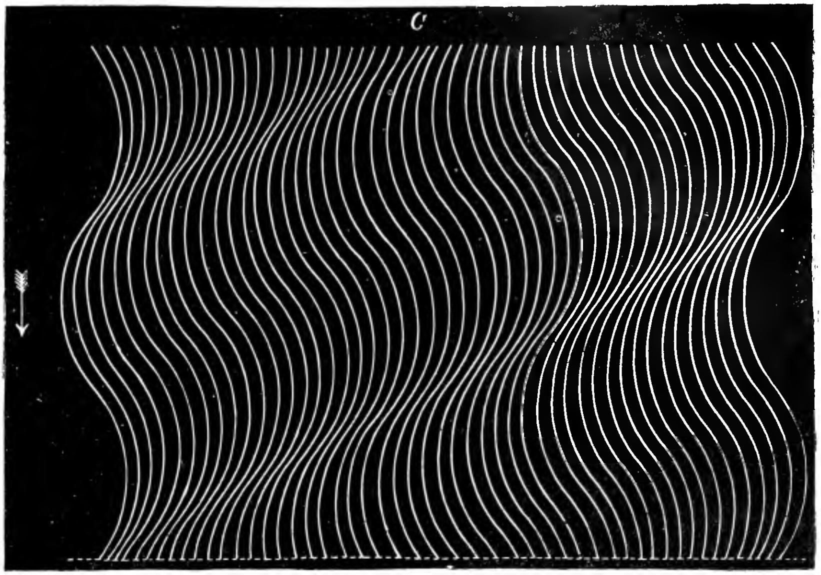


FIG. 8.

We all know that some sounds are what is termed high and others low, a difference which in scientific language is expressed by saying that sounds have a difference in pitch. We know that the difference between a sound which is pitched high and a sound which is pitched low is simply this—that the pulses or waves, as we may call them for simplicity's sake, which go from the sender-forth of the sound (which may be a cannon, a piano, or anything else) to the receiver, which is generally the human ear, are of different lengths. What in physics is called a sound-wave is constructed as follows: We have a line *A X*, which represents the normal condition of the air through which the sound is traveling, and curves which represent to the eye—first, the relative amounts of compression (+) and rarefaction (−) brought about by the sound in the case of each pulse, and secondly the relationship of this to the actual length of the wave, or, what is the same thing, the time taken for the pulse to travel. Thus we may have long waves and short waves independently of the amount of compression or rarefaction, and much or little compression or rarefaction independently of the length of the wave. We know that the difference between a high note and a low note, whether of the voice or of a musical instrument, is, that the high note we can prove to be produced by a succession of *short* waves—such pulses as have been described—and the low note by a succession of long waves.

Now, the loudness or softness of a note does not alter its pitch, that is, it does not alter the length of its waves or the rate at which they travel. I can send a wave along the rope either violently or gently,

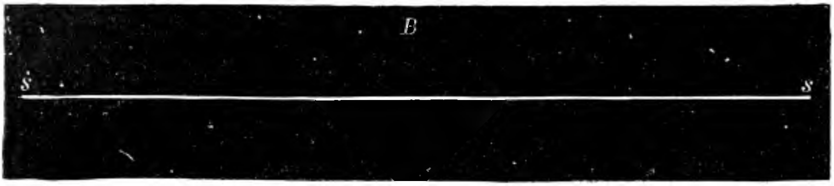


Fig. 9.

but with the same tension of the rope we shall find that the length of the waves is the same, provided the period of vibration is the same. Hence, then, the other idea added to the idea of pitch.

There is another point which is worth noting, although it is not needful to refer to it in any great detail, and that is, that we know that sound travels with a certain velocity, and that this rate is subject to certain small variations owing to different causes.

We not only have to deal with amplitude—that is, the departure of the + and − parts of the curve from the line *AX*—and velocity, but we have this most important and very beautiful fact (for fact it is),

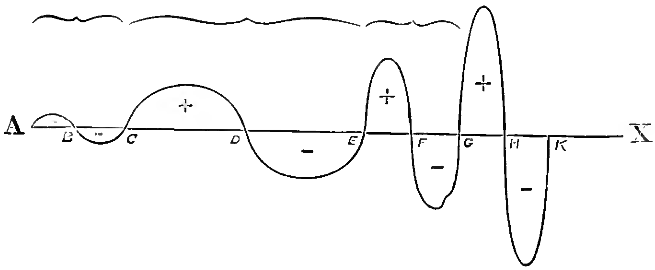


Fig. 10.—Sound-Waves of Different Lengths and Amplitudes.

which some will have observed for themselves: If a person in a room in which there is a piano sings a note, the string of a piano tuned to that particular note will respond; and, if he sing another note, then another string will reply, the first string being silent. And if the experimenter were skilled enough to sing one by one all the notes to which the strings of the piano are tuned, all the strings would be set into vibration one by one, note for note. This fact may be explained in this way: a piano-wire, or similar sonorous body, which is constructed to do a certain thing—in this case to sound a particular note—always sounds that note when it is called upon *in a proper way* to do it. Now this is the point: The proper way may be either (1) that a particular vibration should fall upon it, or (2) that it should be set to work to generate that vibration in itself. If the piano-wire only gives the same sound when struck either hard or soft, it is because it is manufactured to do one particular kind of work, and it can do no other.

Now we may pass from a piano-wire to a tuning-fork. We find that, by using different quantities or different shapes of metal, these instruments give out different notes. If all be of the same metal, the different quantities of metal will give us a difference in the pitch. This demonstrates that the pitch of a note is independent of any particular quality of the substance set into vibration. Now, although a great many musical instruments can sound the same note, yet the music, the *tone*, which one gets out of them is very different. That is, the pitch being the same, the quality of the note changes because the wave, or rather the system of waves, which we obtain is different. For instance, if we sound a note upon the violin, or the French horn, or the flute, or the clarionet, anybody who knows anything of music will tell which is in question, so that here we have in addition to wave-length and wave-amplitude another attribute, namely, that which in French is called "timbre," in German "Klangfarbe," and in English, "tone" or "quality."

THE SCIENTIFIC STUDY OF HUMAN TESTIMONY.

By GEORGE M. BEARD, M. D.

II.

LIMITATIONS OF THE SENSES.—The senses, which have hitherto been regarded as infallible, are even more narrowly defined than the memory or the higher qualities of intellect. So narrow is the range of vision—and the sight is certainly the best of the five senses—that the retina can appreciate a few only of the rays that come from the sun. The vibrations of ether beyond the red at one end of the spectrum, and the violet at the other are of no value in vision, ethereal undulations higher than seven hundred and ninety trillions a second, or lower than four hundred trillions a second, being powerless to affect it.

Equally striking is the limitation of vision as regards distance and magnitude. Only under the most favorable conditions are heavenly bodies of the sixth and seventh magnitude visible to the naked eye. The extreme limit for small objects, according to the experiments of authorities, is represented by a disk $\frac{1}{500}$ of an inch in breadth. The aid afforded to the sight by the telescope and microscope is important, and, in scientific research, indispensable; but, as compared with the infinitely great and the infinitely little in Nature, it is trifling.

The senses, indeed, are not formed to enable man to solve the problems of Nature, but, as with the lower animals, merely to make existence possible, and, in a limited and incidental way, agreeable. And yet it is through these feeble senses that all human knowledge enters the brain, since all deductive reasoning must be based on previous inductive observation. More humiliating still, and more instructive in its relations to human testimony, is the lack of precision and power of appreciating details at long distances through the eye. At the interval of half a mile we are unable to recognize the countenance of our dearest friend; while ordinary type, in order to be read, must be held within a few inches of the face.

A recognition of the limitations of the sight—the king of the senses—makes the recognition of the limitation of the inferior faculties of hearing, smelling, tasting, and touching, easy and inevitable. Vibrations of the air below 32 per second, or above 100,000 per second, at the extreme, make no impression on the human ear; and, as experiments in the presence of audiences have proved, sensitive flames may react to atmospheric vibrations in perfect silence. Ordinary conversation is audible only within a few feet, while powerful-voiced orators in their mightiest efforts reach but a few thousands of people. The sense of smell is so restricted in its capacity that it fails to detect many of the most deadly poisons and causes of epidemics, and is of such slight practical service to man that patients who, through disease, have lost it entirely, sometimes say that they would not care to have it restored.

The sense of touch, of which all the other senses are supposed to be modifications, being of necessity limited to actual contact, is of no value in the study of anything at a distance.

It is clear, therefore, that the senses open but a few rooms in the infinite palace of Nature, and of these few they give us but feeble and imperfect glimpses. Throwing all questions of supernaturalism aside, it must be allowed that the senses bring us into direct relation with only an infinitesimal fraction of the natural; we are practically shut out of a knowledge of Nature, of which we are a part; hence the narrow limitations of human knowledge, all of which must be inductively based on what the senses are able to teach us, although the superstructure may by deduction be raised very high. The elementary and all-important facts in Nature are precisely those of which the senses, singly or combined, give us little information, or none whatever. The great forces—light, heat, electricity, gravity—can be studied in their effects only, not in themselves—in what they do rather than in what they are; hence it is that the great and central advances in science—the Copernican theory, the theory of gravitation, the wave-theory of light—are along the line of deductive, not inductive, investigation. If we depended on induction, we should know nothing of Nature, but would be blind babes wandering in a pathless forest. The first step in the evolution of any great science has ever been and must ever be the cutting loose from the rule of the senses, the making them servants instead of kings ; the base-line the eye may trace out, but reason must construct the triangle ; the arc and chord may be measured by the hand, but only calculation gives us the limits of the circle.

The deceptions of the senses are wellnigh as marked as their limitations ; indeed, are a part of their limitations. Reid, the metaphysician, argues elaborately that the so-called deceptions of the senses are rather mistakes of judgment in regard to the impressions made on the nerves of special sense. Such argument is needless, since all the convictions that we acquire through the senses—the truths as well as errors—are the products of judgment. It is not the eye, but the brain behind the eye, that sees. The impressions made on the retina do not of themselves carry thoughts to the mind, any more than the impression on the photographer's plate carries thought to the instrument behind it. The eye is an instrument through which the brain sees—the telescope and microscope of the mind. Of itself the eye is as incompetent to see as is the telescope to discover a new planet, or the microscope to detect a humble organism.

"The eye sees what it brings the means of seeing;" it is the astronomer and microscopist that discover ; it is the brain that sees through the doors opened by the eye. Conceptions and misconceptions, obtained through the sense of vision, are alike products of the brain rather than of the seeing apparatus. In scientific strictness our senses neither teach nor deceive us.

Although the eye is, as has been said, the best of the senses, it is yet, in some respects, the worst, as more untruths or half-truths enter the brain through this sense than through all the other senses combined ; the very efficiency and value of the vision, its clearness and comprehensiveness, its apparent certainty and grasp of detail, cause us to repose in it with greater confidence, and to yield to its suggestions with fewer questionings. Forgetting the limitations of the optical apparatus, and assuming that its office is not to see but to provide the mechanism of seeing—quite overlooking the obvious facts that we never see the whole of objects but only their surfaces, usually but one or two sides at most; that it is practically impossible to fully fix the attention on two widely-separated objects simultaneously ; that form and color and size, which are learned through sight, may be of far less importance in determining the nature of objects than their other qualities—men erroneously judge that what is seen is necessarily the truth and the whole truth. When I look at any object, as a chair, I do not see it, cannot see it, however near it may be, and however good my eyesight or concentrated my attention ; I see only the bare surface of the portion that is turned toward me, which is but an infinitesimal fraction of the chair itself ; and though I turn it round and round, and look at every side, I can never see it, while only a portion of its surface even can ever be seen at one time. Such is part of the philosophy of the success of jugglery and all the forms of tricks of sleight-of-hand; audiences fancy themselves to be seeing what they do not see. Casting our eyes upward to the sun and moon and stars, these heavenly objects seem to move with measurable slowness across the concave surface of the blue arch of sky; and only through the deductive reasonings and calculations of a Copernicus, a Galileo, a Newton, are we brought to the conviction that the earth is the moving object, that the blue vault but marks in the air the limitations of our vision, and that the shining stars that appear as candles in the sky are gigantic worlds moving with enormous velocity millions of miles away. Sitting in a railway-train at a station, as the train next to us on one side begins to move, we seem ourselves to be in motion, and only by looking on the opposite side and steadily observing some point or object that by previous observation we know to be fixed, can we correct our delusion; but in practical life we are not always able to find a fixed point or object external to ourselves by which we can distinguish the subjective and objective in our retinal impressions. Thus, in all human experience, "truth and lies are faced alike; their port, taste, and proceedings, are the same; we look upon them with the same eyes."[1]

LIMITATIONS OF THE HUMAN BRAIN IN DISEASE.—But the most serious blunders of the sense of sight, or indeed of the other senses, and indeed of reasoning in general, come from confounding the subjective with the objective. In certain states of the system, which are not rare but very common, and which may be either temporary or permanent, the brain has the power not only of modifying the impressions made by external objects over the retina, but of originating impressions even when there are no external objects corresponding to those impressions, and the individuals may have no way of distinguishing subjective from objective visions, or find it very difficult to do so without outside aid.

[1] A critic of Prof. Tyndall, indignant that the philosopher would not accept the reigning delusions of the day, declared that, when called upon to investigate any object, he would look at it, listen to it, touch it, taste it, and smell it, and then not believe it. The critic was not aware that, instead of censuring Prof. Tyndall, he was really giving one of the highest compliments that can be given to a scientific man.

This over-estimate of the capacity of the human brain and senses, united with the present chaotic state of the principles of evidence, affects injuriously not philosophy alone but practical life as well. In medicine, for example, it has for ages been the fashion to ignore or deride symptoms of a purely subjective nature, that have no corresponding lesions or morbid appearances that the aided or unaided senses can discover, and for the study of which it is necessary to depend on deductive reasoning and the statements of patients. This is in general the explanation of the fact that many of the most frequent and distressing diseases, such as nervous exhaustion, hypochondriasis, hysteria, hay-fever, and allied nervous affections, although of the highest scientific and practical interest, have, until quite recently, been almost entirely neglected, and the agonizing symptoms connected with them are dismissed as trifling if not imaginary. A broken leg every one can see, and touch, and handle; but an exhausted brain, oftentimes a far more serious matter, is passed by, and even its existence is doubted merely for this, that it is out of reach of the eye and the microscope.

Not only is it possible for a single individual to be deceived by mistaking subjective for objective impressions, but, as I have proved by repeated experiments, the details of which have already been published, it is possible and easy to cause a large number of individuals, of intelligence and in good health, to see simultaneously the *same* subjective visions without any of them being able to detect the deception. Such experiences of the *simultaneous* confounding of the subjective with the objective are not exceptional to the degree that we might suppose; they are frequently occurring, and can be verified without difficulty by those who are trained to the art of experimenting with living human beings. All situations and experiences that excite the emotions of awe, of wonder, or reverence, or fear, or expectation, either singly or in combination, are liable to produce subjective visions that may appear at the same time and in the same form to large numbers of people, not one of whom shall be able, without external aid, to recognize the deception; and when these various emotions, powerfully aroused, do not thus cause impressions to be absolutely originated on the retina, they may, and often do, so modify the impressions made by objects to which the eyes and the attention are directed as to give rise to delusions that are both absolute and absurd, and out of which the subjects, though perfectly sane and sound, and, it may be, also scholarly, and accomplished, and scientific, can never be reasoned.

Delusions from this cause are in part, though not entirely, the origin of the myths, the legends, and the traditions, of what is called history, and are constant and oftentimes fatal elements of error in all historical criticism. The science of history will never attain the precision of which it is capable until the chaff of the subjective is winnowed from the wheat of the objective; until it is recognized as a physiological and pathological fact that the seeing of any object by any number of honest and intelligent people is no necessary evidence of the existence of that object; and, until it is understood that the claims of what is seen by individuals or by multitudes, all concurring in their testimony, are to be determined, if determined at all, only by reasoning deductively from the known circumstances under which the claims were made, and from general principles of science previously established.[1] Yet further, it must be under-

[1] Gibbon's "History of the Decline and Fall of the Roman Empire," for example, contains a vast number of statements and discussions which, scientifically, are of no value, and indeed by no manner of possibility could have any value. Details of expressions and actions, which, when obtained directly from the authors, must have been largely untrue, become, when filtered down the centuries through armies of non-experts, but the counterfeit of human experience—a satire on history. The historical writings of Prescott and of Irving are especially open to this criticism, and should be commended to the young with the suggestion, always, that they are to be considered as fiction; indeed, the best novels are better histories than much of professed history, since they do not attempt the impossible burden of carrying exact details, but merely aim to teach general facts, principles, and events, concerning which a certain degree of truth is sometimes attainable.

A volume of historical criticism is suggested by the following admission of Carlyle in stood that the claims of what individuals or multitudes concurrently see are, far more frequently than has been conceded, out of and beyond the reach of scientific investigation; the statements of what men experience furnishing oftentimes no basis for the study of those statements. These remarks are restricted to the evidences of the sense of sight; but with less force, proportioned to their feebler importance, they apply to evidences derived from other senses. Sounds and smells, taste and touch, can be subjectively created, even in a sane and healthy brain. Bring a watch near to the ear, so that its ticking is distinctly heard, then carry it slowly away; soon a point is reached where it is difficult to tell whether the sound heard is in the ear or in the watch: it is easy, indeed, for the most attentive listener to mistake the subjective for the objective, where any form of sound is expected, or feared, or waited for; the husband's footsteps are plainly heard by the anxious wife when they are miles away, and heard many times, it may be, before they come near; and between the deception and the reality there is no practical distinction.

Medical students, taking lessons in auscultation and percussion, on sounding the chest, often deceive themselves as well as their teachers, by hearing the sounds of their own ears perfectly counterfeiting the sounds they are hoping to hear. Not only whisperings and voices arise in the brain, but sustained conversations, with varied modulations, are consciously carried on between the cerebral cells, and are heard as though they proceeded from a distant room. These phenomena appear

his "French Revolution:" "Nevertheless, poor Weber saw, or even thought he saw (for scarcely the third part of poor Weber's experiences, in such hysterical days, will stand scrutiny), one of the brigands level his musket at her majesty." Are not all the exciting and critical experiences that make up our histories and biographies hysterical or rather entrancing days? On this topic—the untrustworthiness of which is called history—the following remarks of Saint-Beuve, in his criticism of Guizot, are most pertinent, and, so far forth, are in harmony with the philosophy here announced: "I am one of those who doubt, indeed, whether it is granted to man to comprehend with this amplitude, with this certainty, the causes and the sources of his own history in the past; he has so much to do to comprehend it, even imperfectly, at the present time, and to avoid being deceived about it at every hour!" St. Augustine has made this very ingenious comparison: "Suppose that a syllable in the poem of the 'Iliad' were endowed, for a moment, with a soul and with life: could that syllable, placed as it is, comprehend the meaning and general plan of the poem? At most, it could only comprehend the meaning of the verse in which it was placed, and the meaning of the three or four preceding verses. That syllable, animated for a moment, is man; and you have just told him that he has only to will it, in order to grasp the totality of the things which have occurred on this earth, the majority of which have vanished without leaving monuments or traces of themselves, and the rest of which have left only monuments that are so incomplete and so truncated."

When our youths are taught, as in the future not far away they must be, that the larger portion of historical and controversial literature is of no worth to those who seek for the truth in matters of history and controversy, the process of education will be much simplified; the area of what has hitherto passed for "sound learning" will be greatly restricted, to the relief of all who prefer realities to delusions, and who are oppressed, as every one must be, by the yearly-increasing burden that rests upon those who mingle in the society of scholars.

not only in insanity, but in far more frequent and less severe nervous disorders, as in trance, hysteria, and simple nervous exhaustion.

The Involuntary Life.—The unconscious and involuntary character of much of mental action is now so far allowed that it may be assumed as a basis for argument in discussions relating to the brain. Many psychologists and some physiologists agree in this, that many of our thoughts are practically unconscious, and all agree that mental action is largely involuntary. This truth, as applied to the higher phases of activity, has long been noted; in the words of Lynch, "when our views are most earnest, most solemn, and most beautiful, we are often conscious of being in a state rather than of making an effort." Says Goethe: "No productiveness of the highest kind, no remarkable discovery, no great thought which bears fruit, and has its results, is in the power of any one. All men, who closely watch their inner life, become conscious of these high truths, at least as that life develops. The sign of growth in the soul is, that it gradually loses confidence in its volitional reasonings about best and highest things, and reposes trust rather in what it feels to be given." We work best when we are not working. In the lower realms of activity, through various gradations, what we call volition has oftentimes but a subordinate influence; much is done automatically, and in spite of or against our wills. The noisy rabble of passions and emotions throw the captain overboard, and the mind either drifts or sails furiously and recklessly before the storm; the very attempt of the will to assert its power is the signal for mutiny: it is most influential when it lies low, and gently guides the helm.

The involuntary life—or that side of mental activity that is independent of volition—constitutes even in health the larger part of life, and in certain states of disease man becomes an absolute automaton. The very effort of attention is liable to destroy the scientific value of our observation of the object to which our attention is directed, since it subtracts and draws off the cerebral force from those faculties that are needed in careful and thorough attention; only when one has reached the stage where he can observe without severe, conscious effort, can he be said to be a good observer. An extreme illustration of automatism is the state of trance, a morbid condition of the brain in which, as I have elsewhere sought to prove, the activity is concentrated in some one faculty or group of faculties, the activity of other portions of the brain being for the time suspended. A person in this state may do the very things he especially wills not to do: what he wishes and tries to do he cannot; the will is no longer the master, but the servant. For a person in this state to attempt to observe, is as useless as for a steam-engine to attempt to reason; he is an automaton, a machine, a bundle of reflex actions, like a plant or polypus. He sees, hears, smells, tastes, and feels, whatever may be suggested to his emotions either by individual or by attendant circumstances, and these subjective sensations are to him genuine, objective realities. This state of trance is not infrequent, but is most common and constantly occurring; it is not confined to any one class or sex, but all human beings are subject to it; no degree of intelligence or of culture suffices to insure exemption; it comes often when it is least looked for, and its easiest victims are of all persons most unsuspicious and ignorant of its nature. Trance is entirely a subjective state, external causes acting as excitant only, and, of all the numberless exciting causes none are more influential in the average individual than the witnessing of strange or exceptional events; and as the testimony of those who are even partially entranced in regard to what they have seen, or heard, or experienced, or done, is of no value, and as under the excitement of the emotions produced by the real or supposed occurrences of unusual or marvelous events large numbers of witnesses are liable to be simultaneously and similarly entranced, therefore human testimony becomes practically of the least value in just those crises and situations where evidence both for the purposes of science and law is most needed. The influence of psychical contagion, or the excitation of emotions through involuntary imitation, one person carrying the excitement to another, and so on, through vast audiences, is of special import in relation to human testimony: excitement spreads through a multitude in arithmetical ratio, proportioned to the numbers; a crowd is a multiplier of force, and through the stimulus of sight and sound generates a storm of emotion; out of an insignificant cause each individual in his turn unconsciously adding to the original excitement, just as in the Holtz or Gramme electrical machines each new revolution adds to the force obtained by the first. A large audience may be agitated with laughter or melted into abundant tears by a story which, when told to an individual, causes perhaps but a feeble smile or mildly suffused eyes. Average testimony, therefore, in regard to unprecedented, or marvelous, or wondrous phenomena, as the manifestation of supposed new forces, or strange symptoms of disease, or the raising of the dead, or any unusual appearances in Nature, on the earth, in the air, in the sky—such as would be likely to excite the emotions of awe, of wonder, of reverence, or of fear, in the presence of large assemblages—can have no scientific value; a whole army may be entranced, and may see and hear what is dreaded or expected.

Under conditions that strongly excite the emotions, no force of numbers and no concurrence of testimony can give any value to testimony; a million ciphers are worth no more than a single cipher. The greater the number of eye-witnesses, the greater their liability to be deceived through the influence of mental contagion.[1]

But, aside from trance and allied states—which constitute the culmination of the involuntary life—the value of human testimony is im-

[1] For more detailed analyses of this subject, the reader is referred to my monograph on the "Scientific Basis of Delusions."

paired, as all lawyers learn by experience, through the emotions acting upon the reason, slowly, it may be, and unconsciously, so as to produce in time sincere but utterly untrue convictions in regard to facts of observation. The wish is so far the father to the thought that men, and especially women and children, reason themselves into an honest conviction that they have seen, or heard, or experienced, something directly opposite to that which they actually saw, or heard, or experienced, and this conviction becomes so organized in the brain that neither by their own efforts nor by the arguments of others can the deception ever be disclosed to them. How true this is of speculative beliefs all know; it is not so well known that it is true also of facts of observation and personal experience, thus vitiating most of human testimony. The wish secretly usurps the throne of the will, and, unknown to the subject, guides with a silent and resistless energy the course of thought in the brain. Every day our courts are forced to attend to the testimony of witnesses who are sure they are telling the truth in regard to what happened, although really they are telling what they wanted to happen. Even in science microscopists who are not yet full experts oftentimes see what they are looking for, and afterward believe they have seen what at the time they did not even profess to see. Herein is the psychology of gossip, which usually consists of a mountain of untruth, of fear, and hope, and jealousy, and anger, and love, and expectation, with a few grains of fact—the offerings of falsehood being oftentimes as honest as the offerings of truth.

NEED OF A RECONSTRUCTION OF THE PRINCIPLES OF EVIDENCE.—The acceptance of the above facts and reasonings involves the necessity of reconstruction of the principles of evidence, as thus far taught by all our highest authorities in that department. Disagreeing widely on other and far less important departments, all schools, and languages, and ages—writers on law, on logic, on science—agree in accepting what is called the evidence of the senses, although, as we have seen, the senses of themselves can give us no evidence of anything whatsoever; and in this, likewise, there is passive if not active agreement—that the first qualification of a witness is honesty, and that the concurrence of testimony of large numbers is a solid basis for belief. Sir William Hamilton, with no suspicion of the nature or phenomena of trance as here described, quotes with earnest approval the following statement of Esser:

"When the trustworthiness of a witness or witnesses is unimpeachable, the very circumstance that the object is one in itself unusual and marvelous adds greater weight to the testimony; for this very circumstance would itself induce men of veracity and intelligence to accord a more attentive scrutiny to the fact, and secure from them a more accurate report of their observation."

In this single sentence all the errors of the world in regard to human testimony seem to be condensed—the placing of honesty in the front rank of qualifications, the confounding of general intelligence with special intelligence, the inference that the senses are infallible, and the utter non-recognition of the limitations of the brain and its liability to disturbance in the presence of circumstances that excite the emotions.

Reid, after citing the custom of courts in assuming that the eyes and ears are to be trusted, inquires:

"Can any stronger proof be given that it is the universal judgment of mankind that the evidence of sense is a kind of evidence which we may securely rest upon in the most momentous concerns of mankind—that it is a kind of evidence against which we ought not to admit any reasoning, and therefore that to reason either for or against it is an insult to common-sense?"

More recently still, indeed most recently of all, the anonymous author of "Supernatural Religion," in speaking of the testimony of Paul relating to the resurrection, says that it is not of such a character as would be received in a court of justice, thereby implying that the evidence of courts is evidence of the highest kind, whereas from the scientific point of view it is oftentimes the worst kind of evidence—although practically it may be the best that is possible in the administration of law: the form of swearing, though it may make the dishonest transiently honest, and force truth from unwilling lips, can never compensate for the limitations of the human brain, or correct the errors that enter through the senses, or make an expert out of a non-expert.

Laplace enunciates the formula that the more improbable a statement in which witnesses agree, the greater the probability of its truth —a statement which, in view of our present knowledge of the brain, seems almost satirical; but Abercombie, although a physician, gives full assent to the proposition in these words, which could not have been written by any one who had even a general conception of the philosophy of trance:

"Thus we may have two men whom we know to be so addicted to lying that we would not attach the smallest credit to their single testimony on any subject. If we find these concurring in a statement respecting an event which was highly probable, or very likely to have occurred at the time which they mention, we may still have a suspicion that they are lying, and that they may have happened to concur in the same lie, even although there should be no suspicion of connivance. But, if the statement was in the highest degree improbable, such as that of a man rising from the dead, we may feel it to be impossible that they could accidentally have agreed in such a statement; and, if we are satisfied that there could be no connivance, we may receive a conviction from its very improbability that it may be true."

Again, Abercrombie remarks:

"Whatever probability there is that the eyes of one man may be deceived in any one instance, the probability is as nothing that both his sight and touch should be deceived at once; or that the senses of ten men should be deceived in the same manner, at the same time; . . . if we find numerous witnesses agreeing in the same testimony, all equally informed of the facts, all showing the same characters of credibility, and without the possibility of concert or connivance, the evidence becomes not convincing only, but incontrovertible."

Such are the principles of evidence that are taught in our colleges and schools. It is no marvel that most of human philosophy is one vast *petitio principii.* Men reason that if a large number of witnesses agree in their testimony, if there is no possibility of deception (thus begging the very question of questions), then such and such inferences must follow. On this treacherous quicksand of uncertainty and positive untruth—average human testimony—the world has built, and continues to build, its lofty temples of philosophy, of faith, of history, and of general literature ; no wonder that they so quickly crumble and fall, and that the pathway of humanity is marked by their ruins ! Even Germany, which in philosophy and science does the original thinking for all nations, has not yet attempted to reduce human testimony to a science ; and nowhere is the need for such study more frequently and seriously impressed than in recent German controversial literature.

In many experiments with large numbers of human beings in one room, and operated on simultaneously by some performance that powerfully excites the emotions of wonder, of awe, of reverence, and of expectation, I have proved that a subjective state can be induced in many, if not the majority or all of them, wherein they concurrently see and experience what has no existence; and, after the performance is over, they frequently and permanently persist in their delusions, although they are opposed to the general experience of mankind and all the deductions of science. Why, indeed, should they not do so? They are taught to believe their eyes ; they have seen with their eyes such and such phenomena ; they are logically compelled to accept the testimony of their senses, even though they do not wish it to be true. I have made these experiments, not only with the aid of profoundly imposing pretensions, as of raising ghosts and the like, but with quite simple methods and appliances, such as professing to magnetize the room by the battery, or to throw a pretended magnetic fluid on the body, or to rub away pain or disease. Not only are the symptoms of disease frequently and simultaneously relieved in a number of persons in these experiments, but trance, with many of its physical and psychical symptoms, such as convulsive movements, sighing respiration, quickened pulse, with hallucinations of sight, of hearing, and other senses. These results, which are of the highest scientific and practical interest, and in various directions, are in the power of any cerebro-physiologist to obtain who has sufficient experience in making experiments with living human beings. A powerful and imposing *physique*, positiveness and impressiveness of manner, and a reputation as a performer with those on whom they experiment, are aids to these experiments, but are not essential to them.

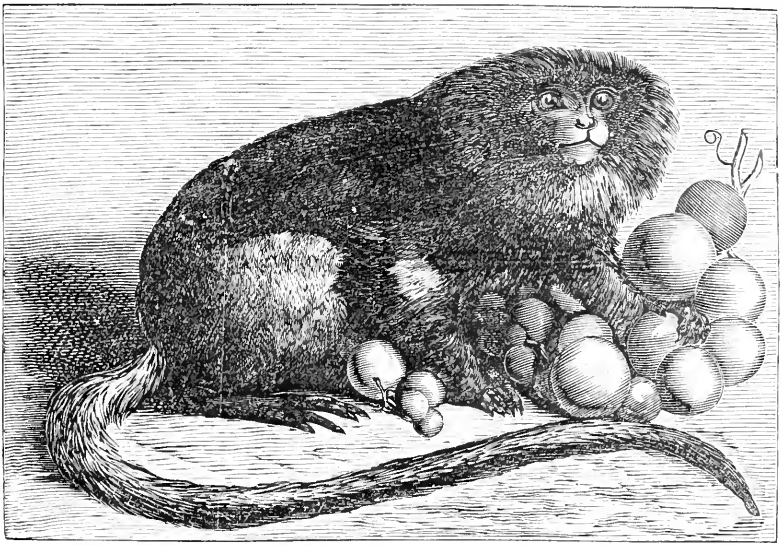
THE PYGMY MONKEY.[1]

By E. OUSTALET.

THERE was lately presented to the London Zoölogical Society, by an engineer attached to the navigation service of the Upper Amazon, a monkey, which may be regarded as one of the smallest representatives of the order *Quadrumana.* The animal is not so big as a squirrel, its body measuring only fifteen centimetres, with a tail of about the same length. The tribe to which it belongs, that of the Hapalians, stands at the foot of the monkey series, at the head of which are the anthropoid apes. While the latter are remarkable for a stature nearly equal to that of the human species, a robust body without caudal appendage, and a voluminous brain with numerous convolutions, the Hapalians, on the other hand, in size do not surpass some of our Rodents. The body is rather slender, but covered with a heavy coat of hair, and terminated by a long tail; the brain is almost perfectly smooth. Like the Cebians, with which they constitute the Platyrrhine family, they have neither callosities nor cheek-pouches, but they differ from the other monkeys of the New World in the claw-like nails of all the fingers except the thumbs of the posterior members, and in the teeth, which number only thirty-two, the great molars being reduced to two on each side of each jaw. To these characters correspond notable differences in the habits and modes of life. Thus certain naturalists have supposed that the Hapalians (which they designate by the not very appropriate name of *Arctopitheci*—"bear-monkeys") must be regarded as an independent family, of the same rank as the families of the Platyrrhines and the Catarrhines. Even though we do not adopt this opinion, we are forced to admit that the Hapalians offer certain affinities with the Rodents, if not in the skeleton and the dental formula, at least in the gait. Like our squirrels, they are essentially arboreal, and run up and down the trunks of trees with great agility, burying their claws deep into the bark. Like the squirrels, too, they are lively and alert during the day, and spend the nights concealed in holes; like them, they shelter themselves against cold by gathering around them their bushy tails; like them, finally, they are exceedingly timid and wary, fleeing at the least noise, and seeking refuge in the foliage. But here the resemblance ends: for, while the Rodents, with their strong incisors and molars, easily cut and bruise the hardest grains and fruits, the Hapalians, whose jaws are of a different conformation, live on birds'-eggs, insects, fruits, and buds. As regards intelligence, the Hapalians appear to be far inferior to other monkeys, and in them the sense of touch in particular is poorly developed, the anterior members terminating in true

[1] Translated from the French by J. Fitzgerald, A. M.

feet, the digits of which are armed with claws, and the posterior members presenting only imperfect *hands*. The head is roundish ; the flat face is animated with small but very bright eyes; the ears are often adorned with tufts of hair, which give an odd character to the physiognomy. Finally, the body is covered with a thick coat of soft, silken hair, often with regularly-arranged bands in the back and tail.[1] By



THE PYGMY MONKEY.

their aspect, and the coloration of their fur, by their size, by their mode of life, as also by the details of their organization, the Hapalians constitute a very natural family. Still, they may be divided into two genera, the Uistitis (*Hapale* or *Jacchus*), with long, tufted tail, with no fringe of hair around the face, but with tufts of hair on the ears; and the Tamarins (*Midas*), whose head is adorned with a fringe, but whose ears are more or less denuded. We will set this latter group completely aside, and consider only the Uistitis.

The species of the genus *Jacchus*, all, without exception, are found in tropical America, between the Isthmus of Panama and latitude 30° south, but chiefly, if not exclusively, in the region lying to the east of the Andes, some of them inhabiting the virgin forests, others the thickets scattered over the plains. The best-known species is the common Uistiti (*Hapale* or *Jacchus vulgaris*), with gray-russet pelt, with alternate red and blackish streaks, and with from fifteen to eighteen rings on the tail, a white triangular spot on the forehead, and long white hairs on the sides of the head. It is a native of Guiana and Brazil, and

[1] The name Hapalians, given to these monkeys by Illiger, is derived from the Greek ἁπαλός, which means *soft*.

was long ago described by Buffon, Illiger, and Geoffroy St.-Hilaire. It is of very small size, but a little larger than the pygmy monkey, recently acquired by the Zoölogical Society; its body measures from twenty to twenty-three centimetres, and the tail about fifty-five centimetres.

The common Uistiti is, no doubt, familiar to our readers, for it is often imported into Europe. It has even reproduced in captivity, and many naturalists, as Cuvier, Pallas, and Audouin, have made some very interesting observations on it. The young ones, which are born with the eyes open, have a very large head, a dark-gray skin of pretty uniform color, excepting the tail, which plainly shows the rings. Immediately after birth they cling to their dam, who, however, does not seem to have any great affection for them, and turns them over to the male as soon as she feels tired; he in turn gives them back to his consort when they try to suck. The adult animals, though they are by nature timid, become attached to those persons who care for them, and, though they do not exhibit much intelligence, they nevertheless appear to be able to associate ideas. Thus, one of the two Uistitis, which Audouin kept for a long time, acquired the habit of shutting the eyes whenever he ate grapes, and this because he had once squirted the juice of grapes into the animal's eyes. At the sight of a wasp this animal, as also its companion, was seized with sudden terror, and took refuge in the bottom of its cage, covering its head with its hands, though this was the first time it ever had seen that insect, and though it daily pursued flies with great address. Audouin, who had observed this occurrence, conceived the idea of offering to his two Uistitis not a live wasp, but a colored picture of one; to his great surprise, the monkeys fully recognized their enemy, and manifested much alarm. Now, we know that most of our domestic animals, and even certain highly-organized monkeys, while they manifest pleasure or rage at beholding their own images in a mirror, are nevertheless perfectly indifferent in the presence of the portrait, however life-like, of an animal of a different species.

Pallas tells us that some Uistitis have endured perfectly well the winter cold of St. Petersburg, while, on the other hand, they were greatly incommoded by the heat of the summer. But this must be an exception, for, as a rule, in our menageries these little monkeys, despite all the care bestowed on them, have great difficulty in living through the winter season. They are fed mainly either on eggs, which they empty with much dexterity, or on fruit; the latter must be soft and sweet, for the Uistiti rejects almonds no less than acid fruits. Flesh-meat has no attraction for them; and, when they seize with their hands a living bird, they first choke it to death and then tear open the cranium to get at the brain. Their cries are various: they express alarm by a sort of bark, anger by a short hiss, joy by a low cry, or by a rather pleasant purring. On the slightest opposition, they bristle the hair of their head and grit their teeth, and endeavor to bite the hand that would seize them. Nevertheless, it is but just to say that these inequalities of temper are seen rather in individuals captured at an advanced period of life than in those taken young. To capture these, the Indians wound or kill the mother, and then, without difficulty, seize the young ones, which she carries on her back.

Very nearly allied to the common Uistiti is the *Hapale aurita*, or eared Uistiti, with fur of russet black, streaked on the back with faint black bands; also the cowled Uistiti (*Hapale humeralifer*), with white face, surrounded with brownish hair, blackish body, a collar of snowy white on the scapular region, and tail bearing incomplete rings. These two species are, like *Hapale vulgaris*, natives of Brazil, and, like that animal, they are noticeable for the tufts of white hair which grow on the anterior surface of the ears. In other Uistitis, on the contrary (as the *Hapale penicillata*), and the white-headed Uistiti (*Hapale leucocephala*), which inhabit the same regions, the tufts on the ears are black. Finally, in the black-tailed Uistiti (*Hapale melanura*), of which, in all probability, Buffon's *Simia argentata* is only an albino variety, the hair, which is light brown, is very short, and the tail is of a uniform, light-brown color. To the same category belong the Pygmy Uistiti (*Hapale pygmæa*)—of which we give a figure copied from nature—and the white-footed Uistiti (*Hapale leucopus*), a species described last year by Gray, and which has the forearms, feet, and hands, of a nearly pure white color, while the rest of the body is brownish gray, with more or less mixture of red. This animal was discovered at Medellin, in Colombia; while the *Hapale pygmæa*—which differs from it both in markings and in size, having red spots and blackish streaks, and being much smaller than *Leucopus*—is confined to certain regions of Brazil and Peru.—*La Nature.*

SCIENTIFIC COURSES OF STUDY.[1]

By F. W. CLARKE,

PROFESSOR OF PHYSICS AND CHEMISTRY IN THE UNIVERSITY OF CINCINNATI.

SOME years ago, a clergyman in one of our Western States became deeply impressed with the conviction that the town in which he lived ought to contain a college. In due time a charter was secured, and a board of trustees appointed. They met, organized, conferred upon the aforesaid clergyman the degree of D. D., and then adjourned forever. I give the story as I heard it, without undertaking to vouch for its truthfulness. It savors somewhat of extravagance, and yet has a sound of probability. Everybody has heard of the establishment of so-called "colleges" upon similarly slender foundations. They exist in almost every Southern or Western State, and because of them our

[1] Read before the Ohio College Association, December 27, 1877.

really good institutions suffer continual discredit. In education, as in all other things, the realities are brought into disrepute by the shams.

Suppose now that the college described above had continued through several successive stages the career so auspiciously begun. It would probably have opened with its clerical founder for president, and a force of one or two professors (should not this be written *professers?*) to help him. It would have announced all sorts of courses of study—a classical course, a scientific course, a mixed literary or ladies' course, a business course, a normal course, and so on, to the limit of its founder's power of invention. These courses, having been organized with various degrees of incapacity, would in due time be supplemented by departments of art and music; and, in short, there would grow up an institution claiming to do all things, but unfit to do any one thing decently. The classics would be taught by a mere grammarian unacquainted with modern philology; the sciences by a teacher destitute of special scientific training; the normal department by an amateur educator; and book-keeping by somebody who had never attempted actual business. Degrees would be given by the dozen to students who had never learned anything but dilettanteism, and whose ideas of scholarships would, as a rule, be limited by the attainments of their teachers.

Does anybody doubt the existence of such colleges as I have sketched? It would be easy to point out twenty institutions in different parts of the country, any one of which would answer tolerably well to my description. Between these extremes and the respectable colleges there are many intermediate grades. There are some schools in which thoroughly good work is done of a low order—work which carries the student to about the point where a fair junior year should begin, and which is honest so far as it goes. The only objection to these schools is, that they call themselves colleges, and confer college degrees. That they have a great value, nobody can doubt. Many and many a country lad who would otherwise remain ignorant gets in one or another of them the foundations of an education. If they would but abandon the college name, cease to grant diplomas, and call themselves academies or high-schools, they would then deserve only praise. It is their pretension to be more than they really are which is so damaging to the cause of higher education.

With all these lower institutions the true colleges have to compete. Every college is directly impeded in its work by their existence. The institution which provides low-grade courses for imperfectly prepared students, actually encourages defects in the preparatory schools, and every other college suffers in consequence. All or nearly all of our universities are in part dependent upon the income received from students. They must get students, or perish; and hence the competition for numbers, which is continually tending to keep down the standards. Nearly every respectable college in America is hindered in this way. Even Harvard and Yale, old and powerful as they are, feel the bad influence. Perhaps the Johns Hopkins University, protected by its great wealth, may escape from the evil tendency.

Not many years ago, partly in consequence of the growth of the natural and physical sciences, and partly because of a popular demand for an education not exclusively classical, a number of American colleges established scientific schools. Naturally, the larger universities led off in this movement, and the smaller soon followed; only the latter, as a rule, inaugurated not separate schools for science, but scientific courses, so called, parallel with the courses in classics. As might reasonably be expected, the attempts at first were crude; nobody knew exactly what was wanted; vagueness characterized the entire subject. The classicists rather distrusted the new policy; looked upon it as an effort to degrade true education; and generally gave it the cold shoulder. Still, they were obliged to concede something to the new education; and their concessions, wrung from them by popular pressure, were seriously affected by the competition for students of which I have already spoken. Even respectable Eastern colleges yielded ground, and established courses of study which were obviously meant to be easier than the older curriculum, in order that they might swell their numbers by attracting students too badly prepared, too stupid, or too indolent, to do the regular, traditional, solid work. In short, there sprang up by degrees, all over the country, courses of study requiring but little preparation on the part of the student to enter them, and not much exertion to remain and graduate afterward. They were, in many cases, mere waste-heaps, in which the college rubbish was allowed to gather, there to remain for four years fermenting before being finally cleared out of the way.

Along with the call for scientific studies came a demand for the higher education of women. Some distinctively female colleges were established, but in the majority of instances coeducation was tried. Again the spirit of false competition for students told against true learning. At first but few girls were well prepared for admission to college; and, consequently, immature students were accepted. They could not well carry on advanced studies; and so, to suit them, in many places special "courses for ladies" were organized; and these were in some instances identical with the courses in science. Thus two distinct movements, both good in themselves, were made to work together for evil. The old classical system of education was well established, was governed by the traditions handed down through centuries of experience, and was therefore able to hold its own. The competition for students, therefore, chiefly affected the new system, and in the direction of science it exerted its strongest degrading influence. The demand was for good scientific education on the one hand, and for the advancement of women on the other; the first result in many cases was the establishment of shams. That women should be admitted to the colleges was right and just; but that low standards should be set up for badly-prepared students, either male or female, was never intended by the advocates of the new departure.

We now see that the general low character of our scientific courses of study may be traced to two distinct causes: first, to the crudeness due to the novelty of the subject; and, second, to the competition for students. With the latter cause we have in the present paper little to do, save to distinctly recognize its baneful action. The former is the one to be particularly discussed.

When courses of study in science were first proposed, our colleges were controlled almost exclusively by men of classical training and bias—men wholly outside of scientific life, unacquainted with scientific work, the scientific method, or the scientific spirit. Upon these men devolved at first the organization of the new courses. With them, study was mainly a matter of book-work; such as recitations and written exercises, aided by an occasional lecture. Laboratory or experimental instruction was rarely thought of, save when a professor exhibited a few specimens upon his lecture-table, or performed some showy experiment. Students went to the professor of chemistry much as they would go to see a conjurer; expecting to be stunned, dazzled, and delighted, but dreaming of no real study except an occasional recitation and the cram for examinations at the end of a term. Mental discipline from such study was out of the question; real scholarship had nothing to do with it; systematic research on the part of either student or professor was almost unheard of. The study of science consisted in empirically memorizing a few disconnected facts, without reference to their mutual relations, or to the growth of any specific department of knowledge. This was the rule; but, fortunately, there were some exceptions. In a few of the larger colleges a better state of things existed—a state which was by no means perfection, but one which afforded a starting-point for healthy growth and improvement. In these colleges the scientific work was controlled by distinctively scientific men, and under their guidance the adverse influences were in part at least overcome. From such centres the scientific spirit has spread; and, now that the early crudeness has worn away, we are able to see clearly what a scientific course of study ought to be, and in what quarters our greater deficiencies lie.

Now, the problem before us is easily stated. It is to devise a course of study in which language is subordinate to the natural and physical sciences, and which shall be fully equal in requirements for admission and in subsequent mental training to the old-fashioned classical curriculum. In such a course the student must receive as solid and systematic a training as was ever furnished by a study of the classics; and for less than this no diploma should be granted. Of course, it is to be understood that the two systems of education cannot lead to identical results: each is in certain respects superior to the other; the equality between them is to be found in an average, and not in a coincidence of details. The classical student will more keenly appreciate the exact meanings of words; but his scientific rival will gain a deeper insight into things: the one may perhaps be more facile and elegant in literary expression; the other, stronger in powers of thought.

First, let us discuss the requirements for admission to scientific courses—what is, and what ought to be done. For entry upon an ordinary classical course a student is examined in the so-called "English branches," in Latin, in Greek, and in mathematics; the amount required of each being different in different institutions. For the scientific course we may properly demand the same English branches and mathematics, so that the question really is, "What shall we substitute for the Latin and Greek?" Now, every good high or preparatory school furnishes instruction in a variety of topics available for this purpose. If the classical student is obliged to know some classics before he can enter college, why should not the scientific student be required to know some science? Or, instead of this, a certain amount of preparation in modern languages might be demanded. French, German, chemistry, and physics, make a good list from which to select subjects, and any two of these might be chosen.[1] These studies, properly learned, will cover the ground, and, at the same time, bear directly upon the subsequent work of the scientific course. If a college cannot get students well fitted in the subjects named above, substitutes might be accepted; as, for instance, additional mathematics or Latin. The Latin, however, is to be regarded merely as a makeshift; a sort of token that the student has had a certain amount of mental discipline. It should never be demanded except when the other more important studies are lacking. But the essential thing is, that the candidate for admission shall have spent as much time and done as much work in preparation for college as the student who intends to follow classical studies. This requirement is not severe by any means, and it is unquestionably just. A scientific course of study ought not to be established upon any weaker basis.

But how many of the colleges which grant the Bachelor of Science degree come up to this mark? Unfortunately, very few. As a general rule, not only in Ohio, but throughout the West, the requirements for admission to a scientific course are the same as for the classical course, minus the classics. In some instances a portion of the Latin requirement is retained, and in a few more other studies are substituted in part for the classical branches. In one college, a little more mathematics is demanded of the candidate for admission in science; in

[1] The University of Cincinnati, for admission to the scientific course, requires algebra, to permutations and combinations; the whole of geometry; the whole of plane trigonometry; elementary inorganic chemistry, including familiarity with laboratory manipulations; elementary physics (Balfour Stewart or Norton); and the elements of either French or German.

another, the elements of a modern language are required. But in very many cases there seems to be not even an attempt to really equalize the two courses of study.

From these facts we see that the average student in a scientific course enters upon his work with a mind less mature than that of his fellow in the classics. Both stay in college for four years, and then receive baccalaureate degrees. Is it strange that in most cases the classically trained scholar comes out ahead? Is it just to attribute his advantage to any lack of educational value upon the part of the sciences? In short, is the comparison between the two systems of education at all a fair one? Obviously, it is not. Until both systems have been tested side by side, both properly developed and with equally good student material to work upon, no reasonable comparison between them can be made. As long as the poorer students are concentrated in one course, and the better prepared in the other, the sciences will be at a grave disadvantage.

So much concerning the requirements for admission. Now let us consider the course of study afterward—what is it now, and what ought it to be? Surely we should expect to find the scientific students learning more science than is taught in the classical courses. Reasonable, however, as this expectation is, in many cases it will be disappointed. If we look over the catalogues of even our Ohio colleges, we shall find that in great measure the purely scientific studies are the same in both courses; the same amount of chemistry, of physics, of zoölogy, of geology, and so on. In one catalogue I find the classical course fully laid out, and after it the explicit statement that "the scientific department will embrace all the above course, except the classics." In a few institutions the scientific student does get a trifle more of science than his neighbor, as much as an extra term in physical geography or surveying. Some of these courses of study have absolutely no right to the name of scientific. Here is the beginning of such a course in an Ohio college:

Freshman Year—*First Term.*—In the classical course, Latin, Greek, and algebra. In the scientific course, the same algebra, easier Latin, and Old Testament history. *Second Term.*—Classical course: Latin, Greek, and algebra, continued; geometry and physiology, taken up. Scientific course: The same mathematics and physiology, easier Latin, and New Testament history.

Sophomore Year—*First Term.*—Classical course: Latin, Greek, zoölogy, geometry. Scientific course: Easier Latin, the same geometry, "physical geography, and geography of the heavens." *Second Term.*—Classical course: Latin, Greek, trigonometry, conic sections and analytics, botany. Scientific course: The same mathematics and botany, general history, Paley's "Natural Theology." And so on to the end of the senior year.

In this particular instance the scientific course contains one term in physical geography over and above the amount of science taught in the classical department ; and, in the main, substitutes for Greek some sort of theological instruction. Perhaps a portion of the latter might be put under the head of Paley ontology, and in that sense be regarded as essentially scientific. But, to speak seriously, the course, as a whole, however respectable it may be from some points of view, has certainly no right to the scientific title. It is an easy, trivial course, fitted to accommodate inferior students, and ought, in common honesty, to be called by some definite and appropriate name. To call such a course "scientific" is simply dishonest. This case, I am sorry to say, is by no means an exceptional one. Scientific courses of this type are exceedingly common ; and, because of their existence, scientific studies often fall into disrepute. There are in Ohio, fortunately, quite a number of colleges which give scientific instruction of a very much higher order than is here indicated, where faithful efforts are made to put the scientific and classical courses upon an equal footing, and which fall short only because of the lower standard for admission to the former. There are still others, and some of our best colleges among them, which refuse point-blank to establish special courses in science at all, on the ground that they have neither the means nor the appliances to make such work as effective as it ought to be. These institutions deserve the highest credit. Although I am fully convinced that the new education is far superior to the old, I also recognize the fact that any genuine work is better than any sham; and that a good drill in the classics is immeasurably better than a mere trifling with science. The former is scholarly ; the latter is not. It is a truism to say that a college had better do one thing well than two things badly ; but this truism is too often forgotten or overlooked. It would be a decided gain if some of our colleges could make the scientific course the one thing well done, but, in default of that, it is cheering to know that the other is properly attended to.

Now, having seen what the scientific courses often are, we find ourselves in a position to discuss what they ought to be. As the name indicates, science should predominate in them, but not necessarily to the exclusion of other things. French, German, mathematics, English literature, logic, and possibly some drawing, ought to be included; the relative proportions of these branches varying with circumstances. A certain range of election should be allowed the student, since different students have very different needs. No prescribed course of study can be devised which shall be universally acceptable and invariably productive of beneficial results. If every student attempts to study everything, no thorough work can be done in any department. A college certainly ought not to be an institution for the encouragement of diffuseness. Scholarship and the character formed by scholarship are its true aims. A student does not gain breadth of mind by dabbling a little in a dozen different things—superficiality and the consequent narrowness are the natural results of such a course. The title "Bachelor of Science" ought not to be equivalent with "Bachelor of Sciolism."

I have spoken of French and German as essential studies in a scientific course. Let me emphasize their importance. At the present day no branch of advanced study can be carried far without the assistance of these languages. Every science and every art is aided by them. Three-fourths of all the researches and of the books written upon pure science are in one or the other of these tongues. Surely a Bachelor of Science ought to graduate fitted for advancement in the studies which he prefers. French and German will be absolute necessities in his equipment; without them he can scarcely develop in any direction. This, to a lesser degree, is true of the classical graduate also. What good work in philology can be done by a man unacquainted with German? What study of literature, art, music, law, medicine, or theology, is not aided by the modern languages? Surely, then, any course of study which omits to provide facilities for learning both French and German is essentially defective, and ought to be revised.

I am sorry to say that a considerable number of our colleges do not come up to this requirement. There are several in Ohio in which there seems to be absolutely no instruction in modern languages furnished. There are others, and among them some institutions of high repute, in which these studies are exclusively elective; a student may take them or not, as he chooses. This is wrong, and for the reasons given above. In the scientific courses, at least, no student should receive a degree unless he is able to use French and German reference-books at sight. Some of our colleges insert Latin among the required freshman studies of the scientific course. This should be crossed out, in order to make room for the more important modern languages. A moderate amount of Latin, however, may well be retained upon the list of elective studies for the benefit of those students who are more especially interested in biological science. But this amount, useful in connection with scientific nomenclature, is very small, and can be acquired in a comparatively short time. For the mathematician, astronomer, chemist, or physicist, none at all is needed.

The quantity of mathematics to be prescribed will naturally vary with circumstances. Probably the best way is to require every student to go through plane analytics; and, after that, to give him opportunities for mathematical electives. The scholar whose particular tastes lead him to the special study of physics, will take up the calculus and mechanics. The chemist will find the calculus of value, but not by any means necessary. The biologist needs no more than the prescribed amount of mathematics, and would probably carry the study no further. As for English literature, logic, and drawing, but little need be said. One study puts before the student good models in composition, another teaches him the laws of exact thinking, the third enables him to represent pictorially what he sees. All three studies give him power, and two of them help to train his sense of beauty.

Now for the main features of the course—the natural and physical sciences. How shall they be taught, and with what purposes in view?

It is a proposition of self-evident truth that a scientific course which gives the student no real insight into the aims and methods of scientific research and scientific thought is a failure. Certainly, a Bachelor of Science ought to clearly understand what science is, what it has accomplished, and what it is trying to do. He should be able to appreciate both its capacities and its limitations, and have some idea of the relations which connect its several branches. He must see that Nature is an organized whole, with all its parts dependent upon one another, governed by inviolable laws, subject to no caprices. If he fails to gain these broad, general conceptions, his work will remain incomplete, and of little intellectual value. Such statements as these are undoubtedly truisms ; and yet there are many colleges in which their force is seemingly never recognized.

In order that these general purposes may be properly carried out, it is best that every student should choose some one science as a specialty. Close and exact work can hardly be done otherwise. He who divides his time equally among all the sciences will not catch the real spirit of any one. He will merely pick up information empirically, without gaining genuine insight into anything, or acquiring much intellectual power. Not that he should confine himself to a single branch alone, for that would not be in accordance with the principles already laid down; but he ought, in his special science, to do as much work as in all the others collectively.[1]

We often hear a great outcry against the danger of making specialists. This outcry is only in part well-founded. A man who is so trained as to be blind to everything beyond his own department is indeed weak—whether that department be a science, art, music, theology, or commerce. A certain amount of versatility is essential to breadth of view; but it is not necessary that the student should be superficial. It is of the utmost importance that there shall be thoroughness somewhere; and yet this fact, of all others, is the one most frequently overlooked in our smaller colleges. If a student in classics were to ask the privilege of continuing both Latin and Greek through the whole four years of his college course, his teachers would probably regard the desire as eminently praiseworthy, and deserving of encouragement. And yet he would be in a measure becoming a specialist in those languages. Why, then, should it not be considered equally

[1] In the University of Cincinnati every regular student, whether classical or scientific, is obliged to choose a specialty. This study must be announced to the faculty at the beginning of the sophomore year, and is to be continued to the end of the course. This modification of the elective system insures thoroughness in something, and bids fair to yield most excellent results.

praiseworthy for a student to seek similar thoroughness in some department of science? If a college course aims to develop the character of the student, depth should be considered as well as breadth; and both are secured by combining the study of a special branch with accessory work in half a dozen others.

The method of study is also important, and just here is where many otherwise good institutions fail. Every student of science should meet Nature at first hand, and learn to observe her phenomena for himself. Lectures and text-books are but minor accessories to study; in the sciences they play a wholly subordinate part; in the laboratory, the field, and the museum, the chief work is to be done. No matter what branch of science is to be pursued, the student from the very first must meet it face to face. The biological sciences ought to be studied in the field, collecting; in the museum, classifying; in the laboratory, with the microscope and the scalpel. Far too often is the study of natural history degraded into a mere memorizing of classifications; as if the transitory part of science were more valuable than the permanent! The student must see, handle, dissect, and investigate, for himself. He is to study the phenomena of life, and not merely the external appearance of a lot of stuffed specimens. Chemistry, and physics also, is to be studied chiefly in the laboratory. It is not enough for a student to see experiments, he must himself perform them. Thus only can he learn the true scope of these great sciences. By a proper drill in qualitative analysis, he learns to observe closely, and to reason from his facts to their interpretation. Quantitative analysis gives him accuracy of manipulation, and an insight into the *absolute* value of experiment. This insight also results from delicate practice with instruments of precision in physics; a kind of exercise of the very highest educational value. If the course of study in any science can be capped by an original research leading to the discovery of new facts, so much the better. In a German university the candidate for a doctoral degree in science is absolutely required to carry out such a research, and to submit a dissertation upon it. This is not a severe requirement—every student who has been decently trained is able to come up to it, all the popular notions about the mysteriousness of scientific research to the contrary notwithstanding. Why should we not aim to equal the German standard?

But, because I lay this stress upon the experimental method in scientific study, I do not therefore undervalue lectures and text-book work. These are valuable auxiliaries to a scientific education, although they need to be handled carefully. The teacher must be in a great measure independent of the text-book, able to make up its deficiencies, and to correct its errors. In lecturing, he must be fully awake to the importance of research, and should lose no opportunity of suggesting to his classes good subjects for investigation. If there is an unsettled question, he may call the attention of his students to it; if he sees a gap in some series of observations, let him point out how easily it might be filled. By instruction of this kind the scientific spirit is awakened, and given food for growth. In the selection of text-books, great care must be exercised. On this point many and many a college catalogue unconsciously betrays the incapacity of certain teachers. A bad book on a college list indicates poor judgment and slight knowledge on the part of the professor who chose it. If a college were to announce as its text-book in German, "German in Six Lessons without a Master," we should all be skeptical as to the quality of its teaching. What, then, shall we think of the institution in which science is taught upon the basis of the well-known "Fourteen Weeks Series?"

Now, to sum up. It seems plain that our scientific courses of study need to be remodeled. We should demand more for admission, and make them equivalent to the courses in classics. Before receiving a degree, a student should know some one science fairly well, understand the bearings of the others, have a good training in mathematics, literature, and logic, and be able to read easy French and German prose at sight. Are these demands extravagant? Are they not rather moderate and within bounds?

THE CARDIFF GIANT, AND OTHER FRAUDS.

By G. A. STOCKWELL, M. D.

THAT great hoax, the Cardiff giant, was conceived by one George Hull, a tobacconist of Binghamton, New York. It was the outgrowth of a controversy held one evening in 1866 between Hull and a Rev. Mr. Turk, of Ackley, Iowa, regarding the former existence of giants in the earth, in which the latter proved victorious, his ready tongue and loud voice easily bearing down and overwhelming his opponent. Hull retired at a late hour, and, being chagrined with his defeat, lay awake the greater portion of the night, thinking of the extreme gullibility of the world in matters where the Bible could be cited as evidence, and in planning how to turn this peculiarity to his advantage. The result was, that he decided upon producing an image which should, after being buried and exhumed, pass muster as a fossil man of unusual size, being assured that such men as his late opponent in argument would aid not a little in contributing to the final success of the undertaking.

In 1868, having studied the subject carefully and completed his arrangements, Hull associated himself with one Martin, and proceeded to Fort Dodge, Iowa, to procure a suitable block from which to carve his image. An acre of quarry-land was purchased, and work commenced, but only to be soon abandoned, owing to the extreme friability of the stone, and the persistent annoyance of the curious and inquisitive inhabitants of the neighborhood. Martin, now thoroughly disgusted, withdrew from the project; but Hull, hearing of another gypsum-bed in a more retired locality, on the line of the Dubuque & Sioux City Railroad, then in process of construction, went thither, and the following Sunday engaged the foreman of the railroad-gang to employ his men in quarrying out as large a slab as the nature of the ground would permit, paying for the labor with a barrel of beer. The result was a slab weighing three and a half tons, measuring twelve feet in length, four in breadth, and twenty-two inches in thickness. With almost incredible difficulty and labor the block was transported over forty miles of terrible road to Montana, the nearest railroad-station, where it was shipped to E. Burghardt, Chicago, who had been engaged to grave the image. On its arrival at that city, it was moved to Burghardt's barn, which had been prepared for its reception, and two men at once set to work upon it—one, Edward Salle, a German; the other, an American named Markham. It was Hull's desire to represent a "man who had laid down and died;" but, as he entertained doubts as to the universal acceptation of the "fossil-man" theory, it was decided to produce an image that might also pass for an ancient statue. This combination of designs was the cause of that curious feature which attracted notice and provoked discussion when the giant came to be exhibited, viz., the lack of hair.

The last of September the stone-cutting was finished, but the work was far from being completed, having the appearance of newness peculiar to freshly-cut gypsum. The figure was now subjected to long and patient rubbing with sand and water, which produced the water-worn appearance so often cited as incontrovertible evidence of extreme antiquity. The pores of the skin were imitated by carefully pecking the entire surface with leaden hammers faced with needles, giving the peculiar "goose-flesh" which puzzled so many. There still remained an appearance of freshness, which was finally obviated by bathing with writing-fluid, and afterward washing with sulphuric acid, giving the desired appearance of antiquity. Packed in sawdust, the giant, now weighing 3,720 pounds, was shipped to Union, New York, where it arrived October 12, 1868. Meantime Hull proceeded to Salisbury, Connecticut, to inspect a newly-discovered cave, in which he hoped to bury and resurrect his giant, but was discouraged by the price demanded. Suddenly remembering that fossil bones had recently been discovered near Syracuse, New York, he now visited a relative, one Newell, living in the locality, at Cardiff, and opened the enterprise to him, proposing to bury the giant upon his farm. Newell at once accepted the terms proposed—one-fourth interest—and it was decided to inter the image near the barn, where a well had formerly been projected.

All being arranged satisfactorily, Hull returned to Union, November 4th, and shipped the "fossil" for Cardiff by four-horse team, under the charge of his nephew, Tracy Hull, and one Amesbury. On the evening of the 9th of the same month the heavily-laden team arrived, attracting little attention, owing to the darkness and rain, though the peculiar appearance of the iron-bound case and its apparent weight, from the amount of motive power demanded in transportation, had excited considerable curiosity and comment on the road. The box was unloaded and concealed in a pile of chaff, and a few nights later the giant was lowered into its resting-place by means of a derrick.

In October, 1869, nearly a year having elapsed, Hull wrote Newell to "find the giant;" when, in accordance with prearranged plans, two neighbors, Gideon Emmons and Henry Nichols, were engaged to sink a well; one Woodmansee was secured to stone it, and Newell, aided by one Parker, began drawing stone. Suddenly the shovel of Nichols struck a hard substance, which, in clearing away, proved to be a massive stone foot, calling forth from Emmons the exclamation, "Jerusalem, Nichols, it's a big Injun!" As the earth was cleared away, revealing the outlines, several neighbors, chancing that way, were summoned to view the wonder. This was the nucleus of a crowd which numbered thousands a few hours later.

It has been asserted that the earth showed no signs of having been excavated so recently as the year previous; but one John Hagan, who was among the first of the sight-seers, in a sworn affidavit says: "I took a shovel and got down into the hole, and as fast as they uncovered the body toward the head I cleared the dirt off about up to the hand on the belly. When we were clearing off from the upper portion of the body, the earth cleaved off from the sod and fell upon the body. I said, 'Boys, this is the spot where he was put down.' No reply was made, but Mr. Newell stepped around, and, taking a shovel, trimmed the sod down square with where it came off."

The following day, Sunday, four medical men of the neighborhood, of scientific pretensions, investigated the subject, swallowing the hoax without the least difficulty, pronouncing it to be a "petrified man." Later it was examined by Dr. Boynton, of Syracuse, a man possessed of some antiquarian knowledge, who decided it to be a statue "made some three hundred years ago by the Jesuit fathers," and at once offered $10,000 for it. This and more tempting offers were declined, as sight-seers at half a dollar per head were apparently unlimited in number. However, Newell, in compliance with Hull's order, sold a three-fourths interest to half a dozen citizens of Syracuse for $30,000. A show-man was now placed in charge, and, in the way of advertisement, invitations were sent to Prof. Agassiz, Prof. Hull (State geologist), S. B. Woolworth (secretary of the university), etc. November 3d a large delegation of scientific men assembled from different parts of the State for deliberate and thorough inspection, who at once pronounced it a statue, the State geologist declaring it to be of great antiquity. Prof. Ward, who filled the chair of Natural Sciences in the Rochester University, said, "Although not dating back to the stone age, it is nevertheless deserving the attention of archæologists." A prominent clergyman wrote, "This is not a thing contrived of man, but is the face of one who lived like all the earth; the very image and child of God;" thus confirming the impression Hull received from his discussion with the Rev. Mr. Turk.

Suddenly a series of reverses overtook the giant. Prof. O. C. Marsh, of Yale College, gave it a telling blow by stating that gypsum is soluble in 400 parts of water, yet the surface of the giant was smooth and little dissolved, though surrounded by wet earth, proving that the burial must have been of very recent date. He also found other indications of fraud, which had escaped the notice of the State geologist, and other scientists; as recent tool-marks, in places where they could not be easily effaced, and adjoining water-worn surfaces. This was corroborated by Palmer, the sculptor. Soon letters were received from parties who had observed the four-horse team and load on its way to Cardiff; then one from Fort Dodge, detailing the operations in that neighborhood; and, finally, the statement of Markham, one of the stone-cutters, was obtained. Hon. Lewis Baldwin, a gentleman well versed in archæology, remarked that the giant could neither be a finished statue nor petrifaction, as it had no hair, though complete in other respects. At last the climax was reached, which connected the person who obtained the stone from the neighborhood of Fort Dodge with the giant, by Newell drawing the money received from the Onondaga County Bank in a draft payable to Hull's order.

Yet, for a time, all this discussion only helped to advertise the exhibition, which had been removed to Syracuse, where it was visited by such throngs of people as to require special trains on all the railroads. Says Mr. McKinney, in speaking of the pecuniary returns, "The giant yielded an income equal to the interest of $3,000,000 at seven per cent., and large bids were offered for its purchase, as high as $25,000 being offered for one-eighth interest."

But the blows given soon began to tell. Barnum, having in vain attempted to purchase a share, and obtain the management of the exhibition, bargained with a Syracuse sculptor for an unfinished imitation, which, when completed, was placed in Wood's Museum, New York, and extensively advertised and puffed by means of a pamphlet description of the original. He denounced the Syracuse exhibition as a humbug, claiming himself to be possessor of the "only true and original Cardiff giant." An application was made to Judge Barnard, of Erie Railroad fame, for an injunction against Barnum; but that functionary replied that he had been in the "injunction business," but had "closed out."

Soon the giant came to New York, only to find itself supplanted. After a few days, it was shipped to Boston, where the excitement bade fair to break out again, from the *furor* created by the learned men of the modern Athens. Ralph Waldo Emerson pronounced it beyond *his* depth, astonishing, and undoubtedly ancient. Cyrus Cobb, the artist and sculptor, declared that any man who called the giant a humbug "simply declared himself a fool." On the 4th of February a number of Solons visited the giant as an official body. They examined it long and patiently; the exterior was tried with acids; the head bored into, and the compass carried around it in search of iron. The conclusion arrived at was very satisfactory, and undoubtedly true, as it was decided to be a "*piece of stratified gypsum, probably very old.*" The subject invaded the Boston clubs, and one whole evening was occupied by the president of the "Thursday Evening Club" to prove that the giant was modern, because its features were Napoleonic!

But a few weeks elapsed ere the proofs of the frauds perpetrated became incontrovertible, and the Cardiff giant was consigned to popular oblivion.

The Colorado stone man proves to be a veritable brother of the giant, having been begotten by the self-same father. Hull cleared some $60,000 by the latter, with which he embarked in business in Binghamton, New York, by which every dollar was lost. Of late he has been given to the pursuit of experimental chemistry, and, taught by the popular views of Darwin, *as expounded by the public press*, he began planning to again astonish the good people of the United States. This seemed to take great hold upon his mind, and he frequently remarked that he would like to set the scientific men quarreling as to the origin of man, and throw the religious world into a vortex of doubt and controversy.

Finally his ideas and experiments assumed a definite form, and he proceeded to put them in execution. Forming a partnership with one Case, who possessed the funds requisite for the enterprise, an hotel was bought in Elkland, a little mountain-town in Northern Pennsylvania, and, as a blind, it was announced was to be converted into a summer resort and mountain sanitarium. In the rear of the hotel a brick building was erected, ostensibly as an ice-house; but in reality as a kiln and workshop. Here, one after the other, two figures were constructed, the principal composition of which was ground stone, pulverized bones, clay, plaster, blood, and dried eggs, the whole, when modeled, being baked in the kiln for two weeks. The first was irretrievably broken in removing it from the furnace; but the second proved more successful, greater care having been taken in its construction. In it bones were inserted in different localities, including fragments of skull in the head. Cox, one of the confidants of the scheme, thus details the parturition of the image, as communicated to him by Hull:

"Cox, I would give a hundred dollars if you could have been with Case and me the night we took him out. We had a rope around his neck, and a pulley up there; and how we worked and tugged at the rope! I went through torture—my whole existence hung by that rope. It seemed as if I lived a thousand years while we were pulling him out; and when he hung up there by the neck, I tell you, he looked alive; he looked as if he was going to talk! Don't tell me the people won't be fooled by this!" (A tail, four inches in length, was one of the appendages of the monstrosity.) "Cox, look at that tail; take hold of it! That tail alone is worth a million! I made a difference in the toes, because it would not do to have him too perfect. The arms we made proportionately longer than the legs, so as to resemble the ape type. We propose to let the scientific men bore into him, but they must confine themselves to certain parts of his body, and there we have fixed him by putting in bones."

At this time, having exhausted their funds, the worthies applied to Barnum for means to bury their prodigy, who advanced $2,000 for the purpose. But where to place him was the query! Barnum declared that Connecticut would not do, for to resurrect him in a State so celebrated for humbugs in the way of "basswood hams," "wooden nutmegs," "fraudulent clocks," and the "Great American Show-man," would at once ruin the enterprise.

Finally Colorado, the "Wonder State," was decided upon, and the stone man sent thither and buried along with a turtle and salmon trout of like composition. Next one Conant visited the Rocky Mountains as a geologist, and, at the proper time, discovered the image. Barnum, happening (!) to be lecturing on temperance in Colorado at the time of the discovery, announced that he would give $20,000 for the "find;" but, this offer, of course, was rejected with scorn. Barnum now gave Prof. Taylor $100 to bore into the image and report. Hull, who had heard from scientific men that boring into a true fossil would show crystals, adroitly substituted crystal dust for that obtained, while the professor's attention was otherwise engaged; and all seemed to be going on swimmingly. Finally Prof. Marsh was again called upon for an opinion, and at once detected the fraud, calling attention to the fact that the image presented a rotundity of figure incompatible with the theory of one who had died and become fossilized, in which case the abdomen would naturally be sunken and collapsed. Remembering the Cardiff hoax, this decision caused the people to fight shy of the exhibition. Ultimately suspicion was confirmed by the admissions of Cox, Case, Babcock, and others connected with the enterprise, who, falling out among themselves, at once spread the facts far and wide, in their desire to injure each other; thus forever blasting all hopes of financial success.

Another would-be candidate for archæological and pecuniary honors was one William Ruddock, of Thornton, St. Clair County, Michigan, who in 1876 manufactured, from water-lime, sand, and gravel, a "petrified man," which was claimed to have been found in the gravel-pits of Pine River. Ruddock's pecuniary resources being exceedingly limited, he contented himself with a figure less than four feet in height, with arms folded across the breast; the model having evidently been taken from an "effigy in lava," which illustrates one of J. Ross Browne's sketches of Iceland, as published in *Harper's Magazine.* This hoax obtained some local celebrity, and even found its way into the general press. Several rural clergymen made it an especial topic in their Sunday discourses; and certain agricultural papers, backed by letters from these same teachers, assured the world that the "Pine River man" was no Cardiff giant, but a *bona-fide* "creation of God!" But even all this evidence failed to make Ruddock's fossil remunerative, and it was sold to the proprietor of a third-rate side-show for a mere trifle.

After these attempts, it is safe to assert that no ignorant person will again attempt a "prehistoric man," either with or without a caudal appendage. And it is probable that no scientist will be guilty of such an imposition. The greatest wonder is that no counterfeits of the only true fossil men discovered—those of the Mentone caves in France—have reached this country. With their success in the manufacture of artificial stone, the Chinese could doubtless produce a figure that would defy any but the most thorough scientific scrutiny. As John is given to such little games, it would not be at all surprising if he should yet enter the field.

ILLUSTRATIONS OF THE LOGIC OF SCIENCE.

By C. S. PEIRCE,

ASSISTANT IN THE UNITED STATES COAST SURVEY.

FIFTH PAPER.—THE ORDER OF NATURE.

I.

ANY proposition whatever concerning the order of Nature must touch more or less upon religion. In our day, belief, even in these matters, depends more and more upon the observation of facts. If a remarkable and universal orderliness be found in the universe, there must be some cause for this regularity, and science has to consider what hypotheses might account for the phenomenon. One way of accounting for it, certainly, would be to suppose that the world is ordered by a superior power. But if there is nothing in the universal subjection of phenomena to laws, nor in the character of those laws themselves (as being benevolent, beautiful, economical, etc.), which goes to prove the existence of a governor of the universe, it is hardly to be anticipated that any other sort of evidence will be found to weigh very much with minds emancipated from the tyranny of tradition.

Nevertheless, it cannot truly be said that even an absolutely negative decision of that question could altogether destroy religion, inasmuch as there are faiths in which, however much they differ from our own, we recognize those essential characters which make them worthy to be called religions, and which, nevertheless, do not postulate an actually existing Deity. That one, for instance, which has had the most numerous and by no means the least intelligent following of any on earth, teaches that the Divinity in his highest perfection is wrapped away from the world in a state of profound and eternal sleep, which really does not differ from non-existence, whether it be called by that name or not. No candid mind who has followed the writings of M. Vacherot can well deny that his religion is as earnest as can be. He worships the Perfect, the Supreme Ideal; but he conceives that the very notion of the Ideal is repugnant to its real existence. In fact, M. Vacherot finds it agreeable to his reason to assert that non-existence is an essential character of the perfect, just as St. Anselm and Descartes found it agreeable to theirs to assert the extreme opposite. I confess that there is one respect in which either of these positions seems to me more congruous with the religious attitude than that of a theology which stands upon evidences; for as soon as the Deity presents himself to either Anselm or Vacherot, and manifests his glorious attributes, whether it be in a vision of the night or day, either of them recognizes his adorable God, and sinks upon his knees at once; whereas the theologian of evidences will first demand that the divine apparition shall identify himself, and only after having scrutinized his credentials and weighed the probabilities of his being found among the totality of existences, will he finally render his circumspect homage, thinking that no characters can be adorable but those which belong to a real thing.

If we could find out any general characteristic of the universe, any mannerism in the ways of Nature, any law everywhere applicable and universally valid, such a discovery would be of such singular assistance to us in all our future reasoning, that it would deserve a place almost at the head of the principles of logic. On the other hand, if it can be shown that there is nothing of the sort to find out, but that every discoverable regularity is of limited range, this again will be of logical importance. What sort of a conception we ought to have of the universe, how to think of the *ensemble* of things, is a fundamental problem in the theory of reasoning.

II.

It is the legitimate endeavor of scientific men now, as it was twenty-three hundred years ago, to account for the formation of the solar system and of the cluster of stars which forms the galaxy, by the fortuitous concourse of atoms. The greatest expounder of this theory, when asked how he could write an immense book on the system of the world without one mention of its author, replied, very logically, "Je n'avais pas besoin de cette hypothèse-là." But, in truth, there is nothing atheistical in the theory, any more than there was in this answer. Matter is supposed to be composed of molecules which obey the laws of mechanics and exert certain attractions upon one another; and it is to these regularities (which there is no attempt to account for) that general arrangement of the solar system would be due, and not to hazard.

If any one has ever maintained that the universe is a pure throw of the dice, the theologians have abundantly refuted him. "How often," says Archbishop Tillotson, "might a man, after he had jumbled a set of letters in a bag, fling them out upon the ground before they would fall into an exact poem, yea, or so much as make a good discourse in prose! And may not a little book be as easily made by chance as this great volume of the world?" The chance world here shown to be so different from that in which we live would be one in which there were no laws, the characters of different things being entirely independent; so that, should a sample of any kind of objects ever show a prevalent character, it could only be by accident, and no general proposition could ever be established. Whatever further conclusions we may come to in regard to the order of the universe, thus much may be regarded as solidly established, that the world is not a mere chance-medley.

But whether the world makes an exact poem or not, is another question. When we look up at the heavens at night, we readily perceive that the stars are not simply splashed on to the celestial vault; but there does not seem to be any precise system in their arrangement either. It will be worth our while, then, to inquire into the degree of orderliness in the universe; and, to begin, let us ask whether the world we live in is any more orderly than a purely chance-world would be.

Any uniformity, or law of Nature, may be stated in the form, "Every A is B;" as, every ray of light is a non-curved line, every body is accelerated toward the earth's centre, etc. This is the same as to say, "There does not exist any A which is not B;" there is no curved ray; there is no body not accelerated toward the earth; so that the uniformity consists in the non-occurrence in Nature of a certain combination of characters (in this case, the combination of being A with being non-B).[1] And, conversely, every case of the non-occurrence of a combination of characters would constitute a uniformity in Nature. Thus, suppose the quality A is never found in combination with the quality C: for example, suppose the quality of idiocy is never found in combination with that of having a well-developed brain. Then nothing of the sort A is of the sort C, or everything of the sort A is of the sort non-C (or say, every idiot has an ill-developed brain), which, being something universally true of the A's, is a uniformity in the world. Thus we see that, in a world where there were no uniformities, no logically possible combination of characters would be excluded, but every combination would exist in some object. But two objects not identical must differ in some of their characters, though it be only in the character of being in such-and-such a place. Hence, precisely the same

[1] For the present purpose, the negative of a character is to be considered as much a character as the positive, for a uniformity may either be affirmative or negative. I do not say that no distinction can be drawn between positive and negative uniformities.

combination of characters could not be found in two different objects; and, consequently, in a chance-world every combination involving either the positive or negative of every character would belong to just one thing. Thus, if there were but five simple characters in such a world,[1] we might denote them by A, B, C, D, E, and their negatives by a, b, c, d, e; and then, as there would be 2^5 or 32 different combinations of these characters, completely determinate in reference to each of them, that world would have just 32 objects in it, their characters being as in the following table:

TABLE I.

ABCDE	AbCDE	aBCDE	abCDE
ABCDe	AbCDe	aBCDe	abCDe
ABCdE	AbCdE	aBCdE	abCdE
ABCde	AbCde	aBCde	abCde
ABcDE	AbcDE	aBcDE	abcDE
ABcDe	AbcDe	aBcDe	abcDe
ABcdE	AbcdE	aBcdE	abcdE
ABcde	Abcde	aBcde	abcde

For example, if the five primary characters were *hard*, *sweet*, *fragrant*, *green*, *bright*, there would be one object which reunited all these qualities, one which was hard, sweet, fragrant, and green, but not bright; one which was hard, sweet, fragrant, and bright, but not green; one which was hard, sweet, and fragrant, but neither green nor bright; and so on through all the combinations.

This is what a thoroughly chance-world would be like, and certainly nothing could be imagined more systematic. When a quantity of letters are poured out of a bag, the appearance of disorder is due to the circumstance that the phenomena are only partly fortuitous. The laws of space are supposed, in that case, to be rigidly preserved, and there is also a certain amount of regularity in the formation of the letters, The result is that some elements are orderly and some are disorderly. which is precisely what we observe in the actual world. Tillotson, in the passage of which a part has been quoted, goes on to ask, "How long might 20,000 blind men, which should be sent out from the several remote parts of England, wander up and down before they would all meet upon Salisbury Plains, and fall into rank and file in the exact order of an army? And yet this is much more easy to be imagined than how the innumerable blind parts of matter should rendezvous themselves into a world." This is very true, but in the actual world the *blind men* are, as far as we can see, *not* drawn up in any particular order at all. And, in short, while a certain amount of order exists in the world, it would seem that the world is not so orderly as it

[1] There being 5 simple characters, with their negatives, they could be compounded in various ways so as to make 241 characters in all, without counting the characters *existence* and *non-existence*, which make up 243 or 3^5.

might be, and, for instance, not so much so as a world of pure chance would be.

But we can never get to the bottom of this question until we take account of a highly-important logical principle[1] which I now proceed to enounce. This principle is that any plurality or lot of objects whatever have some character in common (no matter how insignificant) which is peculiar to them and not shared by anything else. The word "character" here is taken in such a sense as to include negative characters, such as incivility, inequality, etc., as well as their positives, civility, equality, etc. To prove the theorem, I will show what character any two things, A and B, have in common, not shared by anything else. The things, A and B, are each distinguished from all other things by the possession of certain characters which may be named A-ness and B-ness. Corresponding to these positive characters, are the negative characters un-A-ness, which is possessed by everything except A, and un-B-ness, which is possessed by everything except B. These two characters are united in everything except A and B; and this union of the characters un-A-ness and un-B-ness makes a compound character which may be termed A-B-lessness. This is not possessed by either A or B, but it is possessed by everything else. This character, like every other, has its corresponding negative un-A-B-lessness, and this last is the character possessed by both A and B, and by nothing else. It is obvious that what has thus been shown true of two things is, *mutatis mutandis*, true of any number of things. Q. E. D.

In any world whatever, then, there must be a character peculiar to each possible group of objects. If, as a matter of nomenclature, characters peculiar to the same group be regarded as only different aspects of the same character, then we may say that there will be precisely one character for each possible group of objects. Thus, suppose a world to contain five things, α, β, γ, δ, ε. Then it will have a separate character for each of the 31 groups (with *non-existence* making up 32 or 2^5) shown in the following table:

TABLE II.

	$\alpha\beta$	$\alpha\beta\gamma$	$\alpha\beta\gamma\delta$	$\alpha\beta\gamma\delta\varepsilon$
α	$\alpha\gamma$	$\alpha\beta\delta$	$\alpha\beta\gamma\varepsilon$	
β	$\alpha\delta$	$\alpha\beta\varepsilon$	$\alpha\beta\delta\varepsilon$	
γ	$\alpha\varepsilon$	$\alpha\gamma\delta$	$\alpha\gamma\delta\varepsilon$	
δ	$\beta\gamma$	$\alpha\gamma\varepsilon$	$\beta\gamma\delta\varepsilon$	
ε	$\beta\delta$	$\alpha\delta\varepsilon$		
	$\beta\varepsilon$	$\beta\gamma\delta$		
	$\gamma\delta$	$\beta\gamma\varepsilon$		
	$\gamma\varepsilon$	$\beta\delta\varepsilon$		
	$\delta\varepsilon$	$\gamma\delta\varepsilon$		

This shows that a contradiction is involved in the very idea of a chance-world, for in a world of 32 things, instead of there being only 3^5

[1] This principle was, I believe, first stated by Mr. De Morgan.

or 243 characters, as we have seen that the notion of a chance-world requires, there would, in fact, be no less than 2^{32}, or 4,294,967,296 characters, which would not be all independent, but would have all possible relations with one another.

We further see that so long as we regard characters abstractly, without regard to their relative importance, etc., there is no possibility of a more or less degree of orderliness in the world, the whole system of relationship between the different characters being given by mere logic; that is, being implied in those facts which are tacitly admitted as soon as we admit that there is any such thing as reasoning.

In order to descend from this abstract point of view, it is requisite to consider the characters of things as relative to the perceptions and active powers of living beings. Instead, then, of attempting to imagine a world in which there should be no uniformities, let us suppose one in which none of the uniformities should have reference to characters interesting or important to us. In the first place, there would be nothing to puzzle us in such a world. The small number of qualities which would directly meet the senses would be the ones which would afford the key to everything which could possibly interest us. The whole universe would have such an air of system and perfect regularity that there would be nothing to ask. In the next place, no action of ours, and no event of Nature, would have important consequences in such a world. We should be perfectly free from all responsibility, and there would be nothing to do but to enjoy or suffer whatever happened to come along. Thus there would be nothing to stimulate or develop either the mind or the will, and we consequently should neither act nor think. We should have no memory, because that depends on a law of our organization. Even if we had any senses, we should be situated toward such a world precisely as inanimate objects are toward the present one, provided we suppose that these objects have an absolutely transitory and instantaneous consciousness without memory—a supposition which is a mere mode of speech, for that would be no consciousness at all. We may, therefore, say that a world of chance is simply our actual world viewed from the standpoint of an animal at the very vanishing-point of intelligence. The actual world is almost a chance-medley to the mind of a polyp. The interest which the uniformities of Nature have for an animal measures his place in the scale of intelligence.

Thus, nothing can be made out from the orderliness of Nature in regard to the existence of a God, unless it be maintained that the existence of a finite mind proves the existence of an infinite one.

III.

In the last of these papers we examined the nature of inductive or synthetic reasoning. We found it to be a process of sampling. A number of specimens of a class are taken, not by selection within that class, but at random. These specimens will agree in a great number of respects. If, now, it were likely that a second lot would agree with the first in the majority of these respects, we might base on this consideration an inference in regard to any one of these characters. But such an inference would neither be of the nature of induction, nor would it (except in special cases) be valid, because the vast majority of points of agreement in the first sample drawn would generally be entirely accidental, as well as insignificant. To illustrate this, I take the ages at death of the first five poets given in Wheeler's "Biographical Dictionary." They are:

Aagard, 48.
Abeille, 70.
Abulola, 84.
Abunowas, 48.
Accords, 45.

These five ages have the following characters in common:

1. The difference of the two digits composing the number, divided by three, leaves a remainder of *one*.

2. The first digit raised to the power indicated by the second, and divided by three, leaves a remainder of *one*.

3. The sum of the prime factors of each age, including one, is divisible by three.

It is easy to see that the number of accidental agreements of this sort would be quite endless. But suppose that, instead of considering a character because of its prevalence in the sample, we designate a character before taking the sample, selecting it for its importance, obviousness, or other point of interest. Then two considerable samples drawn at random are extremely likely to agree approximately in regard to the proportion of occurrences of a character so chosen. *The inference that a previously designated character has nearly the same frequency of occurrence in the whole of a class that it has in a sample drawn at random out of that class is induction.* If the character be not previously designated, then a sample in which it is found to be prevalent can only serve to suggest that it *may be* prevalent in the whole class. We may consider this surmise as an inference if we please—an inference of possibility; but a second sample must be drawn to test the question of whether the character actually is prevalent. Instead of designating beforehand a single character in reference to which we will examine a sample, we may designate two, and use the same sample to determine the relative frequencies of both. This will be making two inductive inferences at once; and, of course, we are less certain that both will yield correct conclusions than we should be that either separately would do so. What is true of two characters is true of any limited number. Now, the number of characters which have any considerable interest for us in reference to any class of objects is more moderate than might be supposed. As we shall be sure to examine any sample with reference to these characters, they may be regarded not exactly as predesignated, but as predetermined (which amounts to the same thing); and we may infer that the sample represents the class in all these respects if we please, remembering only that this is not so secure an inference as if the particular quality to be looked for had been fixed upon beforehand.

The demonstration of this theory of induction rests upon principles and follows methods which are accepted by all those who display in other matters the particular knowledge and force of mind which qualify them to judge of this. The theory itself, however, quite unaccountably seems never to have occurred to any of the writers who have undertaken to explain synthetic reasoning. The most widely-spread opinion in the matter is one which was much promoted by Mr. John Stuart Mill—namely, that induction depends for its validity upon the uniformity of Nature—that is, on the principle that what happens once will, under a sufficient degree of similarity of circumstances, happen again as often as the same circumstances recur. The application is this: The fact that different things belong to the same class constitutes the similarity of circumstances, and the induction is good, provided this similarity is "sufficient." What happens once is, that a number of these things are found to have a certain character; what may be expected, then, to happen again as often as the circumstances recur consists in this, that all things belonging to the same class should have the same character.

This analysis of induction has, I venture to think, various imperfections, to some of which it may be useful to call attention. In the first place, when I put my hand in a bag and draw out a handful of beans, and, finding three-quarters of them black, infer that about three-quarters of all in the bag are black, my inference is obviously of the same kind as if I had found any larger proportion, or the whole, of the sample black, and had assumed that it represented in that respect the rest of the contents of the bag. But the analysis in question hardly seems adapted to the explanation of this *proportionate* induction, where the conclusion, instead of being that a certain event uniformly happens under certain circumstances, is precisely that it does not uniformly occur, but only happens in a certain proportion of cases. It is true that the whole sample may be regarded as a single object, and the inference may be brought under the formula proposed by considering the conclusion to be that any similar sample will show a similar proportion among its constituents. But this is to treat the induction as if it rested on a single instance, which gives a very false idea of its probability.

In the second place, if the uniformity of Nature were the sole warrant of induction, we should have no right to draw one in regard to a character whose constancy we knew nothing about. Accordingly, Mr. Mill says that, though none but white swans were known to Europeans for thousands of years, yet the inference that all swans were white was "not a good induction," because it was not known that color was a usual generic character (it, in fact, not being so by any means). But it is mathematically demonstrable that an inductive inference may have as high a degree of probability as you please independent of any antecedent knowledge of the constancy of the character inferred. Before it was known that color is not usually a character of *genera*, there was certainly a considerable probability that all swans were white. But the further study of the *genera* of animals led to the induction of their non-uniformity in regard to color. A deductive application of this general proposition would have gone far to overcome the probability of the universal whiteness of swans before the black species was discovered. When we do know anything in regard to the general constancy or inconstancy of a character, the application of that general knowledge to the particular class to which any induction relates, though it serves to increase or diminish the force of the induction, is, like every application of general knowledge to particular cases, deductive in its nature and not inductive.

In the third place, to say that inductions are true because similar events happen in similar circumstances—or, what is the same thing, because objects similar in some respects are likely to be similar in others—is to overlook those conditions which really are essential to the validity of inductions. When we take all the characters into account, any pair of objects resemble one another in just as many particulars as any other pair. If we limit ourselves to such characters as have for us any importance, interest, or obviousness, then a synthetic conclusion may be drawn, but only on condition that the specimens by which we judge have been taken at random from the class in regard to which we are to form a judgment, and not selected as belonging to any sub-class. The induction only has its full force when the character concerned has been designated before examining the sample. These are the essentials of induction, and they are not recognized in attributing the validity of induction to the uniformity of Nature. The explanation of induction by the doctrine of probabilities, given in the last of these papers, is not a mere metaphysical formula, but is one from which all the rules of synthetic reasoning can be deduced systematically and with mathematical cogency. But the account of the matter by a principle of Nature, even if it were in other respects satisfactory, presents the fatal disadvantage of leaving us quite as much afloat as before in regard to the proper method of induction. It does not surprise me, therefore, that those who adopt this theory have given erroneous rules for the conduct of reasoning, nor that the greater number of examples put forward by Mr. Mill in his first edition, as models of what inductions should be, proved in the light of further scientific progress so particularly unfortunate that they had to be replaced by others in later editions. One would have supposed that Mr. Mill might have based an induction on *this* circumstance, especially as it is his avowed principle that, if the conclusion of an induction turns out false, it cannot have been a good induction. Nevertheless, neither he nor any of his scholars seem to have been led to suspect, in the least, the perfect solidity of the framework which he devised for securely supporting the mind in its passage from the known to the unknown, although at its first trial it did not answer quite so well as had been expected.

IV.

When we have drawn any statistical induction—such, for instance, as that one-half of all births are of male children—it is always possible to discover, by investigation sufficiently prolonged, a class of which the same predicate may be affirmed universally; to find out, for instance, *what sort of* births are of male children. The truth of this principle follows immediately from the theorem that there is a character peculiar to every possible group of objects. The form in which the principle is usually stated is, that *every event must have a cause.*

But, though there exists a cause for every event, and that of a kind which is capable of being discovered, yet if there be nothing to guide us to the discovery; if we have to hunt among all the events in the world without any scent; if, for instance, the sex of a child might equally be supposed to depend on the configuration of the planets, on what was going on at the antipodes, or on anything else—then the discovery would have no chance of ever getting made.

That we ever do discover the precise causes of things, that any induction whatever is absolutely without exception, is what we have no right to assume. On the contrary, it is an easy corollary, from the theorem just referred to, that every empirical rule has an exception. But there are certain of our inductions which present an approach to universality so extraordinary that, even if we are to suppose that they are not strictly universal truths, we cannot possibly think that they have been reached merely by accident. The most remarkable laws of this kind are those of *time* and *space.* With reference to space, Bishop Berkeley first showed, in a very conclusive manner, that it was not a thing *seen*, but a thing *inferred.* Berkeley chiefly insists on the impossibility of directly seeing the third dimension of space, since the retina of the eye is a surface. But, in point of fact, the retina is not even a surface; it is a conglomeration of nerve-needles directed toward the light and having only their extreme points sensitive, these points lying at considerable distances from one another compared with their areas. Now, of these points, certainly the excitation of no one singly can produce the perception of a surface, and consequently not the aggregate of all the sensations can amount to this. But certain relations subsist between the excitations of different nerve-points, and these constitute the premises upon which the hypothesis of space is founded, and from which it is inferred. That space is not immediately perceived is now universally admitted; and a mediate cognition is what is called an inference, and is subject to the criticism of logic. But what are we to say to the fact of every chicken as soon as it is hatched solving a problem whose data are of a complexity sufficient to try the greatest mathematical powers? It would be insane to deny that the tendency to light upon the conception of space is inborn in the mind of the chicken and of every animal. The same thing is equally true of time. That time is not directly perceived is evident, since no lapse of time is present, and we only perceive what is present. That, not having the idea of time, we should ever be able to perceive the flow in our sensations without some particular aptitude for it, will probably also be admitted. The idea of force—at least, in its rudiments—is another conception so early arrived at, and found in animals so low in the scale of intelligence, that it must be supposed innate. But the innateness of an idea admits of degree, for it consists in the tendency of that idea to present itself to the mind. Some ideas, like that of space, do so present themselves irresistibly at the very dawn of intelligence, and take possession of the mind on small provocation, while of other conceptions we are prepossessed, indeed, but not so strongly, down a scale which is greatly extended. The tendency to personify every thing, and to attribute human characters to it, may be said to be innate; but it is a tendency which is very soon overcome by civilized man in regard to the greater part of the objects about him. Take such a conception as that of gravitation varying inversely as the square of the distance. It is a very simple law. But to say that it is simple is merely to say that it is one which the mind is particularly adapted to apprehend with facility. Suppose the idea of a quantity multiplied into another had been no more easy to the mind than that of a quantity raised to the power indicated by itself—should we ever have discovered the law of the solar system?

It seems incontestable, therefore, that the mind of man is strongly adapted to the comprehension of the world; at least, so far as this goes, that certain conceptions, highly important for such a comprehension, naturally arise in his mind; and, without such a tendency, the mind could never have had any development at all.

How are we to explain this adaptation? The great utility and indispensableness of the conceptions of time, space, and force, even to the lowest intelligence, are such as to suggest that they are the results of natural selection. Without something like geometrical, kinetical, and mechanical conceptions, no animal could seize his food or do anything which might be necessary for the preservation of the species. He might, it is true, be provided with an instinct which would generally have the same effect; that is to say, he might have conceptions different from those of time, space, and force, but which coincided with them in regard to the ordinary cases of the animal's experience. But, as that animal would have an immense advantage in the struggle for life whose mechanical conceptions did not break down in a novel situation (such as development must bring about), there would be a constant selection in favor of more and more correct ideas of these matters. Thus would be attained the knowledge of that fundamental law upon which all science rolls; namely, that forces depend upon relations of time, space, and mass. When this idea was once sufficiently clear, it would require no more than a comprehensible degree of genius to discover the exact nature of these relations. Such an hypothesis naturally suggests itself, but it must be admitted that it does not seem sufficient to account for the extraordinary accuracy with which these conceptions apply to the phenomena of Nature, and it is probable that there is some secret here which remains to be discovered.

V.

Some important questions of logic depend upon whether we are to consider the material universe as of limited extent and finite age, or quite boundless in space and in time. In the former case, it is conceivable that a general plan or design embracing the whole universe should be discovered, and it would be proper to be on the alert for some traces of such a unity. In the latter case, since the proportion of the world of which we can have any experience is less than the smallest assignable fraction, it follows that we never could discover any *pattern* in the universe except a repeating one; any design embracing the whole would be beyond our powers to discern, and beyond the united powers of all intellects during all time. Now, what is absolutely incapable of being known is, as we have seen in a former paper, not real at all. An absolutely incognizable existence is a nonsensical phrase. If, therefore, the universe is infinite, the attempt to find in it any design embracing it as a whole is futile, and involves a false way of looking at the subject. If the universe never had any beginning, and if in space world stretches beyond world without limit, there is no *whole* of material things, and consequently no general character to the universe, and no need or possibility of any governor for it. But if there was a time before which absolutely no matter existed, if there are certain absolute bounds to the region of things outside of which there is a mere void, then we naturally seek for an explanation of it, and, since we cannot look for it among material things, the hypothesis of a great disembodied animal, the creator and governor of the world, is natural enough.

The actual state of the evidence as to the limitation of the universe is as follows: As to time, we find on our earth a constant progress of development since the planet was a red-hot ball; the solar system seems to have resulted from the condensation of a nebula, and the process appears to be still going on. We sometimes see stars (presumably with systems of worlds) destroyed and apparently resolved back into the nebulous condition, but we have no evidence of any existence of the world previous to the nebulous stage from which it seems to have been evolved. All this rather favors the idea of a beginning than otherwise. As for limits in space, we cannot be sure that we see anything outside of the system of the milky-way. Minds of theological predilections have therefore no need of distorting the facts to reconcile them with their views.

But the only scientific presumption is, that the unknown parts of space and time are like the known parts, occupied; that, as we see cycles of life and death in all development which we can trace out to the end, the same holds good in regard to solar systems; that as enormous distances lie between the different planets of our solar system, relatively to their diameters, and as still more enormous distances lie between our system relatively to its diameter and other systems, so it may be supposed that other galactic clusters exist so remote from ours as not to be recognized as such with certainty. I do not say that these are strong inductions; I only say that they are the presumptions which, in our ignorance of the facts, should be preferred to hypotheses which involve conceptions of things and occurrences totally different in their character from any of which we have had any experience, such as disembodied spirits, the creation of matter, infringements of the laws of mechanics, etc.

The universe ought to be presumed too vast to have any character. When it is claimed that the arrangements of Nature are benevolent, or just, or wise, or of any other peculiar kind, we ought to be prejudiced against such opinions, as being the offspring of an ill-founded notion of the finitude of the world. And examination has hitherto shown that such beneficences, justice, etc., are of a most limited kind—limited in degree and limited in range.

In like manner, if any one claims to have discovered a plan in the structure of organized beings, or a scheme in their classification, or a regular arrangement among natural objects, or a system of proportionality in the human form, or an order of development, or a correspondence between conjunctions of the planets and human events, or a significance in numbers, or a key to dreams, the first thing we have to ask is whether such relations are susceptible of explanation on mechanical principles, and if not they should be looked upon with disfavor as having already a strong presumption against them; and examination has generally exploded all such theories.

There are minds to whom every prejudice, every presumption, seems unfair. It is easy to say what minds these are. They are those who never have known what it is to draw a well-grounded induction, and who imagine that other people's knowledge is as nebulous as their own. That all science rolls upon presumption (not of a formal but of a real kind) is no argument with them, because they cannot imagine that there is anything solid in human knowledge. These are the people who waste their time and money upon perpetual motions and other such rubbish.

But there are better minds who take up mystical theories (by which I mean all those which have no possibility of being mechanically explained). These are persons who are strongly prejudiced in favor of such theories. We all have natural tendencies to believe in such things; our education often strengthens this tendency; and the result is, that to many minds nothing seems so antecedently probable as a theory of this kind. Such persons find evidence enough in favor of their views, and in the absence of any recognized logic of induction they cannot be driven from their belief.

But to the mind of a physicist there ought to be a strong presumption against every mystical theory; and therefore it seems to me that those scientific men who have sought to make out that science was not hostile to theology have not been so clear-sighted as their opponents.

It would be extravagant to say that science can at present disprove religion; but it does seem to me that the spirit of science is hostile to any religion except such a one as that of M. Vacherot. Our appointed teachers inform us that Buddhism is a miserable and atheistical faith, shorn of the most glorious and needful attributes of a religion; that its priests can be of no use to agriculture by praying for rain, nor to war by commanding the sun to stand still. We also hear the remonstrances of those who warn us that to shake the general belief in the living God would be to shake the general morals, public and private. This, too, must be admitted; such a revolution of thought could no more be accomplished without waste and desolation than a plantation of trees could be transferred to new ground, however wholesome in itself, without all of them languishing for a time, and many of them dying. Nor is it, by-the-way, a thing to be presumed that a man would have taken part in a movement having a possible atheistical issue without having taken serious and adequate counsel in regard to that responsibility. But, let the consequences of such a belief be as dire as they may, one thing is certain: that the state of the facts, whatever it may be, will surely get found out, and no human prudence can long arrest the triumphal car of truth—no, not if the discovery were such as to drive every individual of our race to suicide!

But it would be folly to suppose that any metaphysical theory in regard to the mode of being of the perfect is to destroy that aspiration toward the perfect which constitutes the essence of religion. It is true that, if the priests of any particular form of religion succeed in making it generally believed that religion cannot exist without the acceptance of certain formulas, or if they succeed in so interweaving certain dogmas with the popular religion that the people can see no essential analogy between a religion which accepts these points of faith and one which rejects them, the result may very well be to render those who cannot believe these things irreligious. Nor can we ever hope that any body of priests should consider themselves more teachers of religion in general than of the particular system of theology advocated by their own party. But no man need be excluded from participation in the common feelings, nor from so much of the public expression of them as is open to all the laity, by the unphilosophical narrowness of those who guard the mysteries of worship. Am I to be prevented from joining in that common joy at the revelation of enlightened principles of religion, which we celebrate at Easter and Christmas, because I think that certain scientific, logical, and metaphysical ideas which have been mixed up with these principles are untenable? No; to do so would be to estimate those errors as of more consequence than the truth—an opinion which few would admit. People who do not believe what are really the fundamental principles of Christianity are rare to find, and all but these few ought to feel at home in the churches.

ON BRAIN-FORCING.

By T. CLIFFORD ALLBUTT, M. A., M. D.

WHEN the editors of *Brain* sought my aid in the construction of this first number, I felt the honor they did me was not to be lightly refused; but, on the other hand, painfully aware that of late years my life had lain too much in the world to have led me to those results which are won by the patient labor of the student. From direct examination into the finer shapes of brain and nerve of late years, I have become too much estranged; but I trust that observations in the field of practice may compensate, in some measure, the want of closer and more accurate research. On one subject I have long been fain to speak, for it is one in which I am exercised almost daily; moreover, I venture to hope it is not foreign to the purposes of this magazine. Almost daily I am in contention with parents and guardians, schoolmasters and schoolmistresses, clergymen and professors, youths and maidens, boys and girls, concerning the right way of building up the young brain, of ripening the adult brain, and of preserving the brain in age. Grievously ill do we take in hand to deal with this delicate member, and well is it that innate development overruns our schemes and brings the variety of natural good out of the monotony of human folly. It is dimly felt by society that the reign of bone and muscle is over, and that the reign of brain and nerve is taking its place. Even the Gibeonites now have the hydraulic ram and the steam felling-machine; the spectacled general of forces fights in his tent by click of battery and wire, and his lieutenant hoists an iron-clad by the touch of two buttons upon his waistcoat; the patient earth forgets the tread of horse and ox, and is ploughed by steam; and ere long, no doubt, our ministers will wind sermons out of barrel-organs, and our morning egg will be broken for us by a wafer of dynamite. Hence it comes that all classes are for "education!" The village grocer's son goes to a "theological college," and sits up by night over his "Evidences" with green tea in his blood, and a wet cloth about his brows. The gardener's daughter pulls roses no more, and has become a pupil-teacher; she is chlorotic at sixteen, and broken-spirited at twenty. The country parson's son goes to a civil service or a navy "coach," is plucked in his teens, and is left to begin life again with an exhausted brain and an incurable megrim; nay, even the sons of peers are putting on the armor of light, and are deserting the field for the counting-house. To meet this demand, colleges of all kinds and degrees spring up—middle-class seminaries, theological colleges, colleges of science, university boards—even the old universities themselves are stirring from their scholarly ease, are sending out missionaries *in partibus*, and are cramming the youth of twenty counties in the art of making most show with least learning. All this, in a way, no doubt, must be and should be; but so sudden a volte-face cannot be made without a wrench, and it is my desire now to see where the strain will tell, and how to perform our social evolution with the least injury to persons.

Like the alderman of New York, who found it impossible to propose the paving of a street without allusion to the first lines of the Constitution of the United States, so I must venture to preface my essay by some reference to mental function as we find it. We may see the more clearly how to direct and combine our means of culture when we recognize its purposes. Mental philosophy is a subject in which I am little versed, but I must try in some familiar fashion to classify the aspects of nervous activity as they appear to ordinary observers. Without misleading error, and with much convenience, I may regard these activities from the following five points of view, namely, their Quality, their Quantity, their Tension, their Variety, and their Control.

By the higher quality of the brain, or of a part of it, I mean that structure of cell and fibre which corresponds more widely or more intimately with outer conditions, so that by virtue of such relation the individual more readily apprehends things and conceives them. This is genius in the stricter sense. By quantity I mean the volume of nerve-force given off by the brain or its parts, without regard to quality of work done. By tension I mean the power in the nerve-action to overcome inner or outer resistance—"nervous energy," as it is colloquially called. By variety I mean the congregation of different centres, and the weaving of mediate strands which give the possessor, not higher or wider, but a greater number of relations with outer things. In common life this is usually called versatility. By control I mean that subordination of one centre to another, whether inherited or acquired, which if of the lower to the higher results in obedience to the more permanent order of the universe. Thus a man may have a lofty, an abundant, an intense, a versatile, and a well-ruled nervous system, or he may have any measure of each of these states in various proportions.

Goethe, whose life and character are so well known to us, seems to have possessed all these faculties in marvelous combination. His insight or brain quality was vast and penetrating; his stores of nervous energy were inexhaustible, burning with steadfast heat or flaming in passion; his faculties were infinite in variety, and they were under a control rarely in the world's history known to have harmonized endowments so manifold and so potent. To take in like manner a few more names by way of illustration, we may consider Lord Byron as one in whom quality and tension of nervous force were more remarkable than quantity, though this in him was not inconsiderable, and in whom variety was less manifest and control defective. Schiller, again, had high quality, tension, and control, but was defective in endurance and in variety. In Keats we recognize quality, tension, and variety, in high degrees; control in less measure, and quantity in defect. His brain, inconstant in current, was worn out ere it was built up. Macaulay was, if the word be permitted to me, a remarkable "all-round" man, and presented an equable development of quality, quantity, tension, variety, and control, though of course he is not to be compared to the former examples in quality. Brougham had still less quality, but quantity in overflow and at high tension. Sir James Simpson, again, always seemed to me a good instance of a man lacking the higher complexities of brain, but abounding in mental force at high tension. In him also variety was striking, more striking than control. One of the most vivid instances of nervous energy at high tension to be found in modern history is perhaps Admiral Korniloff, as described by Mr. Kinglake, in the fourth volume of the cabinet edition of his "History of the Crimean War" (page 108). He says of Korniloff:

"It can hardly be shown that this chief was gifted with original genius, still less with piercing intellect; nor was Korniloff to be called precisely an enthusiast. Our knowledge of Korniloff must rest upon a perception of what people did when they felt the impulsion he gave. At a time when there seemed to be room but for despair and confusion, he took that ascendant which enabled him to bring the whole people in this place—inhabitants, soldiers, sailors—to his own heroic resolve. In a garrison town of an empire which had carried the mania of military organization to the most preposterous lengths, all those straitened notions of rank and seniority, and, in short, the whole network of the formalisms which might have been expected to hinder his command, flew away like chaff at the winnowing. By the fire of his spirit there was roused so great an energy on the part of thousands of men as has hardly been known in these times; and he so put his people in heart, that not only the depression created by defeat, but the sense of being abandoned and left for sacrifice by the evading army, was succeeded by a quick growth of warlike pride, by a wholesome ardor for the fight, by an orderly, joyous activity."

We may compare with this the description by the same fine hand of General Todleben, in whom quality and quantity of brain, variety of resource and of smiling self-control, were all made efficient by high tension. Mr. Kinglake says:

"Although Todleben seemed to be one to whom the very labors of fighting and of exterminating the weaker breeds of men must be an easy and delightful exertion of natural strength, he had joyous, kind-looking eyes, almost ready to melt with good-humor, and a bearing and speech so frank and genial, strangers were instantly inclined to like, and very soon after to trust in him. From his looks and demeanor, it could not at all be inferred that he was a man who had devoted his mind to a science; nor imagined that his power of doing the right thing at the right time had been warped at all by long study of the engineering art. . . . Few men of great intellect have attained so closely what Englishmen mean by practical."

How great quality and quantity of brain may fall short of achievement, for lack of high tension rather than of control, must be sought in the story of "Hamlet" and like inventions; for, although the unhappy General Trochu is not yet quite forgotten, none such leave an enduring name. How many of us know that quiet friend unnoted of the many, unfelt by the world; whose powers of assimilating knowledge are great, whose intellect is capacious, and whose accomplishments are manifold, but whose nerve-currents are of low or inconstant tension! He finishes no work, he fathoms no research, and he dies leaving but the memory of great powers wasted. Other curious instances of low tension are seen in those unhappy mortals who conceive so truly, and have mental force in such quantity, that they spend their lives in bestowing volumes of good advice upon their fellows, but who never rouse themselves to their own work or duty.

How, lastly, the greatest quality and capacity of mind, varied attainments, and spiritual fire, may be spent as a sky-rocket is spent for lack of control and direction, has been the theme of moralists of all centuries, from the death of Abel to our own time. Of all endowments control is the most precious, and its nurture our most bounden duty. For a happy and useful life, perhaps control is more needful than quality, volume, variety or even tension of brain. But, were not men born to us whose high qualities of brain enable them to see more deeply into the secrets of Nature, our progress would cease; did quantity of brain-force cease from a people, that people would lack endurance; were tension feeble, the lions would roar on in the paths of our enterprise; were self-control wanting, that which were won would hardly be won ere it was lost. Of all gifts, then, to be cherished and nurtured, perhaps we should place first control, as by it effort is husbanded; perhaps of equal or scarcely of the second place comes tension; quality of brain cannot be had for the asking, and lack of quantity in individuals may be compensated by numbers. Variety, however charming, however grateful, is the least precious of these conditions of brain, and is the last which calls for nurture. How, then, are we so to wield our instruments of education as to promote the increase of control, tension, and quantity, without stifling quality and variety, and how are we to use these virtues in the riper man without disabling him?

Quality, as I have said, cannot be had for the asking; it is fitful in its growth, and often born out of due time. It should be favored by the continuous inheritance of culture, but the mode of its epiphany lies in the same darkness with that developmental nisus which lies behind the advance of life upon the globe. Inherited, as it doubtless must be, yet its arising cannot be foreseen in the span of human generation. In the past it has more often burst forth from obscurity as the Greek and Arab from the Orient, the Roman from the Latin, the Pisan, the Genoese, the Venetian from Byzantium, the Tudor English from the England of Lancaster and Plantagenet. Men of high quality do not seem, even generally, to have sprung, like Pallas, from the brain of their fathers, but conceived in the dark womb of time to have lighted upon the world in companies. How then education, by taking thought unto itself, is to breed or make men of great initiative is a hard question. It seems clear, however, that it is not to be done simply by the wedding of brain to brain, but that for its generation may be needed some barbarous and even gross admixture, some strange coition between the sons of God and the daughters of men. But that which they who govern education can do is, to give to genius and to character a free way for expansion and action. We cannot make such a man as Edwards the naturalist of Banff, and the more sad is it that such men when born to us are too often maimed or driven by circumstance, and their gifts despoiled. That many mute, inglorious Miltons are buried in our churchyards, I venture to doubt; the fire of a Burns is not easily hidden under a bushel, but some smaller lights may thus be quenched, and the best of such men, like Burns himself, may be thwarted or broken in heart. Some may aver, and not without seeming of truth, that trial is to genius as the furnace to noble metal. But, surely, this world will always offer to its children a front stern enough for their chastisement, and a law hard enough for their contrition—there needs not the imposition of fetters of ours, nor the devices of our caprice or austerity. One born before his time, in the inertia of his own generation, will find resistance enough to try his steel. Moreover, as I have said, great quality of brain may not be associated to high tension, and a moderate resistance may be fatal to achievement. A man may not be a Luther, a Cromwell, or a Knox, but he may be a Melanchthon, a Cranmer, or a Wishart, and in favoring days may do the work which was done by the former in virtue of high tension as well as of genius.

It is too certain, on the other hand, that by stress of circumstance, zeal may be turned into fierceness, reason into tyranny, and strength into brutality; it is well, therefore, we should see that in our scheme of education we are mindful of two things: 1. That we secure perfect freedom for the individual and toleration for all opinions, and this must be done partly by the repeal of all legal privilege and partly by the gradual enlightenment of societies: 2. That in our scheme of education we give the means of it to all, and full play to individual gifts—not promoting a dull uniformity, nor pinching back the buds of mental growth; nor, on the other hand, forgetting that as great men often appear in unpromising times, so great gifts in the individual are often long in showing themselves. The early dunce often ripens into the later genius. I find this late unfolding of greater gifts, though by no means universal or perhaps even general, yet is so common that as a teacher I have schooled myself into much sympathy with dunces. An observant master may detect the pushing germs beneath the immobile surface of his pupil's mind, but such masters are rare, and perhaps nothing is lost by leaving their quickening to kindly time. Our duty is, meanwhile, not to harass or exhaust the brain prematurely by anxious culture, by stimulant or by systematic forcing. Few men can look back upon their early companionship without seeing, with a feeling akin to surprise, how the race has not always been to the swift, nor the battle to those who were strong:

> "Another race hath been, and other palms are won."

Quality of brain, then, cannot be made nor forced; consisting, moreover, as it probably does, in added ganglionic and commissural structure, it, like all more complex growth, will be late in the bud and later in the bloom. And in pointing this out it must be remembered that we are speaking not only of the rarer forms of genius, but also of character—of that which gives to each person his individual color and value. Quality of brain may, however, be lost if it is not invigorated and impelled by a strong breeze of nervous energy; nay, as in the case of the late Sir James Simpson, dauntless and inexhaustible nerve-quantity may so elevate the spirit and so strengthen the hand as to clothe the individual with a power beside that of genius itself, and urge him to work which will win the undying gratitude of men. Now, happily quantity, unlike quality, of brain-force is much under the power of education. Quantity may be conceived as lying partly in the bulk of the nerve-cells themselves, and partly in the volume of their vessels; partly also in the virtue of the blood itself. It cannot be forgotten that the health of the brain and nervous system, upon which the abundance of its fruit depends, is closely related to the tone and activity of the rest of the corporeal frame. The volume of force issuing from the brain is largely dependent, for example, upon the power of the stomach and allied viscera, upon the power of rapidly digesting and assimilating an abundance of food, and of breaking up and excreting spent material. A dyspeptic may well have nerve-force of high quality and of high tension; but I never met with a dyspeptic whose nerve-force welled continuously forth. Like Brougham and Cavour, men of great power of continuous work have usually been large as well as sound eaters. A "hard-headed" man is also a hard-bodied man, and the national history of

Europe is a long display of the successive triumphs of the men of colder over the men of warmer regions; of the hardy, lusty, and hungry races over the softer, more indolent, and more abstemious. Northern drunkenness is a survival of northern feasting and northern prowess; and the hearty Bishop of Peterborough touched a deep truth when he said he had liefer Englishmen to be drunkards than slaves. It is quantity, then, rather than other conditions of nerve-power, which is favored by "physical education," quantity without which quality may flag; but quality is also indirectly increased, for quality is born, doubtless, out of the fountains of quantity.

If it be true that the sons of genius are often fools, the explanation may be that the parent has spent his great fortune of intellect and passion, and transmitted to his offspring a sapless and atonic brain. It may be true, also, that as from the lesser robustness of women the streams of vitality in them are more slender and less perennial, so the buddings of higher genius in them are fewer and less fertile. The weaving of the higher thought and emotion is found in our experience, even of individuals, to be especially exhausting, and apt, therefore, to alternate in its function with hours of indolence, and even of depression. The greatest master cannot be unconscious of these tides in his creative work; and the lesser, seeking relief and distraction between whiles, drifts into the "Bohemian." To secure, then, quantity of nerve-force directly, and quality indirectly, the encouragement of bodily vigor and sturdy gain is fundamentally necessary. Without wealth of bone and blood, volume of nerve-force will dwindle, and the rarest quality may fail of proof, or lose its splendor. Before women can hope to do hard and high work, sense must expel sensibility, and school-girls must cease to walk out in a row, to veil their faces, to wear stays, and to eat delicately.[1] Nay, if a certain ruggedness be not foreign to mental strength and growth, it may be that women, as a class, if they will excel in originality and endurance, must cease, as a class, to seek after the charms of daintiness and sentiment.

I am not, therefore, of those who think that the love of athletics is as yet in excess. Here and there men may expend in the hunting-field or on the river that which should have been given to their tripos, to their profession, or to their country; yet this at worst is but an individual loss, far outweighed by the impulse given to the hardy, hungry vitality by which the nation thrives, and its general volume of nervous force is augmented. Again, it is an old truth that in youth production and growth or development are in a measure opponent. The gardener, the stock-breeder, the trainer, all know this and act upon the rule. The spontaneous and equable play of all sides of life favors growth and

[1] In the Girls' High-School at Leeds, a well-managed school in many respects, the girls are at work from breakfast to dinner and after dinner, with no interval for digestion, till four—for much of the year, that is, during all the daytime. Their cheeks know not wind nor sunshine.

tone; but to enter the colt for the race, to bloom and seed the young plant, or to put the young male to the stud, is to stint their growth and to exhaust their vigor. Precocity is gained at the cost of feeble maturity and early decay. And yet, can the young brain grow, cell add itself to cell, and fibre knit itself to fibre, without work and play? Can the slack sinew be braced, or the muscle which is idle be increased? To this I would reply that the activity which feeds the waxing strand and ganglion is rather receptive than productive.[1] It is easy to forget how the child and the youth drink in knowledge and virtue imperceptibly as the green leaves spread themselves and feed upon the air. By an equable tide flowing in from every side—by the channels of the senses, by the universal surface of the skin—the inner chambers of the nervous system are expanded, and stored with riches for future profusion. The mischief done daily by calling upon the unripe brain for productive work, for original composition,[2] for competitive examinations, for teaching, and even for preaching, is calamitous, and the evil is increasing. The impatient examinations of young children are as injurious and as foolish as the searching of the roots of the pushing plant. Cram, again, is that which secures the immediate production of brain-results rather than the growth of the brain itself; and it must be thrusting itself upon the vision of all but the moon-struck, that young men who are prize-winners at the ages even of eighteen or twenty years have too often spent their brains before the natural yielding-time. Too often the star of their year is quenched ere their course be well begun, and if their life be not henceforth a failure it may fall far short of its early promise; and the brain which might have been year by year more flexible, more potent, and more enterprising, is warped, stiffened, and staled. Such young men are now sent into the world in numbers, with minds orderly, trim, and garnished, but without *élan*, and without initiative—admirable clerks and formalists—but as men of action spoiled forever.

Pupil-teachers, again, present a curious subject for observation, and a sad one. Called upon as children to teach children, their brains turn backward, or stop at the stage they have attained, and the living stream of thought is congealed into a dead dogmatism. Their minds, no longer open to the dew of knowledge from above, are bent to the work of churning vapid juices for yet callower nurslings. Nor is this all: the striving and jaded brain sucks the kindly sap from the rest of the body, and the weaker sex more especially tend in their years of puberty to become pallid and enfeebled, or to break down altogether between the rival claims of mind and body. Other cases, of which my note-books are full, are those in which brain-power is run low in youth by the untimely pressure of business and of heavy responsibilities. A father

[1] That receptiveness of brain, its play and its productiveness, are but various degrees of function I do not forget, but few differences of degree are more clearly distinguishable.

[2] I believe in many schools mere children are ordered to write "original" essays on set subjects.

dies, leaving his son, aged twenty or less, to carry on a large business, to pay his mother and sisters out of the concern, and to educate his younger brothers. Stanch to the backbone, the lad throws himself ardently into life, carries at twenty years the burdens of forty, pushes onward upon excitement and in ignorance of the mischief doing, labors for a few years or more according to his stores, and falls to pieces ere middle life is reached, and when his powers should be at their best. We label their cases "dyspepsia," "nervous debility," "mental disease," and the like. I refrain from giving scores of them.

But most disastrous, perhaps, of all means of dissipating the stores of the unformed brain are the preaching-tasks of the theological colleges, and especially of the nonconformist colleges. These colleges are filled with young men—ambitious, of generous impulses, and fervent temper—and their teachers, as seems curiously true of schoolmasters as a class, are utterly unconscious of the existence of the science of physiology. These hapless lads are not only spurred on to intense and prolonged study during the week, but are called upon to preach. I do not mean that they are merely taught to use the voice and gesture, which are the instruments of oratory, but they are actually set up to address congregations of people. I will say nothing of those hearers who find edification in the raw dogmatism of an undergraduate, or spiritual increase in the forced and jejune exhortations of striplings to whom spiritual experience is yet unknown; but I will say of the 'prentice preachers themselves that the system is immeasurably cruel. A luckless youth is forced to heat the yet empty chambers of his brain, and to forge false thunder therein at an age when he needs rather to sit at the feet of wisdom. Space forbids me to give instances from my books, but the facts are open to others as to myself. Men whose steps are faltering upon the very threshold of the ministry come to me lamenting that the hope and the fervor, the peace and the joy of their initiation have fled, and in their place are listlessness, weariness, confusion of mind—nay, even satiety and disgust. Their teachers urge them to drown their reaction in more work, and in unhealthy self-examinations. Pallid, dyspeptic, peevish, sleepless, disheartened, many of them creep into orders to come in later years to the physicians, almost cursing themselves because their labors are unfruitful, because they cannot sit down to think nor stand up to pray. The explanation is too clear. The brain has been forced, and has borne insipid fruit out of due season. It may never recover its tone, or recover it only after a long season of rest. It is sad to think how many young ministers have come to me alone with such a history—men otherwise of promise, but whose best efforts have been but as the crackling of thorns under the pot.

We do not realize how long a time the exhausted brain takes to recover itself! A young physician may boldly tell the overtaxed merchant or student to take three months' rest; but probably three months must be added to that, and even six months again to the sum, before any degree of stability is regained. It is nearly always true that a case of brain-exhaustion needs what may seem a disproportionate time to get well. Repair in so delicate an organ is slow, and we know that gardeners and breeders would rather start afresh with young stock than nurse round specimens which have been checked. Yet Englishmen are courageous and enduring, and many fight into the ministry without consciousness of harm. Nevertheless, I would ask concerning even these —if there be found in them any lack of quick and exquisite thought, of keen and catholic vision, of deep and tender passion; or if there be in them any delight in phrases, and any shrinking from realities; any bondage to convention and prejudice, any blenching from the service of perfect freedom—whether the forcing and hustling of their brains in earlier life have not straitened their conceptions, and checked their mental sweetness, freshness, and enterprise.

Another kind of premature brain-forcing is seen in young artists. Young musicians, especially, abandon themselves with perfervid ingenuity, not merely to discipline and culture, but also to original composition and to excessive display. Hence, as the passion of music is of early manifestation, and the vanity of parents insatiable, we find the history of musicians is one long wail over brilliant promise and early exhaustion or death. It is as true of music as of every other art, that its greatest works are works not of youth but of manhood, not of tender age but of maturity. Schubert died at the age of thirty-one, Mendelssohn at the age of thirty-six, Mozart at the age of thirty-six—these, like many other masters prodigiously, even wastefully, productive in the days of their spring, were worn out when their transcendent genius should have borne its harvest. Even in music we find the most lustrous and immortal works were the works not of youth, nor of early manhood, but of riper years; of masters who were endowed with inexhaustible well-springs of force in body and brain, or who had husbanded their stores in earlier days. Händel composed his great oratorios after he had passed his fiftieth year. Sebastian Bach wrote the "B Minor Mass" at the age of forty-eight, and the two "Passions" somewhat later still. Beethoven wrote the "A Major Symphony" and the "Eroica" between the ages of thirty-four and forty-four: he had thus reached formal excellence, and had he then died would, like Mendelssohn, have bequeathed a great name to posterity. Happily he lived on to write his grandest works, such as the "Ninth Symphony" and the "Missa Solennis," after the age of forty-five. If we turn to our own day and regard the life of a genius who, in quality and quantity of brain-activity with tremendous tension and infinite variety, occupies a position perhaps unique—I speak of Richard Wagner—we find he was born at Leipsic in the year 1813, and is now therefore sixty-five years of age, so that "Lohengrin" and the "Ring des Nibelungen" are the works of years more than mature. I will not pursue this argument with the other creative arts, nor stay to prove that works like the "Paradise Lost," the

"Divina Commedia," and "The Tempest," are works not of youth but of age.[1]

I must pass on to consider brain-work under the head of tension. Tension, I believe, depends in some way upon the tides of the blood-vessels—upon their rapidity, perhaps—and more especially upon the rapid distribution of blood in particular directions. It may well be a matter of the *nervi vasorum*. Probably also some relation of capillary to cell, which favors rapid absorption, enters into the matter; for we see that tension diminishes with age—with the susceptibility of nerve and arteriole. It is a factor of infinite value to the man. "Learning," says Falstaff, "is a mere hoard of gold kept by a devil till sack commences it and sets it in act and use" ("King Henry IV.," book iv., scene 3). We may regard tension under several aspects, as in the keen tenacity of intellectual work in such a master as Newton, when it is associated with lofty and powerful control; or again in vivacious temperaments, where control is often less complete. In those "whom Englishmen delight to call practical" we see it associated with dexterity, with readiness of resource, and with keenness of the special senses. This invaluable attribute is happily much under the influence of education. Compare, for instance, the slow wit of the rustic with the mental alertness of the "joly prentis of Chepe." Education can not only instruct the mind, but can make it apprehensive, nimble, and even fiery. "It is of no use to know a thing," we often say to our bedside students, "unless you can deliver yourself of your knowledge." The brain must not be a silent receptacle, but, to use the old phrase, must be a "copious promptuary" of learning and device. In this paragraph, then, we take not the contrary, but the converse of the former, and, while remembering that quantity and quality of nerve-force are diminished by calling upon the tender brain for production, tension, on the other hand, is promoted by busying the student with his work, and by stimulating him with a sense of his duties and of his just ambitions. Hence class-tests and even class-competitions, and the due use of the spur, are to be encouraged so far as they favor readiness, quick and accurate observation, and modest rivalries, but not so far as to call for "original compositions," for heated and straining effort, or for the rapid disgorgement of bolted and undigested book-work. Tension, then, is an endowment of Nature, or is increased by education and example, and especially by the personal influence of an earnest and practical teacher, and by the

[1] The visitor who has lately returned from the magic show of Turner Drawings now in Bond Street, will doubtless remember Mr. Ruskin's words on the opening page of his "Guide," wherein he says of Turner, "He produced no work of importance till he was past twenty—working constantly, from the day he could hold a pencil, in steady studentship, with gradually-increasing intelligence." Of the master's work done between the ages of fifty-five and sixty-five, Mr. Ruskin says (page 9), "In this period he produces his most wonderful work in his own special manner—in the perfect pieces of it, insuperable." In the Slade School at Kensington, subjects are given out for original work, a system which, in my judgment, is more likely to do harm than good.

informing of eye and hand rather than by the straining of thought and memory. Unlike quantity, tension is not immediately dependent upon physical health. Neuralgic and dyspeptic persons often possess this virtue in high degree, and indeed fasting is said by spiritual teachers to intensify mental action. If quantity, however, be not added to tension, great passion or great action is followed by utter exhaustion and depression; and, where high mettle and enduring force are combined, we obtain the greatest results. Certain drugs, such as strychnine, have the property of heightening the tension of nerve; and others, such as iron and cod-liver oil, of enriching it in quantity. In the combination of the two kinds we have the most precious medicines. The so-called "nervous children"—products of a later civilization—need especially the benefits of quantity and control, and intelligent parents secure this by restraining scholastic pressure, by enforcing a regular discipline, and by encouraging physical development.

That endowment which I have called Variety or versatility is also partly innate and partly acquired, but chiefly innate.[1] It must consist in the accretion of a greater number of ganglia and of interweaving fibres. This is not unfavorable to quantity of nerve-force, but perhaps it is unfavorable to the quality or high development of special ganglionic groups, and also to tenacity or steadfast intensity. The schoolmaster therefore abhors versatility, and that greater schoolmaster, the world, grinds it to dust. Without variety the pedant loses the sense of the infinite interests and conditions of life; with variety and without penetration the *dilettante* is ignorant of the depths of his own ignorance. The pedant denies that any knowledge should be taken in small quantities, the *dilettante* is repelled by the isolation of limited research. It would seem to be the aim of good education to insist upon a mastery of one or more subjects, that the grown man should be able to fight with the foremost, to concentrate his powers, and to realize what knowledge is, but that at the same time he should gain some not inadequate notion of the whole field of the battle of life. He will thus gain in sympathy and flexibility of mind, while he is saved from the "failing of omniscience." A happy citizen of the republic of learning must have culture at once liberal and profound, at once general and special; to such a one a little knowledge is no longer a dangerous thing.

Finally, Control is partly innate, but greatly the creature of education. It is, I believe, the earliest work of education, the safest work and the most abiding. As an innate virtue it consists, no doubt, in the superposition of more complex or higher centres upon the lower and upon the weaving of these together by commissures of various orders. These ganglia and fibres, sketched out as it were by inheritance, are nourished and developed by use, i. e., by education. By use

[1] Diderot is the most brilliant instance of the Various man I can at present call to mind.

lines of least resistance are established, and thus habits are formed. A man cannot bite his nails without fingers and teeth, nor can habits be formed in the mind without the preëxistence of conflicting ganglia, but it is infinitely important to test the child for their presence, and to set up in them certain lines of movement, and certain coincident memories or "associations." Thus also appears the Will, that is the revelation to consciousness of the balancing of the faculties, though where consciousness enters we know not, and shall never know on this side of the grave. No mistake, then, is more fatal than that of parents who let children run wild, on the pretense of physical development. This, indeed, they may obtain, and how guarded we are to be in forcing the brain I need not say again; but there can be no misfortune to a child greater than to escape the life of justice, order, and rule, or to escape the training of those perceptions of social needs and social laws which, when graven in our ganglia and long current in our nerves, become habits of sympathy, charity, and self-sacrifice. Herein I fear that the partisans of "secular" education are greatly at fault. Children may be trained in board-schools to habits of cleanliness and order, but they are not trained in the principles of liberty, nor are their eyes turned to the sanctions of religion. From this system I fear there may be a sad awakening for a coming generation. I may sum up thus: The powers of the nervous system with which education is chiefly concerned are Quality, Quantity, Tension, Variety, and Control. Quality is beyond the direct efforts of education; its rarer development, both in nations and individuals, is as yet incalculable: in the early life of the individual it is often latent, and its greatest results belong to years of maturity. On the other hand, education may often overlay it, thwart it, or expend it, and, as quality is largely dependent upon quantity or volume of nerve-force, the ripening of those degrees of it which exist in ordinary men, and the favoring of those revelations of it which occur more rarely, are constantly prevented by brain-forcing in early life. In men of great quality or genius such brain-forcing has too often dimmed or blighted the splendor of their work, or has shortened their days, and has only failed to do so in others by virtue of their perennial springs of inward energy. Quantity, therefore, is a very fruitful possession, and, unlike quality, may be directly reënforced by wholesome conditions—by physical education, and by the promotion of healthy and rapid digestion, assimilation, and excretion.

Tension is a virtue without which quality and quantity of nerve-force may be wasted. By it men overcome resistance, and are fired with impulse. Promptness, alertness, and acute sense, come also of this attribute. Tension may be increased greatly by education, and it springs up in the busier contentions of men. It is largely independent of physical health and of food, but is favored by action and the training of observation. Variety, by which men are enabled to touch the world at many points, can be favored by education. If in excess, it results in aimless dissipation of energy; if duly consorted with full knowledge of one or more subjects, it gives breadth and flexibility to the intellect, and promotes the happiness of personal and social life; it favors general progress by permitting the more rapid diffusion of the knowledge won by the few. Lastly, control is eminently a creature of education, and is perhaps the most precious gift of the individual man. Without justice, temperance, and definite industry, the most brilliant attributes of mind may be impotent for good, and without the habit of social subordination and the bond of social sympathy the most brilliant society would be but a rope of diamonds. Brain-forcing is terribly mischievous. It urges genius into precocious fruitage, it drains the springs of nervous force, it excites high tension without giving volume to fortify it, it stints the variety of mental expansion, and by enforcing control it breaks the spirit. The true purpose of education is, first of all, to teach discipline—the discipline of the body, and the higher discipline of the mind and heart; to encourage the budding faculties to break freely in natural variety; to quicken the eye and the hand, and to touch the lips with fire; to promote the gathering of the fountains of vigorous life by fresh air, simple nutritious diet, and physical exercise; and, finally, to watch for the growth, silent it may be for years, of the higher qualities of character, or even of genius, not forcing them into heated and froward activity, but rather restraining the temptation to early production, and waiting for the mellowness of time: remembering that the human mind is not an artificial structure, but a natural growth; irregular, nay, even inconsistent, as such growths are, wanting most often the symmetry and preciseness of artifice, but having the secret of permanence and adaptability. These words seem almost too simple—these truths too obvious for repetition; yet for lack of that which lies in them our modern schemes of education are day after day ruining the young by over-stimulation and unhealthy competition. Happily, the public is awaking to its error, and is beginning to regret the days when its young dunces grew into its old heroes. What we did blindly in the past by trusting to the hidden wealth of Nature, we may now do face to face by the revelation of her secrets.

P. S.—Since this essay was prepared for the printer, I have received the February number of the *Fortnightly Review*, which contains an article by Prof. Huxley on "Technical Education." In that article Mr. Huxley expresses opinions which must command general attention and adhesion. Although his argument is sped with thought and word far stronger and swifter than mine, and clothed with an authority to which I can lay no claim, yet I may perhaps without presumption call myself a fellow-laborer in the same field.—*Brain.*

SKETCH OF PROFESSOR C. F. HARTT.

By RICHARD RATHBUN.

CHARLES FREDERIC HARTT, whose death by yellow fever occurred at Rio de Janeiro on the 18th of last March, was born at Fredericton, New Brunswick, August 23, 1840. For three years and a half before his decease, he had successfully withstood the fatigues of exploration and the labors of organizing and carrying on the geological commission of Brazil, an undertaking beset with many trying difficulties, only to succumb at last, the victim of an epidemic which caused him but two days of suffering.

Prof. Hartt's father was the late Jarvis William Hartt, for a long time closely connected with the educational interests of New Brunswick and Nova Scotia. The subject of our sketch received his early education mainly in Nova Scotia, under the direct supervision of his father. Later he entered Horton Academy, Wolfville, and afterward completed the academical course at Acadia College, where he graduated with honor in 1860. His connection with natural history dates from boyhood, and at the age of ten years he had already made a good beginning. Encouraged by Prof. Cheesman, he made rapid progress in his favorite studies, without, however, neglecting the other branches of learning. But his particular bent always lay toward natural history, language, music, and art. The former subject became his principal occupation, but the latter three, in which he made many original observations of great value, ever aided him much, especially in his studies in ethnology.

While a student at Acadia College, he undertook, under the direction of Dr. Dawson, extensive researches into the geology of Nova Scotia, which province he explored on foot from one end to the other. In 1860 he accompanied his father to St. John, there to establish a college high-school. This change of location brought him into another field for exploration, that of the geology of New Brunswick, and he commenced his new labors at once. The Devonian shales at the locality called Fern Ledges, in the vicinity of St. John, were the principal objects of his research. These shales occur on the shore of the bay of Fundy, and are situated mostly between high and low water marks, being thus very difficult of access. After a long siege of hard work, however, he was amply repaid by discovering an abundance of land plants and insects, of which the latter still remain the oldest known to science. Prof. Agassiz was attracted by this last discovery of the young Canadian naturalist, and invited him to enter his museum at Cambridge as a student. This he did in 1861, but in so doing his connection with provincial geology was not severed, for each vacation he returned, either to New Brunswick or Nova Scotia, to continue his explorations, in the course of which he would often lecture in the different towns to obtain means of paying his field expenses. In 1864 Mr. Hartt was employed, with Profs. Bailey and Matthews, on the geological survey of New Brunswick, and, while engaged in this work, obtained the first full proof of the existence of primordial strata in that province. Many of his discoveries in Nova Scotia and New Brunswick were published in the Provincial Government reports, and also in Dr. Dawson's "Acadian Geology." Hartt's constitution, though well able to withstand the severest kind of fatigue in exploration, was not proof against the damp, chilly atmosphere of his native land, and from this cause he often suffered much; so it was probably fortunate for him that just about this time his attention was attracted toward a new field.

Upon the organization of the Thayer Expedition to Brazil, by Prof. Agassiz in 1865, he was appointed one of its geologists, and henceforth to the time of his death he was ever a most devoted investigator of South American natural history. As a member of Prof. Agassiz's party he explored the neighborhood of the coast from Rio de Janeiro to Bahia, and ascended many of the rivers, making large zoölogical collections, but finding little of interest in the geology. Aided by New York friends he returned to Brazil alone in 1867, this time examining with the greatest care the reefs of the Abrolhos Islands, and those of the coast, as well as the geology of a part of Bahia and Sergipe. With the material thus far collected he began the work of writing up his geological reports in the capacity of geologist to the Thayer Expedition. This report was to have been included along with those of his chief, but under Hartt's hands it grew to such size that it was published separately in 1870 as the "Geology and Physical Geography of Brazil." In addition to the account of Hartt's researches, it included the best results of all who had ever published on the geology of the country.

After his return from the Thayer Expedition, the time he spent in this country until 1868 was devoted mostly to scientific teaching and lecturing in and around New York City, where he attained much success and made many warm friends. Early in 1868 he was elected Professor of Natural History in Vassar College, a position he resigned in the fall of the same year, to accept the chair of Geology in Cornell University. Shortly after assuming his duties at Cornell, he was married to Miss Lucy Lynde, of Buffalo, New York, who is now left with two children. In 1869 he was made General Secretary of the American Association for the Advancement of Science, to serve at the meeting of 1870; but a third expedition to Brazil, which he had been planning, called him away before the Association met. This trip was made in company with Prof. Prentice and eleven students of Cornell University, and was the largest of his own organizations from the United States. With this party he entered what was really a new region for geological exploration—the Amazonian Valley—hoping there to discover, at the falls of the different tributaries of the Amazonas, other fossiliferous formations than the Cretaceous, which latter alone he had found along the coast. He was well rewarded, and returned to the United States with large collections of fossils of the Palæozoic age, and sufficient other evidence to allow of his giving us a very accurate though general idea of the formation of the Amazonian Valley. His results were strongly opposed to the theory of Prof. Agassiz, of its glacial origin. Not entirely satisfied with the amount of material obtained on this last expedition, he returned again to the Amazonas in 1871 with Mr. O. A. Derby, who had accompanied him on the former trip. Together they carefully reëxplored the same regions gone over before, adding much to the stores already brought to the United States, and also examining the ancient Indian mounds and shell-heaps of numerous localities. The two Amazonian trips of Prof. Hartt were rendered possible through the liberality of Mr. Edward Morgan, of Aurora, New York, in whose honor they have been called the "Morgan Expeditions."

Returning from Brazil once more, he remained at Cornell University about three years, quietly working up the results of his later trips, and publishing his reports upon them; but his active spirit would not allow him to remain in this condition long. He conceived the idea of systematically exploring the entire empire of Brazil, a country possessing an area almost as great as the United States. In August of 1874, by request of the Brazilian Minister of Agriculture, he went to Rio de Janeiro to submit his plans for the organization of a Geological Commission of Brazil. He first suggested the forming of a very large party similar to those engaged in our own national explorations; but it was found that the existing appropriations would not suffice for so grand an undertaking, and he was forced to begin on a more modest scale, the commission dating from May 1, 1875. In addition to the chief, there were never more than five or six assistants at any one time, comprising two assistant geologists, one topographer, and two other assistants, and at times a photographer or other specialist. His former experiences in Brazil aided him in rapidly attaining good and important results. He took the old grounds which he had already examined as starting-points for his new explorations, and worked outward from them in all directions, quickly but carefully enlarging the known area of fossiliferous and other rocks. This kind of work he was, of course, able to carry out only on the Amazonas and in the northern coast provinces; but to the south of Rio he had everything to begin, and in those localities his examinations were more hasty, bearing the character of preliminary surveys; but they were also productive of valuable results.

On the reorganization of the National Museum at Rio, in 1876, Hartt became director of its department of Geology; but, on account of his many other duties, he was soon obliged to resign that position. The results of his researches may be briefly summed up as follows: Before he went to Brazil on his second trip, in 1867, scarcely anything was known of fossiliferous deposits there, and thus no material existed toward the study of the systematic geology of the country. A few Cretaceous fossils had been recorded from Bahia; the Danish naturalist Luns had very fully described the bone-caverns of Lagoa Santa in Minas Gerães, and we knew of coal-plants from Rio Grande do Sul; but beyond this the paleontology of Brazil was a perfect blank. Hartt's greatest achievement in Brazil was probably his solution of the structure of the Amazonian Valley. It was founded on the best of paleontological evidence which proves the existence of an immense palæozoic basin lying between the metamorphic plateau of Guiana on the north, and that of Central Brazil on the south, and through which flows the river Amazonas. Silurian, Devonian, and carboniferous rocks, make up the series in regular succession, and in many localities are highly fossiliferous. He has explained the character of the isolated Cretaceous deposits, mostly discovered by himself, existing along the coast from Pará to Bahia, and of the Carboniferous and other regions south of Rio. He has shown us the manner in which the rocky structure of Brazil was built up, and has done much toward solving the relations of the crystalline rocks which compose by far the larger portion of its surface. He has explored the shell-heaps, burial-mounds, and other relic-localities of the prehistoric tribes from far up the Amazonas to the southernmost coast province. We owe to him also the first real satisfactory explanation of the reefs of Brazil, which he distinctly shows to be of two kinds—sandstone and coral. He spent much time in studying the customs and languages of the modern Indian tribes of the Amazonas and Bahia, and collected very much material toward a grammar and dictionary of the Tupé Indian language in several of its dialects. But to attempt a complete account of Prof. Hartt's Brazilian explorations and discoveries would require a longer article than we can give here. In connection with the Geological Commission of Brazil he founded a large museum in Rio de Janeiro, which will always bear testimony to his great final undertaking. His field-parties made very extensive collections of rock-specimens and fossils, and in the explorations of the reefs they gathered a large collection of marine invertebrate animals of all kinds. About a year ago, when the members of his survey were mostly recalled to Rio for the purpose of writing up their reports and of studying the material they had collected, it was found that some six hundred cases had been sent in from the field, and were awaiting suitable quarters. A large building was obtained, and in the course of several months there appeared a museum of geology and marine zoölogy that would have done credit to a much larger commission working a much longer time. It contained fossils, minerals, and rocks, from nearly every known geological locality in Brazil, and thus formed the most complete repository of South American geology in the world. Among the collections of marine zoölogy those of the corals, crustacea, and mollusks, were notably large and complete. But one of the most interesting parts of the museum was its collection of antiquities, which comprised many new and curious forms of pottery and stone implements, and was also rich in human remains.

A start had just been made toward publishing the reports of the commission when the death of Prof. Hartt deprived it of its main support. But, though this will occasion some delay in the publication, it is to be hoped that we shall soon have before us the entire results of one of the grandest series of explorations ever carried on by an American in a foreign country.

Prof. Hartt's published works are not very voluminous. He was so confident of a longer life that he delayed too long, but still he was a constant contributor to American scientific periodicals. In addition to his large volume, "The Geology and Physical Geography of Brazil," he has given us the following, among other very valuable reports:

"Amazonian Drift" (*American Journal of Science*, vol. i., 1871, pp. 3).

"Brazilian Rock-Inscriptions" (*American Naturalist*, vol. v., 1871, pp. 9 and figures).

"The Ancient Indian Pottery of Marajó, Brazil" (*American Naturalist*, vol. v., 1871, pp. 13, many figures).

"On the Tertiary Basin of the Marañon" (*American Journal of Science*, vol. iv., 1872, pp. 6).

"Recent Explorations on the Valley of the Amazonas" ("American Journal of the Geographical Society of New York," 1872, with map).

"Morgan Expeditions 1870–'71." Contributions to "The Geology and Physical Geography of the Lower Amazonas—The Evevé, Monte Alegre District, and the Table-topped Hills" ("Bulletin of the Buffalo Society of Natural Science," January, 1874, pp. 35).

"Morgan Expeditions 1870–'71. Report of a Reconnaissance of the Lower Tapajos" ("Bulletin of Cornell University (Science)," vol. i., No. 1, 1874, pp. 37).

"Evolution in Ornament" (The Popular Science Monthly, January, 1875).

"Notes on the Manufacture of Pottery among Savage Races" (Rio de Janeiro, 1875, pp. 70).

"Amazonian Tortoise Myths" (Rio, 1875).

"Nota sobre algumas Tangas de Barro cosido dos Antigos Indigenas da Ilha de Marajó" ("Archivos do Museu Nacional de Rio de Janeiro," vol. i., 1876, pp. 5, 3 plates).

CORRESPONDENCE.

THE LOGIC OF PROBABILITIES.

To the Editor of the Popular Science Monthly.

IN the April number—"Illustrations of the Logic of Science," p. 706—the writer says: "What is the probability of throwing a six with one die? The antecedent here is the event of throwing a die; the consequent, its turning up a six. As the die has six sides, all of which are turned up with equal frequency, the probability of turning up any one is one-sixth." Admitted; but is not this also true: that if you throw a single die, say twenty times, and fail to turn up a six, the probability thereafter of turning up a six is increased? One would say so; and for the reason that, *in the long run*, there must turn up as many sixes as ones or twos or threes or fours or fives. "The die has six sides, all of which are turned up with equal frequency." Of course, the greater the number of throws, the nearer will the numbers of times which each side of the die falls uppermost approximate each other—approaching relatively nearer all the way from six throws to sixty million, and on to infinity. If a six has failed to turn up for twenty throws, and if it must turn up as frequently as the other numbers, it must some time after the twentieth throw make up the deficiency. To *average up*, six must begin some time to turn oftener; that is, with each failure to fall uppermost, its chance or probability of doing so is increased.

On the other hand, suppose you have thrown the die twenty times, or twenty thousand times, and have failed to turn a six, even then the twenty-thousand-and-first throw, considered by itself, manifestly affords one-sixth (no more, no less) of a chance of turning up a six.

How is this logic to be reconciled?

Respectfully,

CHARLES WEST.

SAN FRANCISCO, CALIFORNIA, *April* 2, 1878.

WE insert this letter because it gives expression to a fallacious notion which is very current. At the gambling-places they distribute cards upon which the players can, by prickings, mark the number of times which black and red have turned up, so as to bet upon the color which is in deficiency. The confusion is between the following two statements, of which the first is true, the second false:

1. "If a die be thrown a sufficient number of times, the *proportion* of times with which it will turn up six, will approximate (within any desired limit) to one-sixth." This is true.

2. "If a die be thrown a sufficient number of times, the *number* of times with which it will turn up six will approximate (within any desired limit) to one-sixth of the total number of throws." This is plainly false. Suppose a die be thrown six times in all, then the number of times in which six comes up cannot differ by more than five from being exactly one-sixth of the total number of throws. But does anybody imagine that, if it were thrown six hundred times, the number of sixes would often lie between 95 and 105, or within five of one-sixth of the total number?

Recognizing this distinction, our correspondent's argument falls at once to the ground. Suppose that the first twenty throws of the die were to be *six*, and thereafter just one-sixth of the throws were to be six, then the frequency of sixes would be as follows:

After 20 throws, the frequency would be $\frac{20}{20} = 1.$

After 80 throws, the frequency would be $\frac{20+10}{80} = 0.375.$

After 620 throws, the frequency would be $\frac{20+100}{620} = 0.19354839.$

After 6,020 throws, the frequency would be $\frac{20+1{,}000}{6{,}020} = 0.1694352.$

Thus the frequency would continually approximate toward one-sixth or 0.166666 . . ., although sixes were thrown exactly one-sixth of the time, after the run of twenty sixes. Our correspondent is, therefore, in error when he says: "If a six has failed to turn up for twenty throws, and it must turn up as frequently as the other numbers, it must some time after the twentieth throw make up the deficiency. To *average up*, six must begin some time to turn oftener." On the contrary, if, after the twentieth throw, it turns up exactly one-sixth of the times, its frequency approximates indefinitely in the long run toward one-sixth.

The table given in the April number, p. 715, shows that, as the number of throws increases, the difference between the *number* of sixes and one-sixth of the number of throws generally increases, being proportional to the square root of that number; at the same time the difference between the *proportion* of sixes and one-sixth generally decreases, in the same proportion that the discrepancy of the *number* increases.

In 6 throws, the *number* of sixes will probably lie between 0 and 2; the proportion between 0 and 0.3333. . .

In 60 throws, the *number* of sixes will probably lie between 8 and 12; the proportion between 0.133 and 0.200.

In 600 throws, the *number* of sixes will probably lie between 93 and 107; the proportion between 0.155 and 0.178.

In 6,000 throws, the *number* of sixes will probably lie between 980 and 1,020; the proportion between .163 and .170.

In 60,000 throws, the *number* of sixes will probably lie between 9,938 and 10,062; the proportion between .1656 and .1677; and so on.

All this relates to independent events; that is, those of which the occurrence of one neither increases nor diminishes the probability of the occurrence of another. If an urn contains a number of balls, of which one-sixth are black and the rest white, every drawing of a black ball decreases the relative number of black balls among those which remain. If there were but one hundred and twenty balls in all, at first, and the first twenty drawn were black, it becomes absolutely certain that all the remaining drawings will be of white balls. The greater the total number, however, the less influence will the run of twenty black drawings have upon those which follow; and, if the total number were endless, the case would be similar to the repeated throwing of a die.

EDITOR'S TABLE.

THE STUDY OF THE BRAIN.

THE recent activity of psychological study, and the many valuable results arising from it, induced some of its leading students, two or three years ago, to found a new periodical entitled *Mind: a Quarterly Review of Psychology and Philosophy*, to be devoted to the investigation of mental phenomena, especially from the hitherto neglected physiological side. This review has done excellent service. It was a protest against the inadequacy of the old method of metaphysical and purely introspective study, and represented that class of philosophical thinkers who hold that, in treating of mind, its organic conditions are not to be lost sight of, but that mind and body are to be considered together.

A further and very significant step, in the same direction, has now been taken by the establishment of another quarterly magazine, under the title of *Brain: a Journal of Neurology*.[1] The starting-point is here physiological, and the brain and nervous system are studied with reference to their various vital and psychical functions and effects. The editors are all eminent medical men, who have either acquired distinction through large experience in the treatment of nervous maladies involving intellectual and emotional derangement, or have achieved eminence in the department of experimental physiology of the nervous system. The method is here thoroughly scientific. The brain is not merely something to be recognized, but it is taken as the pri-

[1] *Brain: A Journal of Neurology.* Edited by J. C. Bucknill, M. D., J. Crichton-Browne, M. D., D. Ferrier, M. D., and J. Hughlings-Jackson, M. D. 142 pages quarterly. Price, 3*s.* 6*d.* New York: Macmillan & Co.

mary and fundamental object of inquiry—an organ, the properties of which give limits and law to psychology. That mind is conditioned and manifested by the nervous, and especially the cerebral, system, is now no longer intelligently disputed; and, in beginning the study of mental phenomena here, we have the advantage of light derived from the physical and organic sciences, we get free from the overwhelming bias of metaphysical traditions, and become familiar with a wide range of facts that are of immense value in the conduct of every-day life.

The important practical results that must follow from this order of study, by which the organic substratum of mind receives the first attention, are well illustrated in the admirable articles of Dr. Beard, on "The Scientific Study of Human Testimony," of which the second is herewith published. Dr. Beard indicated his point of view in the first paper as follows:

"Human testimony comes from the human brain; the scientific study of human testimony is only possible through a knowledge of the human brain in health and disease, and is therefore a department of cerebro-physiology and pathology. Only recently have the laws of cerebro-physiology and pathology been sufficiently understood, even by the very few who cultivate that specialty, to enable them to formulate principles for the scientific study of that most important product of the human brain—human testimony. If, then, Bacon and Descartes, Hume and Hamilton, Whewell and Jevons, Greenleaf and Wharton, have failed to adapt their analyses of the principles of evidence to the needs of our time, their failure is due to the backwardness of physiology and pathology, that must constitute the basis of the study of evidence, and on which the foundations for a reconstruction must be laid. We do not yet know all of the human brain, either in health or disease; but our knowledge of it is sufficiently advanced to make it possible to see, with sufficient clearness, its relation to testimony. If we do not know just how the cerebral cells evolve thought, we do know that thought is evolved by them or through them, and that various diseases of the brain and nervous system—now pretty well understood, but of which, twenty years ago, little or nothing was known—may utterly destroy the objective worth of thought and render it, scientifically speaking, valueless."

Assuming these positions to be valid, the study of mental physiology must work a revolution in the theory of jurisprudence and the practice of the legal profession.

The extreme importance of this point of view is also further exemplified in an article "On Brain-forcing," by Dr. Clifford Allbutt, which we reprint in the present number of the Monthly, from the new quarterly. Taking their cue from old metaphysical text-books, our teachers are ever talking about mind, while what they really have to deal with is the brain. And not only that, but they have control of it during the period of its development. Education is, in fact, a physiological art, and all its methods and resources take effect upon the plastic organism of the nervous system. The development of intelligence, the discipline of emotions, the establishment of habits, and the formation of character, are all dependent upon definite corporeal laws, of which the study of mental philosophy, as usually pursued, gives us but little information. Dr. Allbutt shows very impressively, not only how the varied endowments of nerve-substance are at the basis of all culture, but how easy it is to mismanage the work of education, and perpetrate grave and lasting mischief, when these physiological conditions are unheeded and unknown. Nor is the ignorance of teachers upon the subject the worst thing about it; they have views and beliefs and opinions which stand in the way of real knowledge, and under which they work with blind, dogmatic confidence, that prevents all recognition of the injuries their practice inflicts upon pupils under their charge.

A case in point has been recently reported by the newspapers as occurring in the management of the Jersey

City High-School. The account given of it by the *World* is mainly as follows:

"The course of study is of a high grade, and is arranged in three divisions—a commercial, a modern English, and a classical course. The English course comprises algebra, natural philosophy, geometry, trigonometry, physiology, chemistry, geology, astronomy, surveying, botany, languages, English literature, civil government, history, mental philosophy, and theory and practice of teaching. The classical course is made up of algebra, geometry, Latin (Cæsar, Cicero, and Virgil), Greek (Anabasis, Homer), Roman and Grecian history, Latin composition, and outlines of history. During each term the students are required to study three of the above subjects. The courses are otherwise optional, and many of the students study five subjects. The course extends over three years, and, in order to complete their studies in that period, the young women who are in the higher classes have to devote close attention to their work. In 1876, at the close of the first course of the institution, the graduating class consisted of twenty-two young women and two young men. The excitement of the closing examination, which was very strict, and the fatigue attending the prolonged course of study, left many of the young women, it is said, with impaired health, but except in a few instances there were no serious results. Fourteen of the young women began to teach in the public schools after graduation, and, in addition to this, they were compelled to prepare for a second examination to enable them to pass the Saturday Normal School, which they were obliged to do before they could obtain a diploma that would make them eligible as teachers in the grammar and higher grade schools. This necessitated close study, and left them comparatively little time for recreation. All, however, except three, pulled through successfully, without any material injury to their health. The additional study was not forced upon them, but they were ambitious and anxious to attain the highest possible position in their profession.

"Of these female graduates, two bright and promising young women died in early womanhood, one is now an inmate of an insane asylum, and two or three others are said to be in delicate health."

When the principal of the high-school was seen and questioned by the reporter, he denied that the course of studies was too severe for female students, and remarked: "I have been teaching for eighteen years, and my experience is that girls are more studious and more ready to learn than boys. They can master the higher branches of education far more readily than boys." From which the obvious inference is, that they will be readier victims of a forcing system, administered under the competitions and rivalries of such institutions. All the pressures of our educational system are for conspicuous and telling results which will make the best show at examinations. The teacher takes his rank and holds his position, and calculates upon compensation and promotion, by attaining these striking results. His interest is therefore to drive, to overload, and to stuff and cram the memory of pupils with verbal acquisitions that may be flaunted on parade. School-work becomes a steady pull in these directions, with no time for reflection or observation or independent exercise of thought upon the subjects chosen. The system affords no check against overdoing. The teachers push on those who should be held back, and, if they do not break down and die outright, no harm is recognized. The idea that pupils, girls especially, can be sustained by excitement and carry off the honors in apparent health, while their constitutions are undermined, ill-health entailed, and the power of vigorous accomplishment through life destroyed, seems hardly to enter into the minds of educators. It is one of the fruits of our dominant, high-pressure, machine system of culture that the mass of teachers and of education journals pooh-pooh the notion of overwork in school.

It is not to be expected that all teachers will be physicians, but it is a part, and a most essential part, of their business to inform themselves with some thoroughness in regard to the mechanism, normal workings, laws of endurance, and morbid indications, of the nervous system. They should read so widely and carefully upon this subject as to induce caution, and not become the heedless instruments of an inexorable policy, that takes no account of physiological circumstances, hereditary defects, abnormal temperaments, constitutional dullness or precocity, and various other conditions that ought often to qualify school-room management. Familiarity with such subjects would go far to protect from rash judgments and the various evils that are liable to follow. Parents are often greatly to blame in this matter, but teachers ought to be qualified intelligently to withstand the interferences that are due to parental ignorance and vanity.

The first number of *Brain* contains the description of a case, by Dr. A. Hughes Bennett, which, although it was so obscure as to baffle the physicians, is yet well calculated to enforce the cautious reserve we have insisted on, and the necessity of greater general familiarity with this class of facts. A tall, full-grown, well-developed, healthy-looking young woman, aged sixteen, consulted the doctor in 1876, complaining of blindness, deafness, and loss of power in her lower extremities. She had not a very good reputation, that is, she had always been a very "naughty child," who took special delight in annoying and playing malicious tricks on her companions. She had a reputation for willfulness, cunning, and bad temper, though she could make herself amiable and agreeable when she pleased. In school her behavior was characterized by indiscretions, lack of modesty customary in persons of her position in society, and general misconduct, and from one school she was expelled. She pretended to become suddenly blind, but, as this was immediately after correction for mutinous conduct, the schoolmistress thought she was malingering, or feigning illness. She declared herself deaf, but it was found that she could hear; she asserted that she had lost the power in her lower limbs, and could not walk, which was supposed to indicate her desire to avoid the daily walks which she disliked. She had nervous attacks, and shouted, laughed, and threw herself about, striking the nurse. Physicians were consulted, who said nothing ailed her but hysterics, and ordered her to be placed under strict "moral control." Dr. Bennett ascertained that her father was of excitable temperament and had had several attacks of mania. Her mother died when she was an infant, and nothing was ascertained concerning her health, but an aunt was said to be of unstable mind. Her sisters were all nervous and hysterical, and one of her brothers seemed to inherit her father's mental disposition. She consulted Dr. Bennett April 1st, but grew worse, becoming fitfully blind, deaf, unable to walk, restless and excited; wandering, delirium, and wild raving followed, and she at length became suddenly comatose, and died on the morning of May 1st. Dr. Bennett had the greatest difficulty in obtaining an autopsy, but on opening the brain a tumor was found in the right cerebral hemisphere, about the size and shape of a hen's-egg. The cause of the intermittent blindness, deafness, muscular feebleness, and various other derangements, was now apparent. As the tumor had been growing, probably, for years, pressure was exerted upon the surrounding parts, the circulation was impeded, the nervous connections disturbed, and the disorganization of cerebral structure and functions produced insanity of conduct. It is in the highest degree probable that she inherited an unhealthy brain, which became gradually the seat of positive disease. Dr. Bennett was satisfied of the existence of some form of cerebral malady, but he had great difficulty in assuring the friends of the patient, even in her last days, that it was not a case of mere deception, perversity, and vicious caprice.

This example enforces its own lesson. Happily, tumors in the brain are not frequent, though they may be met with at any time. But the delicate and complex organ of thought and feeling is subject to numerous diseases of all grades of intensity, to morbid predispositions that come down as taints in the ancestral stream, to defective nutrition, to early perversion and arrest of growth by premature organization, to debility and exhaustion from overwork and lack of necessary rest—all of which are liable to disturb the mind and derange the conduct as absolutely as the existence of a tumor buried in its lobes.

Is there provision for communicating knowledge upon these subjects with any efficiency to teachers, in a single normal school in the land? While it should be at the foundation of the teacher's preparation, it is neglected everywhere. In all other vocations that are *studied*, the first thing is to get a knowledge of the nature and properties of the material which the student is to be employed upon; but, strange to say, in the training of teachers this kind of knowledge is practically left out of the curriculum.

THE PROGRESS OF JOURNALISM.

We have received, printed on a fly-sheet, the article contributed by Prof. Sumner to *Scribner's Magazine*, on "What our Boys are reading." It is earnestly commended to the attention of editors in an accompanying circular, signed by Presidents Porter and Woolsey, and other eminent gentlemen of New Haven, and we are glad to have the subject thus weightily presented. Prof. Sumner says that—

"There is a periodical literature designed for boys of from twelve to sixteen years of age, that has been growing up among us within the last few years, until it is widely circulated, and that is of a very pernicious character. The boys' newspapers contain stories, songs, mock-speeches, and negro-minstrel dialogues, and nothing else. The literary material is either intensely stupid, or spiced to the highest degree with sensation. The dialogue is short, sharp, and continuous, is broken by the minimum of description, and by no preaching. . . . The stories are not markedly profane and they are not obscene. They are indescribably vulgar."

Prof. Sumner gives illustrations of their coarse vulgarity, and points out that the type of character illustrated and applauded is that of the vagabond, the adventurer, the prize-fighter, and the blackguard. It is deplorable that such a style of literature should have appeared among us, and grown to an extended influence. Familiarity with it cannot fail to be vicious and degrading, and it is well to warn parents and teachers of this insidious agency of mischief, to which our youth are exposed.

Nevertheless, we must be fair to the boys, and remember the examples that are set them by older people. Prof. Sumner observes: "We say nothing of the great harm that is done to boys of that age by the nervous excitement of reading harrowing and sensational stories, because the literature before us only participates in that harm with other literature of far higher pretensions." But, instead of "saying nothing," we think Prof. Sumner should have felt it incumbent upon him to give emphasis to this consideration, and sharply reprobated a system of adult journalism, the imitation of which leads to such corrupting results. For the boys' newspapers are nothing less than imitations of more pretentious newspapers, only a grade or two lower in coarseness and vulgarity, as suits the immature condition of mind to which they are addressed. Prof. Sumner says that "these papers poison boys' minds with views of life which are so base and false as to destroy all manliness and all chance of true success." But pray, what are the "views of life" currently set forth in our mature literature of the widest circulation? They are false, extravagant, distorted, and misleading, to the last degree. But, instead of being condemned and forbidden, this literature is widely read and freely indorsed, and, under the sordid inducements its disseminators are able to offer, the talent of the country is at their disposal. How long is it since a journal, whose blood-and-thunder stories had pushed it into enormous circulation, bought up statesmen, and *littérateurs*, and clergymen, and presidents of colleges in dozens, who contributed their perfunctory essays to be sandwiched among the stupid clap-trap tales for which the sheet was bought? The boys' newspapers have probably not money enough yet to buy respectability in this way, but with sufficient enterprise they may imitate this feature also. Are we not told that newspapers must suit supply to demand, that they are made to sell and must be adapted to the state of mind of their patrons and publish what people want to read?—how far do the boys' newspapers deviate from this primary requirement of a successful press? Villainous caricatures in family journals are mildly objected to by some, but the aggrieved publishers beg to know how else they are to get an "enormous circulation." The ideals of the boys' newspapers are said to be low. What is the altitude of the sporting ideals recognized by popular newspapers? If the rich may have their fun in horse-racing, and the colleges may enjoy their rowing-matches, how can the boys be much censured for taking some interest in the prize-ring? A notorious bruiser, tired of mauling his fellow-creatures, turned black-leg and politician, giving alternate attention to the gambling-den and the Senate-chamber, and, when he dies, the newspapers are overrun with multifarious discussions about him! The boys' papers will probably take up the topic of Morrissey, and improve it in their own way. Prof. Sumner said that "this subject is of interest to the students of social phenomena," and this is our concern with it. But it is the province of these students to consider facts in their relations and mutual dependencies. The boys' newspapers are not isolated things; and they can be condemned for no reasons that have not a much further application.

SEDGWICK ON THE "VESTIGES OF CREATION."

Adam Sedgwick was Professor of Geology in the University of Cambridge and President of the Geological Society of London, and in an anniversary address before that body, in 1831, he said, "*We have a series of proofs the most emphatic and convincing that the approach to the present system of things has been gradual, and that there has been a progressive development of organic structures subservient to the purposes of life.*" This is rank evolution, even for to-day, though uttered forty-seven years ago! But in 1834 Dr. Sedgwick got a fat and easy church sinecure, becoming Prebendary of Norwich, which perhaps accounts for the sour milk in the following cocoanut. In 1844 the reverend geologist wrote to Macvey Napier, editor of the *Edinburgh Review*, concerning the "Vestiges of Creation," and his letter contains the following passage, which is to be taken as representing the Norwich prebendary, rather than the President of the Geological Society who speaks in our previous quotation:

"I now know the 'Vestiges' well, and I detest the book for its shallowness, for the intense vulgarity of its philosophy, for its gross, unblushing materialism, for its silly credulity in catering out of every fool's dish, for its utter ignorance of what is meant by induction, for its gross (and, I dare to say, filthy) views of physiology—most ignorant and most false—and for its shameful shuffling of the facts of geology so as to make them play a rogue's game. I believe some woman is the author; partly from the fair dress and agreeable exterior of the 'Vestiges,' and partly from the ignorance the book displays of all sound physical logic. A *man* who knew so much of the surface of physics must, at least on some one point or other, have taken a deeper plunge; but *all* parts of the book are shallow. . . . From the bottom of my soul I loathe and detest the 'Vestiges.' 'Tis a rank pill of asafœtida and arsenic, covered with gold-leaf. I do, therefore, trust that your contributor has stamped with an iron heel upon the head of the filthy abortion, and put an end to its crawlings. There is not one subject the author handles bearing on life, of which he does not take a degrading view."

There is not much writing in this style nowadays, a generation having made a great difference in the spirit with which this subject is discussed. It is noteworthy that the furious denunciations of the doctrine that man has been created through the unfolding of the universe, rather than by a special miracle, are now put less on the ground of mere dislike and disgust than on that of its scientific falsity. It is strangely said that the idea of the derivation of the human race by the operations of natural law, such as govern the development of the individual, is unscientific, while the notion that man was supernaturally injected in a perfect state into the existing system of things is held to be the true scientific view. For the benefit of those who want to hear both sides, we republish, in the May SUPPLEMENT, a vehement diatribe, by Dr. Elam, purporting to be a reply to Prof. Tyndall's "Man and Science." He is at home in the style of Sedgwick when writing upon the "Vestiges," but he has the sense to see that the question is after all a scientific one. He says:

"Not because it is unutterably disgusting and humiliating, but because the idea is profoundly and irredeemably unscientific, founded on false data, false conceptions, and false reasonings, do I altogether repudiate our 'wormy' and ape-like ancestry. Upon man everywhere, debased, degraded, fallen from his high estate though he may be, I see the seal and impress of his *special* and divine origin."

THE Rev. Joseph Cook seems to be trying, commendably, to state things as they are, but finds it difficult. The other Monday he characterized THE POPULAR SCIENCE MONTHLY as a "useful" periodical, and in this he was quite correct. He also affirmed that it is "crudely edited," and here he was, no doubt, much nearer the truth than he is wont to be. But when he speaks of Virchow in connection with the Monthly his old propensities overcome him. He said of Prof. Virchow's discourse on "The Liberty of Science in the Modern State:" "THE POPULAR SCIENCE MONTHLY has indeed published an imperfect report of this great address; but it has failed, as has also Asa Gray, of Cambridge (in an article in the *Independent*), to bring out the breadth of the collision between Virchow and Haeckel." A false impression is here created, to say the least. We have not printed an imperfect report of Virchow's address, but a full and faithful translation of it. As to our having failed to bring out the "breadth of the collision between Virchow and Haeckel," it happens that we have done that very thing, and are the only parties that have done it. We printed both speeches—side by side—in the February POPULAR SCIENCE SUPPLEMENT, and, moreover, so that they can be sold with ten other elaborate articles at half the price that Murray charges for Virchow's speech alone. If, therefore, any one wishes to get a clear notion of the breadth, depth, height, and momentum, of this remarkable "collision," he will find it in the periodical which, according to Mr. Cook, did not contain it.

In an elaborate article entitled "Virchow and the Teachings of Science," contributed to the *Nineteenth Century*[1] by Prof. Kingdon Clifford, the great German has received his decisive and annihilating answer. So clean and finished a piece of controversial work we have rarely seen. There is, of course, much in Prof. Virchow's address that is true and important, but that which gives it celebrity is the avowal, by an eminent biologist, that the doctrine of evolution is not proved. This is at once a question of the nature, extent, and validity of evidence, and Prof. Clifford takes it up as a logician, in a very quiet way, with much delicate humor and a peculiar charm of style, for which he is unrivaled. Prof. Clifford points out the baselessness of Virchow's conclusions in regard to the evidence for the descent of man, and, then passing to the question of education, he not only answers him effectually, but does it in such a manner as to make his paper a very important contribution to educational philosophy.

[1] Reprinted in The Popular Science Supplement for May.

LITERARY NOTICES.

Stargazing: Past and Present. By J. Norman Lockyer, F. R. S. New York: Macmillan & Co. Pp. 496. Price, $7.50.

In this elegant volume Mr. Lockyer gives an excellent popular account of the rise and progress of instrumental astronomy. His work is an admirable illustration of the law of mental evolution by which great results have been attained through prolonged periods by minute increments of improvement. There were, of course, many conspicuous cases in which the science went forward, apparently by strides, as when Hipparchus invented the astrolabe, which led to the discovery of the "precession of the equinoxes," or when Galileo discovered the isochronism or equal-time oscillations of the pendulum, or when Dollond invented achromatic lenses for the telescope, or when photography and spectrum analysis were applied to celestial objects. But in all these cases of apparent sudden leaps, there was a previous time of preparation, in which numerous failures, or partial but inadequate successes, led up to the matured result. It is interesting to trace in Mr. Lockyer's pages the intimate and absolute dependence of astronomical progress upon the skill of the mechanic in the workshop. The genius of the inventor was always hampered by mechanical difficulties that could only be resolved by the dexterity and ingenuity of machinists and workers in metals, glass, and other materials. The bold speculator could conjecture, and the mathematician could verify, but all had to wait for the proficiency of the practical manipulator.

Mr. Lockyer opens his book with an account of early star-gazing in the pre-telescopic age, which terminates with Tycho Brahe, who died early in the seventeenth century. The second division of his work is devoted to the development of the telescope; the third, to time and space measurers; the fourth, to modern meridional observations with transit-instruments; the fifth part deals with the equatorial, and the mounting of large telescopes, and modern observatory equipments; and in the last division of the work, astronomical physics, Mr. Lockyer treats of the chemistry of the stars, spectrum analysis, and photography, applied to the heavenly bodies. His book is elaborately illustrated, and is a useful popular contribution to astronomical literature.

International Scientific Series, No. XXIII. Studies in Spectrum Analysis. By J. Norman Lockyer, F. R. S. D. Appleton & Co. Pp. 251.

The name of Mr. Lockyer is eminent in connection with spectrum analysis, and will secure intelligent attention to whatever he writes upon it. But the subject has been so thoroughly sifted and expounded for the last five years, that, in contributing a volume upon it for the International Scientific Series, he had by no means an easy task. Declining to follow in the beaten paths of compilation, and avoiding a mere restatement of rudiments, or the detailed treatment of systematic treatises like those of

Schellen and Roscoe, Mr. Lockyer has adopted an intermediate and independent course, and made an instructive volume of moderate size on questions at present most interesting in the theory and practice of spectroscopy. Treating but briefly of the construction of the spectroscope, which is so fully dealt with in the current works, he gives more attention to its uses and results in connection with problems that are now undergoing investigation. Chapter I. contains an excellent statement of the laws of wave-phenomena, that are at the foundation of the theory of spectrum analysis; and, as an example of the style and illustration of the book, as well as the interest of the exposition, we reproduce a portion of it in the present number of the Monthly. Chapter IV., treating of atoms and molecules, presents admirably the views at present held by chemists and physicists respecting the molecular constitution of matter in its relations to spectral phenomena. But the volume of Studies is mainly devoted to topics that concern amateurs and experimenters in the laboratory or the observatory. Besides the numerous woodcuts and the colored map of radiation and absorption spectra, Mr. Lockyer has introduced a series of photographic plates showing actual effects more accurately than would be possible with engravings; and this feature somewhat enhances the cost of the book.

The Epoch of the Mammoth, and the Apparition of Man upon the Earth. By James C. Southall, A. M., LL. D. With Illustrations. Philadelphia: J. B. Lippincott & Co. Pp. 430.

We cannot deal with this book better than to give here a portion of the able article devoted to it in the *Saturday Review*:

"The advance of prehistoric archæology, the latest of the sciences, is not altogether as yet the continuous onward flow which enthusiasts in the study would have it to be. It is more like that of a tidal river—periods of reaction or reflux alternating with the general progressive set of the current onward. Bound up as it is with the theory of evolution as represented in the main by the views of Mr. Darwin, there is no wonder that the new study is met at times by a certain ebb in popular favor, or even in the acceptance of serious inquirers. None need complain, however, if the ground has to be thus gone over again with increased care and in a more critical spirit, so that the result be to consolidate more thoroughly what has been really gained from the study of the evidences, as well as to put a wholesome check upon tendencies which threaten a dangerous expansion of theory beyond the limits of fact. In this way much good may be done by attempts like that of Mr. Southall, in his 'Epoch of the Mammoth,' to bring to a focus the scattered rays of light which the most recent inquiries have shed upon the chronology of human life, tracing the history of man to the period of its dawn, and seeking to assign to its beginning something like a definite term of years. In the work recently published he urges once more, with the aid of fresh arguments and additional evidences, the views previously advanced in his 'Recent Origin of Man.' There can be no inquiry more important to the interests of science, if not to interests still wider and more sacred, or which more requires to be treated in an open, calm, and candid spirit. Unhappily it is not altogether in such a spirit that we find it approached by Mr. Southall, who soon makes it apparent that his object is to enforce a foregone conclusion rather than to conduct a critical and unbiased inquiry. He holds as it were a brief against a certain school of opinion, instead of taking his seat upon the bench of scientific judgment. In his opening chapters he hastens to lay down the conclusion to which he is desirous of leading the reader, and the issue on which he is prepared to stake his cause. If he can but succeed in bringing down the date of man's origin immensely within the limits assigned to it by geologists and paleontologists in general, there will be no room left for any gradual and slow development of humanity from a low and savage state, still less for man's emerging from relationship with even lower animal forms. The result will be a verdict for what was till lately the received or orthodox belief, that man appeared abruptly upon earth in the plenitude of his powers, stature, and organization, at a definite moment of time not many thousand years ago.

"Undismayed by the long array of distinguished names which he acknowledges to be opposed to his view of man's comparatively recent origin, Mr. Southall boldly proclaims the theory of evolution a failure. As for the existence of man during the Miocene or Pliocene age, he may safely speak of the evidences as speculative at the best, no remains of man or of his works having been actually produced from strata of that period. It is with quaternary man at the furthest that he feels called upon to deal. And he seeks to bring down the proofs of man's existence within limits narrow indeed, compared with the million years inferred by Mr. Wallace, Prof. James Geikie, and Mr. Vivian, from the stalagmitic deposits of the Devonshire and other caves, with the 800,000 years originally assigned by Sir C. Lyell, or with the 200,000 to which that eminent geologist was latterly inclined to reduce his figures, and at which Mr. Croll arrives from elaborate calculations of the successive glacial periods. We fail, however, to see him grapple so directly or tenaciously as we could have wished with the evidences of man's existence during, or even prior to, the last glacial epoch, i. e., at the time when the ice-sheet enveloped Northern Europe as far south as latitude 54°; for the glacial stage still lingers in Switzerland and the Pyrenees, and continues in full sway in Greenland and Labrador. We find no adequate reference made to the implements met with in the till or bowlder drift. He is content to set aside many an important issue, such as this, with the assurance that 'physical science has its fashions like metaphysics, that theories are ever changing, and that Darwinism and prehistoric archæology, twenty years from to-day, may be both forgotten.' A great point with him, in opposition to the antiquity of man, is the unity of the human race, for which, beyond denial, a strong case is to be made out, and which, as it stands by itself, must be regarded as the most solid and the best-welded link in his whole chain of argument. But this unity, resting upon the world-wide diffusion of symbols like the pre-Christian cross, the legend of the deluge, or of a terrestrial paradise, with common habits of interment, and domestic usage and similarity of speech—even when pushed to the extreme length which such arguments attain in the hands of enthusiasts like Mr. Southall—is far from compelling the narrow contraction of time within which he would reduce the differences entailed by the disruption of that primary unity. It is true that many arguments brought forward on the side of extreme antiquity have broken down; but what are the few that our author may have disposed of, beside the host of facts which the industry of paleontologists and the critical study of language and of race have verified and correlated? The zodiacs of Dendera and Esne may be given up as works of art more than 5,300 years old. The fossil man of Guadaloupe may be reduced to the status of a commonplace Carib not many centuries back, in company with the fossil man of Denise buried under the lava of Auvergne, and the human remains found, as at first alleged, under the coral limestone of Florida, but since referred to the recent fresh-water sandstone formation. The cone of the Tinière may be brought down from a date of 10,000 years to less than a third of that amount; and the notches in bones from the Pliocene beds of the Val d'Arno, said to bear the marks of knives, may be referred to the gnawings of porcupines or of some extinct rodent. But what is this more than to say that because, for instance, not a few palæolithic implements, so called, have been proved to be fictitious, therefore the countless stores which crowd our museums are to be set aside as worthless? In this easy and high-handed manner are the inferences drawn from the innumerable implements met with in the river-gravels (sometimes, as our author allows, a hundred feet above the present water-level) summarily disposed of. These gravels he admits, whether of higher or lower level, to have been deposited about the close of the Glacial age, and such, therefore, we may regard the date of man. Within the human period then, at least, the valley of the Somme has been hollowed out, and the Thames brought within its existing narrow limits from the wider range to which its beds of gravel, with bones deeply buried, bear record. With the ordinary explanation of valley erosion, as laid down by Sir C. Lyell, and other standard writers upon geology, our author is wholly dissatisfied. Instead thereof, he brings in the portentous hypothesis of a *Palæolithic flood*, induced either by an inflow of the sea, or (as more in conformity with the fact of the gravels being those of fresh water) a 'pluvial period' on an immense scale following the Glacial period—in fact, the down-pour due to the melting up of the vast ice mass.

"What were the impressions made upon the dwellers by the banks of the Ouse, or the fens of East Anglia, as the sea rose a hundred feet higher than it is now, aggravated as it was by the pluvial rainfall which 'overwhelmed the habitations of the contemporaries of the mammoth,' we utterly fail to realize. Paroxysmal effects, on a scale so gigantic as this, have long been removed from the conception of sober geologists of the English school. On continents later known and less thoroughly explored—within whose vast boundaries Nature seems to have carried on, or still to carry on, her operations in the stupendous fashion to which the cañons of America and valleys like the Yosemite bear witness—phenomena of this kind may seem conceivable enough. And it is upon observations and estimates such as those of Prof. Andrews, of Chicago, based upon the aspects of Nature in the great far West, that our author rests his representation of the catastrophes of man's early history. It is with limited, settled, old-world countries like England that we for our part have to do. And are we to conceive our quiet little island, within the scanty ten thousand years or so doled out by our author as the 'age of the mammoth,' raised up some hundreds, if not thousands, of feet—for Mr. Southall concurs with established geology as to the fact of oscillations to this extent—and swept by pluvial storms till the gravel was piled up a hundred feet in places? Are we to believe that within the same period the British Islands were still joined by a broad tract of land to France and Holland, 'the waters of the Thames and the Rhine forming a common trunk, discharging itself into the North Sea, and the rivers of our south coast uniting with the Seine and the Somme to run westward into the Atlantic?' Why, the period since the Roman invasion carries us back to very nearly a fifth of this range of time, and in all these years we find the general level of the southern coast not disturbed one inch, the apparent local changes being due to erosion of the land by tide and storm, as at Winchelsea and Reculver, or to heaping up of shingle and sand, as at Pevensey and Sandwich. It may do in the New World to quote Humboldt for 'Jorullo in Mexico being seen to rise from a level plain, on September 14, 1759, to a height of 1,681 feet,' as a proof that 'force, no less than time, is an element in geological action.'

But our dull imaginations have too much in common with the sluggish physical movements of our island-home for us to soar to the heights of calculation which seem so easy to Mr. Southall.

"It is in dealing with the age of the great extinct mammals that our author shows most conspicuously this tendency to shirk (unconsciously, of course) the difficulties with which the problem is surrounded in Europe. That early man was contemporary—in what is now England, Southern France, and Germany—with the lion, the bear, the hyena, the gigantic elk, the reindeer, and the mammoth, the conditions under which their bones are found intermingled have long placed beyond reasonable doubt. In the case of the reindeer and the mammoth, the evidence is raised to certainty by the discovery of outlines of those animals etched, with rude but highly-expressive art, upon fragments of bone."

Chemical and Geological Essays. By Thomas Sterry Hunt, LL. D. Second edition. Salem: S. E. Cassino. Pp. 536. Price, $2.50.

We noticed this admirable volume upon its first appearance three or four years ago, and are glad to observe that it has passed to a second edition. The plan of the work is not changed, as its essays have something of an historical import, which it was thought inexpedient to disturb, so that in the work of revision the author has confined himself to the correction of typographical errors in the text. But he has prefixed to the volume an elaborate essay of very great interest upon questions connected with the general scope of the work, upon which decided progress has been made since the first publication, and these additions are well worth the price of the new edition. We quote a portion of this preliminary essay, which treats of the ancient constitution of the air, and from which the author rises to the consideration of cosmical atmospheres and the diffused medium of celestial space:

"On pages 46-48 is a suggestion, made many years since, regarding the question of the temperature of the earth's surface in former geological periods, which, from its bearings, both direct and indirect, on some recent geological theories, calls for further notice. From the great amount of carbon and hydrocarbons of organic origin found in the rocky strata of the earth, it has long been inferred that the atmosphere of earlier times must have contained a large quantity of carbonic dioxide (carbonic acid) which yielded up its carbon for the nutrition of the ancient floras. From this the late Major Edwin B. Hunt concluded that, the atmosphere in former periods being much denser than at present, the temperature at the earth's surface, due to solar radiation, would be greater than now. It was subsequently pointed out by the present writer that, as already shown by Tyndall, the relations of carbonic acid to radiant heat are such that a quantity of this gas too small to affect considerably the weight of the atmospheric column would, by preventing the loss of heat, suffice to produce a tropical temperature over the earth at the sea-level.

"The quantity of carbon which has been removed from the air by vegetation in past ages is, however, very considerable. In a communication by the writer to the American Association for the Advancement of Science, at Buffalo, in 1866, it was stated that the whole amount of free oxygen in the present atmosphere is no more than sufficient to form carbonic acid with the carbon of a layer of coal covering the globe one metre in thickness, and that the aggregate of carbonaceous matter in the earth's crust would probably much exceed this. Such a layer of coal, of specific gravity 1.25, would have a weight equal to 3,160,000 gross tons to the square mile; while Mr. J. L. Mott, in a communication to the British Association for the Advancement of Science, in 1877, estimates the total amount of carbonaceous substances in the earth at not less than 3,000,000 tons of carbon to the square mile, and probably many times greater. This minimum amount of pure carbon is equal to 600 times the present amount of carbonic acid in the atmosphere, or to nearly one-fourth its entire volume; and, inasmuch as the fixation of carbon by vegetation liberates a corresponding volume of oxygen, would represent, according to him, a greater amount of this gas than the present atmosphere contains. In addition to this, it must be considered that the composition of the various hydrocarbonaceous minerals shows a deoxidation not only of carbonic acid but of water. The amount of liberated oxygen derived from water equals, for the various coals and asphalts, from one-eighth to one-fourth, and for the petroleums one-half of that set free in the deoxidation of the carbon which these hydrocarbonaceous bodies contain. To this must be added also the oxygen set free in the generation of metallic sulphides by the deoxidation of sulphates, which is effected through the agency of organic matters, and indirectly liberates oxygen. Against this we must, however, set the unknown but very considerable amount of oxygen absorbed in the peroxidation of ferrous oxide liberated in the decay of the silicates of crystalline rocks; which may, perhaps, serve to explain the disappearance from the air of the whole of this excess of oxygen.

"The terrestrial vegetation and the air-breathing fauna, which we find from Palæozoic ages, are, it is unnecessary to remark, incompatible with an atmosphere holding one-fourth its volume of carbonic acid, and the difficulty of the problem is greatly increased when we consider that this amount, corresponding to the carbon fixed in the earth's crust in deoxidized forms, is insignificant when compared with that which has been absorbed during the decomposition of silicated rocks and is now fixed in the form of limestones. The magnitude of this process is seen when we consider that all the argillaceous rocks and clays of the stratified formations have come from the decay of the feldspars and other silicates of the earlier eozoic terrenes through the intervention of carbonic acid, and that the resulting alkaline and earthy carbonates are now represented by the limestones so abundant in the earth's crust. It was shown, in the author's communication already quoted, that a layer of pure limestone covering the earth's surface to a depth of about twenty-eight feet (8.61 metres) corresponds to an amount of carbonic acid which, if set free, would double the weight of the present atmosphere, and the existence of great limestone and dolomite formations, many hundred feet in thickness, at different geological horizons over wide areas, will, it is believed, justify the conclusion that the earth's crust contains, fixed in the form of carbonates, an amount of carbonic acid which, if liberated in a gaseous form, would be equal in weight to at least two hundred atmospheres like the present one. A portion of this carbonic acid was doubtless separated at an early period in the history of our globe, since the limestones of eozoic rocks are of considerable thickness, and those of more recent times are in part derived from the solution and re-deposition of the older limestones. The only known source of carbonic acid, apart from combustion and respiration, are certain terrestrial exhalations of the gas, probably due to chemical reactions liberating small portions which had long before been fixed in the form of carbonates. We are thus forced to one of two conclusions: either the wholly improbable one that the atmosphere, since the appearance of organic life on the earth, has been one of nearly pure carbonic acid, and of such immense extent that the pressure at the surface would have sufficed, at ordinary temperatures, for its liquefaction; or else, the atmosphere being so constituted as to permit vital processes, that carbonic acid, as fast as removed by chemical action at the earth's surface, was supplied from some extra-terrestrial source. We may, in accordance with this last hypothesis, admit that the atmosphere is not terrestrial but cosmical, and that the air, together with the water surrounding our globe (whether in a liquid or a vaporous state), belongs to a common elastic medium, which, extending throughout the interstellary spaces, is condensed around attracting bodies in amounts proportional to their mass and temperature, while in the regions most distant from these centres of attraction this universal atmosphere would exist in the state of greatest tenuity. Such being the case, a change in the atmosphere of any globe, whether by the absorption or disengagement of any gas or vapor, would, by the laws of diffusion and of static equilibrium, be felt everywhere throughout the universe; and the fixation of carbonic acid at the surface of our planet would not only bring in a supply of this gas from the worlds beyond, but, by reducing the total amount of it in the universal atmosphere, would diminish the atmospheric pressure at the surface of our own and of other worlds.

"This hypothesis is not altogether new. Sir William R. Grove, in 1842, put forth the notion that the medium of heat and light may be 'a universally diffused matter,' and, subsequently, in 1843, in his celebrated 'Essay on the Correlation of Physical Forces,' in the chapter on Light, concludes, with regard to the atmosphere of the sun and the planets, that there is no reason why these atmospheres 'should not be, with reference to each other, in a state of equilibrium. Ether, which term we may apply to the highly-attenuated matter existing in the interplanetary spaces, being an expansion of some or all of these atmospheres, or of the more volatile portions of them, would thus furnish matter for the transmission of the modes of motion which we call light, heat, etc., and possiby minute portions of these atmospheres may, by gradual accretions and subtractions, pass from planet to planet, forming a link of material communication between the distant monads of the universe.' Subsequently, in his address as President of the British Association for the Advancement of Science, in 1866, Grove further suggested that this diffused matter might be a source of solar heat, inasmuch as the sun may 'condense gaseous matter as it travels in space, and so heat may be produced.'"

Pottery: How it is made, its Shape and Decoration. With a Full Bibliography of Standard Works upon the Ceramic Art, and 42 Illustrations. By George Ward Nichols. New York: G. P. Putnam's Sons. Pp. 142. Price, $1.25.

This seems to be a useful little manual, on a subject that is now attracting a good deal of attention. It is elegantly illustrated and beautifully printed, and it will be especially prized by many on account of its copious bibliography of the principal works upon the ceramic art. The volume is thus characterized by the author, in a few words of preface:

"It is the object of this book to show that the manufacture of pottery may become one of the great art-industries in the United States; to describe the laws which govern the form and decoration of pottery; and to give practical instruction in the art of painting, either with vitrifiable or common oil colors, upon hard or soft porcelain, or upon earthenware. It is the result of long and careful study, and is intended not only for the benefit of professional potters and decorators, but for that large class of persons who are seeking to acquire this art, either for entertainment or as a remunerative occupation."

Primitive Property. Translated from the French of Emile de Laveleye. By G. R. L. Marriott, B. A., LL. B. With an Introduction, by T. E. Cliffe Leslie, LL. B. New York: Macmillan & Co. Pp. 356. Price, $4.50.

This is an able work on land-tenure from the point of view of modern investigation into early social conditions. The author holds radical views upon the subject, which differ widely from those that prevail in this country: "He is of opinion that the dangers of democracy lie in the inequality of conditions, and that, unless the catastrophe can be prevented by measures of state on a large scale, the same struggle between rich and poor which destroyed the republics of antiquity will destroy the modern states also. He holds that the economists have made a fatal mistake in pressing the advantages of individual property in land, and that the abstract arguments by which private property is explained and defended as an institution are in favor, not of private and exclusive ownership, but of a form of tenure under which each man, as he comes into the world, shall be a proprietor." M. de Laveleye assumes the law of evolution of property in land, and traces the history of its development in England, China, Italy, Holland, France, Belgium, Russia, India, Switzerland, and Germany. The questions opened by Sir Henry Sumner Maine, in his "Village Communities," are here vigorously pursued, with large accessions of new and interesting matter.

Syllabus of Lectures in Anatomy and Physiology, for Students of the State Normal and Training School at Cortland, N. Y. By T. B. Stowell, A. M. Syracuse, N. Y.: Davis, Bardeen & Co. Pp. 82. Price, 50 cents.

This book is prepared merely as an aid to students in anatomy and physiology. The author does not assume for it that it is in any sense a substitute for a text-book, or other book of reference, but that economy of time and greater thoroughness may be secured by thus directing the attention to matters of chief importance. It is intended to be used in connection with anatomical demonstrations, charts, diagrams, and the microscope. Terms which are merely technical, as the names of the muscles and the bones, have been omitted.

PUBLICATIONS RECEIVED.

Walks in London. By A. J. C. Hare. New York: Routledge. Two vols. in one, pp. 480 and 511. $3.50.

Arguments before the Committee on Patents of the Senate and House of Representatives. Washington: Government Printing-Office. Pp. 454.

American Journal of Mathematics, Pure and Applied. Vol. I., No. 1. Published under the auspices of the Johns Hopkins University, Baltimore. Pp. 104. $5 per vol., $1.50 per single number.

Dictionary of Music and Musicians. Part II. London and New York: Macmillan. $1.25.

Incrustation on Brick Walls. By W. Trautwine. Philadelphia: W. P. Kildare print. Pp. 8.

Fifty-sixth Annual Commencement of the National Medical College. Washington: Darby & Duvall print. Pp. 30.

Free Ships. By J. Codman. New York: Putnams. Pp. 38. 25 cents.

Carbonic Oxide. By H. Morton, Ph. D. Reprinted from the *American Gas-Light Journal*. Pp. 12.

Metasomatic Development of the Copper-bearing Rocks of Lake Superior. By R. Pumpelly. From "Proceedings of the American Academy of Arts and Sciences." Pp. 57.

Bulletin of Hayden's Survey of the Territories. Vol. IV., No. 1. Washington: Government Printing-Office. Pp. 311.

Instruction in Physiology for School-Teachers. Johns Hopkins University, Baltimore. Pp. 74.

The Chinese Question. By J. H. Boalt. Pp. 16.

Report of the Citizens' Committee on the Nuisances of New York City. New York: S. Hamilton's Son print. Pp. 17.

The American Mountain Sanitarium for Consumption. By Dr. S. E. Chaillé. From *New Orleans Medical and Surgical Journal*. Pp. 16.

Principles of Breeding. By W. H. Brewer. From "Report of New Hampshire Board of Agriculture." Pp. 20.

Micrometrical Measurements of Double Stars. (Cincinnati Observatory.) Pp. 83.

House Air the Cause and Promoter of Disease. By Dr. F. Donaldson. From "Maryland Board of Health Reports." Pp. 23.

Water-Supply of New Jersey. By A. R. Leeds. From *Journal of the Franklin Institute*. Pp. 17.

Contributions to North American Ethnology. Vol. III. (Powell's Survey of the Rocky Mountain Region), "Tribes of California." By Stephen Powers. Washington: Government Printing-Office. Pp. 635, with Plates and Map.

Hayden's Survey of the Territories. Vol. VII. Contributions to the Fossil Flora of the Western Territories. By L. Lesquereux. Washington: Government Printing-Office. Pp. 366, with 65 Plates.

Proceedings of the American Chemical Society. Vol. II., No. 1. New York: Baker & Godwin. Pp. 50.

Nursing of the Insane. By A. E. Macdonald, M. D. New York: Bellevue press. Pp. 24.

Geological Investigations along the Line of the Cleveland, Canton, Coshocton & Straitsville R. R. By E. B. Andrews. Cleveland, O.: Robison, Savage & Co.'s print. Pp. 29.

POPULAR MISCELLANY.

The Disinfection of Streets and Sewers.—How some of the worthless by-products of chemical works might be turned to good account in disinfecting the streets of our American cities, is shown by Mr. H. G. Debrunner, in the Philadelphia *Chemist and Druggist*. He is led, by the results of experiment, to believe that street-mud and the sewer-water containing the same are the main factors in the distribution of contagious disease. This matter could be effectually disinfected, and that without extraordinary expense, by treating it with certain waste products, such as the mother-liquors of copperas and alum. Many a factory would be glad to get rid of this refuse, and would give it away for nothing. With these disinfectants, diluted with water to the desired strength, the streets should be sprinkled; most of the waste substances are so powerful that they may be greatly diluted without losing their efficacy. In street-dust, the author has found, besides the usual inorganic bodies, a number of organic substances—as, for instance, glutinous matter coming from abrasions of the hoofs of cattle. This matter varies in quantity from one-half to five per cent., and in some dust taken from roads leading to stock-yards it has been found in the proportion of as much as fifteen per cent. It decomposes readily, especially in the presence of water, and microscopic examinations of aqueous extracts of the mud from such localities show living beings of the lowest classes of the vegetable and animal kingdom—algæ, fungi, and various forms of infusoria.

The Harpy Eagle.—The harpy eagle (*Harpyia destructor*), of which a sprightly description is given by Dr. Felix L. Oswald in the *American Naturalist*, has its native home in the forests of Southern Mexico. Its common English and its systematic name, as well as its Spanish title, *Aquila real* (king-eagle), and its old Mexican name of "winged wolf," fitly characterize the rapacity of this bird. It has a square, strong head, armed with a powerful bill that can without any special effort crush a man's finger-bones. Its broad, compact wings are moved by shoulder-muscles of enormous strength; and its stout legs, feathered to below the tarsi, terminate in claws of such extraordinary power and sharpness that they leave their marks on the tough leather of a Mexican saddle, like the bite of a wild-cat. Its plumage is so elastic, so compact, and so firmly imbricated, that buckshot, striking on the wings or the breast of the bird at a certain angle, glance off, or fail to penetrate to vital parts. The fully-grown hen measures about three feet from its crest to the base of the tail, and from six to seven feet from tip to tip of the outstretched wings. The male is somewhat smaller, but the strength of the bird in proportion to its size is altogether abnormal. A tame old harpy eagle once engaged in mortal combat with a big shepherd-dog, and was only vanquished by a second dog that came to the assistance of his fellow. In a fight of ten minutes the first dog had received a deep gash in his throat (from which he soon bled to death), lost one of his eyes, and the bones of his skull and breast had been laid open in numerous places. In a fight between a harpy eagle and a Mexican lynx which had been crippled by a shot through its haunches, but was otherwise in good fighting condition, the bird was torn to pieces, but the lynx did not survive him many minutes, having been literally flayed from its shoulders to the tip of the nose. The following narrative shows the bird's tenacity of life: A Mexican miner, before daybreak one morning, in the mountains near Orizaba, surprised a pair of harpies, and with a cudgel knocked down one of them, which flew directly at his head. The miner now dispatched the bird as he thought, with a few well-aimed whacks, and, shouldering his game, resumed his journey toward the valley. Half-way down the mountain-side he reached a steep cliff, and shifted his burden to his left shoulder, to use his right arm to better advantage. But at the most critical moment of the dangerous descent he suddenly felt the claws of the eagle at his neck, and, in order to save himself, had to drop his stick, which fell down the cliffs and into the bed of a mountain-torrent. Holding on to the bird with one hand, he managed to reach the foot of the precipice, where he seized the struggling captive by the legs, and, swinging it up, dashed its head against a rock, till its convulsions had ceased entirely. His arrival in the village, with the story of his adventure, created quite a sensation; but, when the bird was deposited on the ground to be examined at leisure, it revived for the third time, struck its claws through the hand of its captor, struggled to its feet, and would have escaped after all, if the enraged miner had not flung himself upon it, seized a stone and hammered its head to a jelly.

Muslin Glass.—The mode of producing so-called "muslin glass" is as follows: After carefully cleaning the surface of a plate of glass, a layer of vitrifiable color is laid over it, the vehicle being gum-water, and care being taken to have the pigment evenly applied. The glass is then submitted to a gentle heat until the water has evaporated, when a stencil of the desired pattern is laid over the surface, and with a stiff brush the pigment is removed from the parts which are to be transparent. The glass is next inclosed in a frame, and above it is extended a piece of tulle or, if desired, embroidered lace, the embroidery in the latter case being so disposed as to harmonize with the ground-pattern previously made. The whole is then hermetically closed in a box which contains in its lower portion a reservoir holding a certain quantity of dry color in the form of impalpable powder. This by an air-blast is blown evenly upon the glass and adheres to the latter wherever the surface is not protected by the threads of lace. In this way the pattern of the latter is defined. In order to fix the powder, the sheets of glass are placed in a steam-chamber where the steam moistens the gum and causes the powder to adhere. The color is then burned in a special furnace.

Variability of the Nebulæ.—In a lecture recently delivered at Paris, under the auspices of the Scientific Association of France, the eminent Swiss astronomer Wolf gave an account of recent researches on the "variability of the nebulæ." His conclusions, as stated in *La Nature*, are: that some of the nebulæ are certainly in a state of relative motion—at least one double nebula being known to astronomers, the component parts of which revolve about each other; that in all probability some of the nebulæ are waning and disappearing—as instances of this he cites three nebulæ in the constellation of Taurus; that possibly some of the nebulæ are undergoing a change of form; the spiral nebula in Canes Venatici appears to afford an illustration of this fact. As for the distances of the nebulæ, they cannot yet be determined, but there are grounds for believing that many of them are not more remote from us than the fixed stars.

Copying Designs by Photography.—A new process of making photographic copies of machinery, drawings, plans, maps, etc., in blue lines on a white ground, has been invented by H. Pellet, a chemist of Paris. This process (says *La Nature*) is based on the peculiar property possessed by perchloride of iron, whereby it is converted into protochloride by exposure to light. The protochloride is not affected by contact with prussiate-of-potash solution, but the perchloride at once becomes blue. M. Pellet sensitizes a sheet of paper by dipping it in a bath consisting of water 100 parts, perchloride of iron 10 parts, oxalic or some other vegetal acid 5 parts. In case the paper was not sufficiently sized, gelatine, isinglass, dextrine, or some such substance, would have to be added to this solution. The paper so treated—M. Pellet calls it now cyanofer-paper—is dried in the dark, and may then be kept for a length of time. It is very sensitive to light. To make a copy of a drawing made on transparent paper, the drawing is spread over a dry sheet of the cyanofer, a plate of glass laid over all, and the whole exposed to the light. In summer, with exposure to the full sunlight, it takes from fifteen to thirty seconds to decompose so much of the perchloride of iron as is not protected by the lines of the drawing. In winter, an exposure of forty to seventy seconds is necessary. In the shade, in clear weather, the exposure varies from two to six minutes, and in cloudy or rainy weather, from fifteen to forty minutes. The electric light may be used instead of sunlight, the time of exposure varying according to the intensity of the light and the distance. After exposure, the paper is dipped in a bath of prussiate of potash (15 to 18 per 100 parts of water), and it at once assumes a blue color wherever the perchloride is unaltered, all the rest of the surface remaining white. The image is then freely washed in water, and passed through a bath of chlorhydic acid (8 to 10 parts to 100 of water), which removes the protoxide of iron salt; it is then washed again in water, and finally dried. The drawing then appears in blue lines on the pure white ground of the paper.

The Chinese Loess or Loam Deposits.—The origin of the "loess" deposits of China has long been a perplexing problem for geologists. This deposit is spread almost continuously over an area as large as the German Empire, besides existing in detached areas of nearly half that extent. Usually, the loess is several hundred feet in thickness, and in some places as much as 1,500 or even 2,000 feet. It is an earthy substance, of a brownish-yellow color, friable, chiefly consisting of argillaceous materials, with a small proportion of carbonate of lime; it has also mixed with it more or less of fine sand, the grains of which are very angular. The Baron von Richthofen, in his work on "China," the first volume of which has appeared, offers the most satisfactory theory yet presented of the origin of this loess. A very clear statement, both of the problem itself and of Von Richthofen's solution of it, is given by Prof. J. D. Whitney, in the *American Naturalist*, who states that the first geologist to notice and describe these remarkable deposits was Prof. Pumpelly. According to him, the loess of China is a lacustrine formation, each of the basins in which it occurs having been once the bed of a lake. But the absence of stratification and of fresh-water shells, and the presence of the bones of land-animals, appear to be utterly incompatible with this theory. Besides, the loess indicates by its structure the growth on its surface of an abundant vegetation. But a greater difficulty still stands in the way of the theory of a lacustrine origin—namely, the fact that everywhere the loess plainly shows itself to be a deposit which was not laid down till after the surface of the country had assumed its present configuration. Hence Richthofen unhesitatingly declares himself in favor of a subaërial origin of the loess. Wind and rain are, according to him, the agencies which produced these deposits. In the first place, he assumes the district of the loess to have been once destitute of outward drainage, and to have, in fact, consisted of a number of closed basins, such as are still found in the adjacent region, to the west, in Central Asia. These closed basins were prairies, and the loess is *the collective residue of innumerable generations of herbaceous plants.* It is the inorganic residuum which has accumulated during an immense lapse of time, as the result of the decay of a vigorous prairie-growth, ever renewing itself on the surface of the slowly-accumulating deposit. But how is the increase of the deposit provided for by the theory? Unless there be some source supplying material from without, there can evidently be no gain in thickness, however many generations of plants succeed each other. The necessary addition of mineral matters Richthofen considers to have been brought into these basins by two agencies, the rain and the wind, and the latter especially plays an important part in his theory. Each basin being surrounded by a rim of rocks, constantly undergoing decomposition, the particles thus set free were either swept down the mountain-sides toward the central area by rain, or blown thither by air-currents, and, once entangled among the vegetation, could not be caried farther.

The Pennsylvania Oil-Regions.—The oil-regions of Pennsylvania are, in an article by M. C. A. Ashburner, in the *Journal of the Franklin Institute*, divided into three districts, the southwestern, the western, and the northern, the southwestern lying south of the Ohio and west of the Monongahela, the western occupying the water-basin of the Alleghany, between Pittsburg on the south and the Philadelphia & Erie Railroad on the north, and the northern district extending north from the line of the same railroad. In the first of these districts the petroleum comes from the highest rocks, and in the third from the lowest, while in the second it comes from the rocks intermediate between the two. The "oil-sand group" of the southwestern district is composed of three sandstone members, separated by intervals containing coal-seams, slate, and shale; but the second of these three members—the Mahoning sandstone—is the principal repository of petroleum in the southwestern district. The "oil-sands" of the western district are also three in number. The first sand of this group yields a heavy lubricating oil, 30° to 35° gravity; the second, an oil about 40° gravity; the third, a light oil, 45° to 50° gravity. This third sand is the most productive, and supplies most of the oil of commerce. The "Warren oil-sand" of the northern district is very irregular in character, and the oil is found at horizons varying from 600 to 800 feet below the "third sand" of the preceding group, whose oil it, moreover, resembles. But at a depth of about 300 feet below the Warren horizon, and in the same northern district, is the Bradford oil-belt of McKean County, Pennsylvania, and Cattaraugus County, New York, the surest and safest oil-territory in all the oil-regions. The oil of the Bradford belt is of the same gravity as "third-sand oil."

The Ancient Beaches of Great Salt Lake.—The mountains round about Great Salt Lake bear plain evidences of the existence at some early period of a much larger lake in the same locality. The sides of these mountains rise, as it were by steps, to the height of 1,000 feet above the surface of the present lake, these steps marking the successive levels of the lake as it shrunk from its primeval dimensions—345 miles long, 135 miles broad—to the size it now possesses. Mr. G. K. Gilbert, of Powell's Survey, has made a very thorough study of these ancient beaches, and publishes an article on the subject in a recent number of the *American Journal of Science*. This ancient lake has received from geologists the name of Lake Bonneville, and the great problem was, to discover the outlet through which its waters were drained away. To this end it was necessary to find a point where the Bonneville shore-line was interrupted by a pass of which the floor was lower than the shore-line, and which led to a valley not marked by a continuation of the shore-line. These conditions are satisfied at Red Rock Pass, and, in addition, there is a continuous descent from the pass to the Pacific Ocean. All about Cache Valley the Bonneville shore-line has been traced, and it is well marked within a half-mile of the pass. The floor of the pass at the divide is 340 feet below the level of the shore-line, and its form is that of a river-channel. The gentle alluvial slopes from the mountains at the east and west, which appear once to have united at the pass, are divided for several miles by a steep-sided, flat-bottomed, trench-like passage, 1,000 feet broad, and descending northward from the divide. At the divide Marsh Creek enters the old channel from the east, and, turning northward, runs through Marsh Valley to the Portneuf River, a tributary of the Columbia. In Marsh Valley the eye seeks in vain for the familiar shore-lines of the Salt Lake Basin, and the conclusion is irresistible that here the ancient lake outflowed. On the sides of the mountains, from the highest shore-line, known as the 'Bonneville Beach,' down to the level of the modern lake, there is a continuous series of wave-wrought terraces recording the slow recession of the water. As many as twenty-five have been counted on a single slope. Some are strongly marked and others faintly, and some that are conspicuous at one point fail to appear at other points; but there is one that under all circumstances asserts its supremacy and clearly marks the longest lingering of the water—the 'Provo Beach,' which runs about 365 feet below the Bonneville Beach. When the discharge of the lake began, its level was that recorded by the Bonneville Beach. The outflowing stream crossed the unconsolidated gravels that overlay the limestone at Red Rock, and cut them away rapidly. The lake-surface was lowered with comparative rapidity until the limestone was exposed, and thenceforward the process was exceedingly slow. For a long period the water was held at nearly the same level, and the Provo Beach was produced. Then came the drying of the climate, and the outflow ceased; and slowly the lake has since shrunk to its present size.

Discolored Sea-Water.—While engaged in a survey of the Gulf of California—the *Mar Vermijo*, or Vermilion Sea of the early Spanish navigators—Surgeon T. H. Streets, of the navy, examined some of the water in order to ascertain the cause of the peculiar coloration. This red color occurs in patches, and does not extend to the whole area of the gulf. Having reached one of these patches, Dr. Streets had a bucket of the water taken on board the steamer, but it was found to be perfectly transparent. But, on sinking the bucket half a fathom or more below the surface, water was brought up which contained the coloring-matter in abundance. "When first drawn up," writes Dr. Streets in the *American Naturalist*, "and viewed in a glass vessel, by the unaided eye, the water had a faint reddish tinge. When allowed to stand for half an hour, the coloring-matter settled to the bottom of the vessel as a greenish-yellow precipitate; and when some of this was taken up by a pipette and examined under the microscope, it was seen to be composed of minute roundish bodies," the remains of ciliate infusoria, as they were proved to be after much laborious investigation. Under the microscope certain small objects were seen repeatedly darting across the field of vision, when the water was placed fresh upon the glass slide, but they disappeared as quickly as they came, and for a long time it was impossible to tell what had become of them. But at length one of the little bodies stopped directly in the centre of the field of vision and commenced a rapid rotatory movement, which presently ceased, and the animal was quiescent for a second or two; then rupture occurred, the molecular contents oozed out, and the transparent envelope of the organism became invisible. The observation was again and again repeated. The author quotes from Darwin's "Naturalist's Voyage around the World" a passage in which a similar observation is recorded with regard to certain patches of discolored water encountered off the coast of Peru.

Grape-Culture.—To determine the influence of girdling grape-vines on the growth and composition of the grapes, Prof. C. A. Goessmann last year made a series of experiments which are described in the "Proceedings of the American Chemical Society." He had a number of vines girdled during the first week of August, about the time when in the berries of the Concord grape the free acid had attained its highest development, and the grape-sugar was beginning slowly to increase. Entire vines as well as large branches served for the trial. Two incisions from one-eighth to one-quarter of an inch apart were made through the bark and the cambium layer, and the mass between these cuts down to the wood carefully removed. A marked difference in the degree of growth was soon perceived, which persisted during the entire season, until the grapes on the girdled branches had just become ripe. The tests made at this point with both the grapes of the girdled and of the ungirdled branches, grown on the same vine, showed a remarkable difference in the quality of the entire grape and in its relative degree of development. In some instances the girdled branches were two to three weeks in advance of the others. At the close of the season the girdled vines did not show the slightest difference from the ungirdled ones, the place where the bark had been removed being grown over.

Disadvantages of the Health-Lift.—The use of the "health-lift," so called, was under discussion recently in the Philadelphia County Medical Society, and Dr. Benjamin Lee read a paper on the subject, in which he condemned the practice as being neither rational, scientific, nor safe. The paper has been published in the *Medical and Surgical Reporter*, from which journal we select a few of the objections brought by Dr. Lee against the "health-lift." Exercise, according to Dr. Lee, in order to produce beneficial effects, must extend over a considerable length of time each day, and must be so moderate in its character that such continuance shall not render it exhausting. But it is claimed as the distinctive merit of the "health-lift" that it accomplishes a maximum of exercise in a minimum of time: "Ten minutes a day only is required." That is, "ten minutes a day" to fill the lungs up to their utmost capacity with pure, fresh, oxygenated air, so that every cell may do its duty. "Ten minutes a day" to set in full activity the thousand ducts of the sweat-glands, and to carry off noxious matters out of the blood; to recreate the weary brain-cells; to provoke absorption of the effete materials lying outside of the vessels throughout all the vessels of the body. In the next place, the first requirement of rational exercise is to call into play as far as possible all the muscles;

and the second is, that it should be so varied as to afford at the same time pleasurable mental excitement or occupation. In both of these points the theory of the "health-lift" is faulty. It calls into action almost exclusively the extensor muscles of the lower extremities, and the erection of the spine with the associate dorsal groups. As far as the upper extremities are concerned, the only muscles called into activity are the flexors of the fingers; those of the arm and shoulder are simply put on the stretch, an operation which, without corresponding contraction, weakens rather than strengthens muscular fibre. At the same time, the ligaments of the joints are violently stretched, which must tend to diminish the completeness of the apposition of the joint-surfaces, and thus diminish precision and rapidity of motion. As regards *variety and occupation for the mind*, the "health-lift" confessedly possesses no such quality. Finally, the "health-lift" is not a *safe* mode of exercise. It tends to produce apoplexy, rupture of blood-vessels, hernia, and other serious evils. The author concludes with these words: "Concentrated exercise is as unsatisfying to the muscle as is concentrated nourishment to the stomach. The latter demands bulk in its contents, the former a certain duration in its period of activity."

NOTES.

The third session of the Bowdoin College Summer School of Science will open on July 15th, in the Cleaveland Lecture-Room, and will continue for six weeks. Three courses will be given, viz., Chemistry, by F. C. Robinson, Instructor in Chemistry in the college; Mineralogy, by H. Carmichael, Professor of Chemistry; and Zoology, by L. A. Lee, Instructor in Natural History. This school is designed to give to teachers, gradates of colleges, and others, of both sexes, a practical acquaintance with science.

Dr. George M. Beard is collecting materials for a work on "writers' cramp," and other diseases of an analogous nature, as the cramp of artists, pianists, violinists, telegraphers, etc. He invites those who possess any information regarding these subjects to communicate the same to him. He will supply blanks on application. His address is "41 West Twenty-ninth Street, New York."

Captain Lunginers, of the Danish vessel Lutterfeld, reports that while off the coast of Terra del Fuego, latitude 65° 15′ 10″ south, longitude 75° 12′ 10″ west, at 3.30 A. M. of December 10, 1876, the man on the lookout espied at no great distance a considerable mass of land rising above the surface of the water in the shape of a hill about thirty metres high. As the charts had no mention of an island in that place, the captain resolved to lay-to till morning so as to investigate the discovery more fully. The next day at 5.30 A. M. the island appeared to be much smaller, but he went to visit it with a boat's crew. The island was found to be spherical in shape, its sides pretty steep. One of the sailors sprang ashore, but he had to return to the boat quickly, for the ground was intolerably hot. The island continued to sink, and at 8 A. M. it was no more to be seen; and one hour later the vessel passed over the place where it had stood.

From a series of observations made by Dr. Jarvis Wight, of Brooklyn, it appears that in at least seventy-five cases out of every hundred the lower limbs of human subjects are of unequal length; nor does this difference exist in the total length of the leg alone, but also in the length of the several long bones which constitute its skeleton. The inequality varies from one-eighth of an inch to one inch, the average being one-fourth.

Prof. Cope, it is stated in the *American Naturalist*, has received from Oregon a collection of fossils from a Pliocene lake-bed, including, with others, *Elephas primigenius*, *Equus occidentalis*, and many other extinct species. But a circumstance of uncommon importance is that, in the same deposit in which these fossils were found, occur numerous flakes of obsidian, with arrow and spear heads of the same. All were lying mingled together on the surface of a bed of clay, which was covered by a deposit of volcanic sand and ashes, of from fifteen to twenty feet in depth.

According to Prof. F. J. Burrill, of the Illinois Industrial University, the catalpa possesses great advantages as a timber-tree, being the cheapest and easiest grown of all our forest-trees, native or introduced, and also the most rapid in its growth. On the same ground it has outgrown the white or American elm, white-ash, European larch, Osage-orange, black-walnut, etc. It is not attacked by insects, and is free from disease. A board sawed from a catalpa-log, which had lain on the ground for one hundred years, was found to be perfectly sound and strong, and susceptible of a fair polish.

Julius Robert Mayer, who shared with Joule the honor of working out to a demonstration the mechanical theory of heat, died on March 20th. He was born in 1814; studied medicine at Tübingen and in Paris; in 1840 he visited the Dutch East Indies, and while there was led to study the relation between heat and work. His first publication on this subject appeared in 1842. In 1871 he was awarded the Copley medal by the London Royal Society.

The Colorado potato-beetle is reported to have made its appearance in New Zealand, where it now exists in formidable numbers in some localities. It appears to have been introduced with some American potatoes.

At Borsigwerk, in Silesia, the experiment has been successfully made of growing mushrooms in a coal-pit, at a depth of 126 metres below the surface of the earth. The fungi grow rapidly and plentifully in an average temperature of 8° Réaumur. The mushrooms so grown are said to be of finer flavor than those developed in the open air, and command higher prices.

The line of an interoceanic canal across the Isthmus of Darien, proposed by Ferdinand de Lesseps, starts from the Pacific coast, and ascends in the first place the Tuyra River as far as the island of Piriaque; thence a straight cutting, 16,200 metres long connects the Tuyra with the Chucanaque; the line then ascends the Chucanaque for 11,400 metres; then, turning to the northeast, it continues up the valley of the Tiati, to a point where a tunnel appears to be more economical than a very deep cutting. The tunnel passes to the south of the Peak of Gandi. On emerging, the canal continues through an open cutting for about ten kilometres to the deep waters of Port Gandi. The probable length of the tunnel is between thirteen and fourteen kilometres, and the cost of making the whole canal is estimated at 600,000,000 francs. This ship-canal, if ever completed, will doubtless be the most stupendous engineering work in the world.

It will be a surprise to most readers to learn that Theodor Schwann, founder of the "cell-theory" in biology, is still not only living, but actually "in the traces." He is Professor of Physiology in the University of Liége, Belgium, and will soon complete the fortieth year of his professorial life. It is proposed to celebrate this noteworthy anniversary of the venerable professor by the presentation to him of an address, signed by prominent anatomists and biologists of all countries.

A company has been established in Paris for operating the system of pneumatic clocks successfully adopted in Vienna, an account of which was recently published in these pages.

Prof. Luvini, of Turin, has experimented upon the action of different gases, such as pure atmospheric air, oxygen, hydrogen, carbonic acid, chlorine, and sulphurous acid, on the eggs, or "grains" as they are called, of silkworms. Lots of eggs numbering one hundred each were kept in each of these gases for over two months, and then hatched. It was found that the silkworms produced from eggs that had been kept in carbonic acid showed more vivacity and vitality than any of the others. Those from eggs kept in hydrogen were the most backward in development. Those in oxygen became large and fat, but slow and lazy in their movements; after the fourth month especially, they would remain in one position for hours at a time. The eggs kept in pure air produced good-sized silkworms, which, however, did not reach a large growth.

To ventilate a room without draft, make a hole through the wall to the outer air, in a corner of the room just above the skirting. Through the hole put one arm of a tube three inches in diameter, and bent at right angles. The arm of the tube reaching to the outer air should be in length equal to the thickness of the wall, and the other arm should be two feet long, standing vertically in the corner of the room; if desired, it can be covered with paper of the same pattern as that on the wall. A tube of the diameter given above is sufficient to ventilate a room of moderate size.

Near Nienburg, Hanover, waste pyrites from the manufacture of sulphuric acid having been employed for making roads and paths, it was soon found that grass and corn ceased to grow. Also, a farmer, on mixing well-water with warm milk, observed that the latter curdled. The explanation is, that the waste pyrites contained not only sulphide of iron and earthy constituents but also sulphide of zinc, and that by the influence of the oxygen of the atmosphere, and the presence of water, these sulphides were gradually converted into the corresponding sulphates, and the latter, continually extracted by the rain-water, soaked into the soil and contaminated the wells.

With a view to obtain, if possible, reliable data for the localization and diagnosis of cerebral disease, Dr. Lombard made a number of experiments designed to show, first, the normal relative temperature of different parts of the surface of the head; and, second, to show the effect of different mental states upon the different portions of the head previously examined. Mental activity, he finds, raises the temperature; the same effect is produced by simply awakening attention. The temperature is very rarely the same in all portions of the head when the brain is in the quiescent state.

EMIL DU BOIS-REYMOND.

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CIVILIZATION AND SCIENCE.[1]

By Professor EMIL DU BOIS-REYMOND,

OF THE UNIVERSITY OF BERLIN.

PART I.

I.—The Primordial Period, or Age of Unconscious Inferences.

THE relation of man to Nature primordially and of savage races in the present day is, as we know, very different from what it has been represented to be by poets and philosophers. In the delightful pictures their fancy painted there was nothing true: the idyllic conditions amid which they fancied the still youthful human race as living never have existed anywhere. The history of man the world over has its beginning not in a golden age, but in an age of stone. Instead of noble shepherds and lovely shepherdesses, who, under benignant skies amid picturesque scenes, live in innocence on the produce of their flocks, decorously enjoying all the purest gifts of fortune, the reality presents to our view rude, uncouth hordes struggling against hunger, against wild beasts, against the inclemency of the seasons; buried in filth, in groveling ignorance, and brutal selfishness; their women made slaves, their old people cast out; practising cannibalism first out of necessity, and then because superstitious usage had hallowed the custom.

Into the mental state of such beings we can enter as little as into that of children. We cannot strip ourselves of the acquisitions made by the generations whose successors we are, and whose priceless hoardings of the fruits of their labor now inure to our benefit. If, as Paul Broca teaches, the mean cerebral mass of Parisians in the present day exceeds that of Parisians in the twelfth century, may we not assume

[1] An address delivered before the Scientific Lectures Association of Cologne. Translated from the German by J. Fitzgerald, A. M., and carefully revised by the author.

our brain to have, by a process of gradual improvement, become more highly developed than the brain of the men of the stone age, 100,000 years ago? And this brain, more perfect as it is by nature, has been, at an early period of its life, subjected to innumerable unconscious influences, and, later, to the conscious influences of education, which render it in some sense incommensurable with the brain of those as yet half-brute creatures.

The instinct of causality, the questioning about the "why" of things, which we greet in our children as a precious token of their awakening human intelligence, is by some philosophers regarded as an original characteristic of man's mind. Others hold even this to be a derived faculty—that it results from the faculty of generalization. So much is certain, that, among men in a low grade of culture, the instinct of causality is satisfied with reasons for things that hardly deserve the name of *reasons*. Nothing, we are told by Charles Martins, strikes one so forcibly in conversing with the inhabitants of the Sahara as their lack of development in this respect. These people have no idea of "cause" or of "law" as we understand those terms. For them it is the *natural*, and not the *supernatural*, that has no existence. The French officer of engineers who sinks through the gypsum crust of the desert an artesian well, thus procuring for them the blessing of a new date-grove, is, in their eyes, not a man of superior acquirement whose eye penetrates to the interior of the earth, and who knows how to discover what there is hid, but a miracle-worker, who, albeit an infidel, is on better terms with Allah than themselves, and who, like Moses of old, strikes water from the rock.

In that stage of human progress science does not as yet exist. It is the childhood period of our race, and as such it has many points of resemblance to the childhood of the individual man. As this is *par excellence* the period of unconscious inferences, so it is to be admitted that such inferences, guided by experiment, have led to the invention of the first tools. These were invented, not by one man, nor at one spot upon the earth, but by many, and at points very distant from one another. Thus originated levers, rollers, wedges, and axes; clubs and spears; slings, *sarbacands*, lassos; bows and arrows; oars, sails, and rudders; fishing nets, lines, and hooks; finally, the use of fire, by which, as by speech, man is best distinguished from animals, and which even anatomically stamps him with the character of a soot-stained lung. Man, therefore, at an early period was unquestionably entitled to the epithet bestowed upon him by Benjamin Franklin of "the tool-making animal."

II.—The Anthropomorphic Age.

Now, whatever confronted him in the shape of a compelling power of Nature, being either beyond or adverse to his own will, and whether the same affected him favorably or unfavorably, in it, owing to a propensity deeply rooted in the human mind, he recognized the act of beings like himself, though usually hidden to his senses, whom he fancied to be free from the limitations to which he himself was subject, but who for the rest had the same emotions of love and hate, gratitude and revenge, with himself. The sum of such imaginings of a given nation at a given time we call its religion; but it might also be regarded as the personificative or *anthropomorphic* stage of our system of Nature. This attitude of man toward Nature is very clearly seen in Homer.

According to David Friedrich Strauss,[1] the bias of man's mind toward the personification of the forces of Nature has its root in the fact that so he hopes to win the favor of those unknown and dreaded powers. Perhaps a profounder reason could be assigned. Man originally knows no other cause of occurrences save his own will, the exercise of which is matter of direct experience, and hence it is that he refers all events back to the action of a will like his own. This explanation appears all the more probable, inasmuch as the same conception, only in a more refined form, still unconsciously pervades our theories of natural science. For undoubtedly this is the origin of the idea of Force which has done so much mischief in science, and which, despite all that we can do, is still ever creeping in.[2] We even see certain addle-brains in dead earnest entertaining the fantastic conceit that, by the aid of such anthropomorphic ideas as these, the mutual attractions of bodies across empty space can be explained. What difference is there between that Will which, according to our latest Nature-philosophers, drives the atoms together, and the gods of antiquity who animated the planets? The serpent of human knowledge has once more bitten its own tail; human science has reverted to its starting-point.

Very conclusively, as would appear at first sight, Buckle, in his "History of Civilization,"[3] from the aspects of Nature in different regions, deduces the religions there originating. He shows us India bounded on the north by the Himalayas, where Mount Everest towers to a height twice as great as that of Mont Blanc, where the Pass of Kwen-Lun leads into Thibet at an elevation equal to that of Caucasus, and where the Eiger, the Mönch, and the Jungfrau, piled on top of one another, would only fill up one of the lateral valleys. Toward the south he shows us the Indian Peninsula, with its harborless coasts, projecting into a sea that stretches uninterrupted to the pole, and which is often swept by cyclones. From the mountains to the sea streams not to be bridged over flow, passing through interminable jungles, in which wild beasts and venomous serpents threaten the life of the wayfarer at every step. According to the official returns, about 11,000 persons lose their lives annually in British India from the bites of serpents, especially the cobra de capello.[4] Failure of crops, famine, and

[1] "The Old Faith and the New," New York, 1875.

[2] *See* Du Bois-Reymond's "Untersuchungen über thierische Elektricität," Berlin, 1848, vol. i., p. xlii.

[3] "History of Civilization," New York, 1878, vol. i., chapter ii.

[4] Fayrer's "Thanatophidia of India," London, 1872, p. 32. Most probably, the num-

inundations, succeed one another with lamentable regularity in Bengal. The cholera-plague has its home in the delta of the Ganges; and in the devastating Indian pestilence of Rajastan, characterized by gangrene of the lungs, Hirsch recognizes the black death of the middle ages, the Florentine pestilence described by Boccaccio, which, like cholera in our times, held its ghastly circuit through the world.

In the face of such aspects of Nature as these, asks Buckle, which are ever menacing him with annihilation, must not man feel himself small and powerless? He arrives at no conscious, reasoned conclusion, but stolidly fancies to himself certain dominant and unfriendly powers as the authors of these dire calamities. He deifies the objects of his fears, erects altars to them, and offers to them sacrifice.[1] Hence it is that Hindoo mythology teems with monstrosities. Men there live 100,000 years. The ages of the world are reckoned by units followed by sixty-three zeros. The god Siva, who constitutes with Brahma and Vishnu the Indian trinity, is a monster with three eyes, wearing a necklace of human bones and a girdle of serpents. In one hand he holds a skull; a tiger's skin is his mantle; and over his left shoulder the deadly cobra rears its head. His wife Doorga is represented as of a blue complexion, with gory hands, lolling tongue, four arms, a giant's skull in one hand, a necklace of human heads; round her waist are the hands of her victims. All Hindoo deities are in like manner characterized by some inhuman or monstrous aspect—for instance, an excess of limbs or an unnatural complexion.

Buckle thinks he finds in Central America evidences of a like influence npon man's religious ideas of the dangers of life in tropical regions. The traveler Kennan refers the Shamanism of the inhabitants of the Siberian steppe to the dismal aspects of Nature by which they are surrounded. Alone on the *toondra* with his herd of reindeer, watching in the glare of the northern lights the howling wolves round about, the Korak stands on guard through the polar night, and fancies himself to be beleaguered by evil spirits, whose wrath he seeks to conjure away by offering to them his dogs, or by the practice of magic arts.[2] It needs not to be told how fully the gloomy sublimity of the Eddas accords in the same sense with the aspects of Nature in Iceland, where volcanic forces are ever striving with ice for the upper hand.

As contrasting with these aspects of Nature and the religions which owe to them their origin, Buckle points to the tamer and more pleasing scenery of Greece, and thence would infer the humanly beautiful character of the Hellenic mythology. With its multitudinous promontories, forming landlocked harbors, and itself surrounded by a number of beauteous islands, Hellas rises out of the Mediterranean, bearing

ber of victims is 20,000. (*See* also Sir James Paget *apud* Archibald Dickson, "The Vivisection Question," London, 1877, p. 38.)

[1] *See* Edmund Burke's *lumen dicendi* in the proceedings against Warren Hastings *apud* Macaulay, "Critical and Historical Essays," vol. iv.

[2] "Tent-Life in Siberia," New York, Putnams, 1870, p. 209.

not a single peak covered with everlasting snow; it has no great streams, volcanoes, or deserts, and so healthful is its climate that during 1,000 years it was visited only by one great epidemic—the plague described by Thucydides. Here, says Buckle, man did not feel himself overpowered by Nature. Here it was possible for those myths to have their rise which still delight us with their undying charm, and this because, instead of personifying the destroying forces of Nature, they rather glorify whatever is purely human. True, even Grecian mythology is haunted by many monstrous shapes, which, though an abomination to the eye of the comparative anatomist, even yet in some measure disfigure the imaginations of our artists. Yet even against the worst of these monsters man could hold his own, as Ulysses against Scylla; often he triumphs over them, as Bellerophon over the Chimæra, Theseus over the Minotaur; and, by insensible gradations, ending in the pleasing personifications of the spirits of tree, and mountain, and spring, these creatures of the artistic imagination of the Greeks at last become perfectly human figures.

It is an easy thing to carry still further these ideas of Buckle's—which have also been put forward by Lecky—and to deduce the monotheism of the Semites from their inhabiting a desert region, where Nature, in its majestic uniformity, presented itself to them lacking in color and form. It is not to be denied that in this idea of an agreement between religious forms and the aspects of Nature there is a certain degree of truth; still, like many another of Buckle's deductions, this theory bears the impress of a rather superficial rationalism. Buckle overlooks a multitude of complex intermediate facts. He makes the connection between forms of religion and the aspects of Nature far too direct. In particular, in deducing Hindoo mythology from the assumed terrifying aspects of Nature in India, he surely errs. Between the Himalayas and the Indian Ocean are thousands of square miles of fertile and now very thickly-populated country, where Nature offers nothing at all to excite the imagination in an unwonted degree. And to the originators of the Brahmanic faith what was a mountain-range which they had no occasion to cross, or an ocean which they had no occasion to navigate? Can any one suppose that, had the Jews been transplanted to the region between the Indus and the Ganges, they would have excogitated the Brahmanic, or the Koraks the Hellenic religion, had *they* migrated to the Peloponnesus? This brings us to a point on which neither Buckle nor Lecky has bestowed sufficient attention. If we were to maintain that the general psychological character of any given portion of the human race results from (among many other conditions) the local impressions under which they have developed, and that, again, from this psychological character, combined with many other circumstances, has come its form of religion, we should be stating with more correctness the causal connection between these two orders of phenomena.

III.—The Period of Speculative and Æsthetic Contemplation of Nature.

In the next place, from the nature of the country inhabited by the Hellenes, Buckle infers the symmetry of the Hellenic mind. Here, says he, for the first time the imagination was in some degree tempered and confined by the understanding, though without impairing its strength or diminishing its vitality; and, though originally the Greeks may have borrowed a good deal from the Egyptian priests, they were nevertheless the first people in history to look on Nature from anything like a scientific point of view, as distinguished from the point of view of anthropomorphism. Though still strongly tinged with anthropomorphism, this scientific contemplation of Nature had its origin in the teaching of the Ionian physical philosophers; and then, in the course of 250 years, it had attained such a height in Epicurus that in his doctrines we already find foreshadowed the law of the conservation of energy, on which the proud edifice of mathematical physics to-day rests. And though Epicurus could neither strictly formulate this law, nor illustrate it by an example, he nevertheless makes in favor of it an argument that is almost exactly the same as one made 2,000 years later by Leibnitz. Thus, then, with respect to the ultimate questions of philosophy, those ancient thinkers were, in fact, as well advanced, or rather as little advanced, as ourselves—a fact of no small importance for our theory of understanding.

When we contemplate the advances made in mathematics, astronomy, and acoustics, even by Thales and Pythagoras, it looks as though the instinct of causality had already reached maturity among the Mediterranean nations, and as though it was destined to lead men infallibly on to the latest results of scientific inquiry, as reached in our own times, and so on to domination of Nature resulting therefrom. Every one knows how different from all this the event really was.

Under the term Natural Science, we here mean not only the sum of our knowledge of Nature, organic and inorganic, its phenomena, its effects, and its laws, but also the conscious insight into the one method which aids in enlarging that sum of knowledge, and also the conscious application of this knowledge to the useful arts, to navigation, medicine, etc.—in short, the mastery and exploitation of Nature by man with a view to increasing his own power, comfort, and enjoyment.

Natural science in this sense was all unknown, we may say, to the Greeks and Romans. Those apparently so promising beginnings lacked persistent force. It is true that, during the 1,000 years which intervened between Thales and Pythagoras and the fall of the Roman Empire of the West, individual minds attained extraordinary heights. Aristotle and Archimedes must unquestionably be reckoned among the greatest teachers that have ever appeared. So, too, for some time a steady advance of science appeared to be insured by the labors of the

Alexandrine school. But nothing so plainly exhibits the hesitating step of natural science among the ancients as the simple fact that 400 years after Aristotle's day—an interval equal to that between Roger Bacon and Newton—so uncritical a collector as Pliny could exist. The case is as if Herodotus and Tacitus had exchanged places.

The history of the human mind offers few more noteworthy phenomena than this. Here are nations whose poetry and sculpture still afford us the highest delight; who, in metaphysics, history, and the science of law, produced works which, both in form and in substance, constitute the models for all ages; who to this day are our instructors in oratory, the art of war, government, and jurisprudence; but who, in their knowledge of Nature, never advanced beyond the puerile stage of credulity, and in which they rested content with the broaching of futile hypotheses. Their minds, ever ready, Icarus-like, to essay flights into the region of supersensual speculation, lacked the painstaking assiduity required to ascend the difficult path of induction—the only safe path—from particular and sharply-circumscribed facts, up to general propositions, thus rising gradually and methodically from the apparently accidental to the conception of law. True, the germ of the inductive process appears in Socrates and Aristotle; still the method which in general and theoretically was recognized as correct no one knew how to apply to particular cases; and beyond this feeble beginning nothing was done by the ancients. Even when by chance they observed aright, their very first attempt at an explanation would involve them in a tangle of such absurd and ridiculous fancies that one much prefers the theory of old Pan with his train of golden-haired nymphs ruling forest and field; of Poseidon with his trident agitating and again calming the sea; of Zeus hurling his thunderbolts. The picture drawn by Prometheus Bound of his services to humanity is a true representation of ancient science, when with astronomy, arithmetic, the alphabet, breeding of animals, navigation, mining, and medicine, he directly couples as equally important gifts the interpretation of dreams, of the flight of birds, and of the signs found in the entrails of immolated animals.[1]

In his very instructive rectorate address on "The Backwardness of the Ancients in Natural Science,"[2] Herr von Littrow deduces, from Plutarch's dialogue on "The Man in the Moon," a striking evidence of the inability of the ancients to reason scientifically. He might have quoted to the same effect Plato's "Timæus," a work abounding in intolerable absurdities; or the whole of a treatise that has come down to us bearing the name of Plutarch as its author, and entitled "Opinions of the Philosophers,"[3] of which Biot affirms that it contains the germs

[1] Προμηθεύς δεσμώτης, v., 442, *et seq.*

[2] *See* Popular Science Monthly, vol. ix., p. 438.

[3] Περὶ τῶν ἀρεσκοντων τοῖς φιλοσόφοις. Concerning the doubtful authorship of this work, *see Monatsberichte der Berliner Akademie*, 1874, p. 485.

of all modern discoveries, nay, those discoveries themselves. Unfortunately, however, he observes, truth and error are here both equally the work of chance; the opinions here stated are like lottery-tickets, whose value is known only after the drawing.

But it is further shown by Littrow—and this is a point to which less attention had been directed—that the ancients were incapable even of *observing* scientifically.

That the eye must be trained, we know from physiology. The vast majority of mankind have no suspicion that we constantly see double images, but that we very properly disregard them. But few persons note the subsequent images remaining in the eye after having looked on an object, the opacity of the visual media, occurring even in the state of perfect health, or the hallucinations that precede sleep. It was only two hundred years ago discovered by Mariotte, that in each eye we have a blind spot, over which we throw the ground-color of the object contemplated, thus giving to this blank in the field of vision its most probable interpretation. From the year 1809, when Malus discovered the polarization of light, observers like Arago, Biot, Fresnel, and Brewster, had vainly endeavored with the naked eye to distinguish polarized from ordinary light. But since 1844, when Haidinger succeeded in doing this, the yellow tufts which bear his name belong, for every trained eye, to the normal aspect of the blue sky.

In the domain of tone-sensations, the harmonic notes, as we know, at first evade our immediate perception, though the *timbre* they give to the sound is at once noticed by every one, except those portions of the German race whose vocalization is faulty.

With such minutiæ as these, however, we are not here concerned, but with such striking objects as the stars, for the observation of which the ancients, under their favoring skies, had far better opportunity than ourselves; and which, furthermore, were to them of the greatest practical importance, both on land and sea, before the discovery of the mariner's compass. Yet the elder Pliny states the number of observed stars, i. e., of the stars according to him visible to the naked eye, as only 1,600; while Argelander reckoned 3,256; and Heis, to whom the stars appeared as points without rays, added to the last figure 2,000 more. To all this add the fact that the ancients, owing to their living in lower latitudes, could survey a larger portion of the celestial sphere than we can [in Germany]. The stars noted by the ancients decrease in number as they rise in the order of magnitudes, though, in fact, each successive class of magnitudes embraces more stars than all the preceding classes taken together. Of nebulæ and star-clusters, five were known to Ptolemy; Argelander saw nineteen with the naked eye. Hipparchus and Ptolemy take no note of the nebula in Orion, or of that in Andromeda. But the most striking circumstance of all, perhaps, is the fact that the ancients did not count the Pleiades correctly, though their number was matter of dispute, and hence an object of keener observation, and though that constellation was of importance to them in determining the seasons.[1] According to Aratus, who flourished under the successors of Alexander, there are only six Pleiades, and it is a vulgar error to admit that they were seven, and that one of them was lost. Hipparchus, however, corrected Aratus, and fixed the number of the Pleiades at seven. Nevertheless, Ovid says of the Pleiades:

> "Quæ septem dici, sex tamen esse solent;"[2]

—and the poets went on speaking of a lost Pleiad.[3] But nowadays ordinary observers, with good eyesight, can discern fourteen to sixteen stars in this constellation.

The ancients, then, according to Littrow, described the heavens as imperfectly as though they had been to some extent short-sighted, or as though—but this supposition is negatived by other facts—the discriminating power of the human retina had since become more acute. On the other hand, we cannot sufficiently admire the refinement of their artistic sense in reproducing the forms of the human body. In counting the Pleiades they erred. But the wavy lines of female beauty have never been rendered with greater perfection than by them; and the Borghese Gladiator gives evidence in every one of his quivering muscles of such close observation as to lead to the supposition that in the ancient art-schools there was an esoteric teaching of anatomy.[4] It is customary to attribute the supreme skill of the ancient sculptors in representing the human body to the advantages they enjoyed, as compared with our own artists, who can only study professional models, in frequently viewing the nude in unconstrained action in gymnasia and at the public games. But, with respect to the female figure, the ancient sculptors had no such great advantage over our own, and yet here, too, they have attained unequaled excellence. So, too, our artists have as fair opportunity of studying the breast of a live, nude horse as the ancients had of observing nude athletes; and yet it was said, during the lifetime of Franz Krüger, that he was the only artist who knew how to paint a horse's breast. The truth is, that the ancients had a special inclination for this kind of observation, but it lay altogether outside their habits of thought nicely to determine the limits of a phenomenon as regards space, time, and weight. Hence, in all that concerns artistic forms their eye was very highly developed, but they lacked the training needed for grasping scientific facts.

They were utter strangers to the art of experimentation, wherein methodical observation under arbitrarily determined conditions combines with a fervid inventive imagination and a calm judgment to pro-

[1] Whewell, "History of the Inductive Sciences, vol. i., p. 130, London, 1847.

[2] "Which are said to be seven, though they are but six." Ovid gives two mythological hypotheses for the disappearance of the seventh Pleiad, "Fasti," lib. iv., v. 170–178.

[3] *Cf.* Byron's "Beppo," stanza xiv.

[4] Salvage, "Anatomie du Gladiateur combattant applicable aux Beaux-Arts," 1812, p. iv.

duce a purely modern form of mental activity, which oftentimes not only leads to certitude in the experimental science, but even evokes new phenomena. Thales already was acquainted with "the soul of amber," and the power of the Heracleian Stone was well known to the ancients as a matter of simple curiosity. But they never got beyond the first crude observation of those effects out of which the modern mind has developed a whole world of facts and ideas.

In the time of Alexander the Great, however, interest in remarkable natural curiosities was so far developed that he used to send back from his expeditions such objects to his teacher Aristotle. But how little was done later by the Romans toward utilizing the unparalleled opportunities they enjoyed for increasing the knowledge of Nature! From every quarter of their immense empire they gathered animals for their vulgar shows and feasts. At enormous expense they raised all manner of animals for food. We read, too, of their aviaries. But we learn nothing of any establishment in Rome for exhibiting plants and animals—a managerie or a botanic garden—such as we find even among the Aztecs.[1]

Without scientific observation, experiment, and sound theory, no enduring progress can be made in the useful arts. Such progress necessarily depends on conscious utilization of natural forces observed in their orderly workings. Of this, on the whole, the ancients had no idea. True, they carried to a high state of perfection some few branches of useful art. In architecture, road-making, and bridge-building, in bronze-casting and the art of cutting precious stones, they were masters. The art of fortification and the siege enginery of the later Romans are truly wonderful. But, if we would estimate aright the degree of technical skill reached by the ancients, we must compare it with the results attained by other nations. The technical skill wherein they excelled belongs to a comparatively low grade of culture. In architecture, for instance, the Egyptians, too, as well as the Assyrians, the Hindoos, and even the Peruvians under the Incas, were very proficient. A much higher degree of culture is marked by the invention of the mariner's compass, gunpowder, and printing. Next comes the steam-engine, an invention which we owe to modern European civilization.

The second of these stages of technical evolution the ancients never attained. On the other hand, it was reached at a comparatively early date by the civilized peoples of Eastern Asia, who, in other respects, seem barbarous as compared with the Greeks and Romans. These Asiatics, it is true, only employed the compass on land-journeys, used gunpowder only for fireworks, and they did not in printing employ movable types, owing to the clumsiness of their mode of writing. But, even in their pottery and textile fabrics, the classic nations were surpassed by the Hindoos, the Chinese, and the Japanese. The ancient civilization always stood, so to speak, with one foot in the bronze age.

[1] Prescott, "Conquest of Mexico," vol. i., p. 124, *et seq.*; vol. ii., pp. 60, 108, *et seq.*

To get an idea of the tardiness of their progress in the useful arts, we might compare the difference in material culture between the time of Pericles and that of Constantine on the one hand, and between Barbarossa's time and our own on the other. All industrial occupations among the ancients were, for the most part, confined to the servile class. This is the reason often assigned for the low state of industrial art among them. But may we not rather recognize, in the contempt of the freemen for industrial occupation, their small capacity for the same? However this may be, the material culture of the ancients evinces a one-sidedness and an imperfectness corresponding to the deficiencies we have already found to exist in their theoretical culture.

Hence comes the disproportion between technical and æsthetic performance, so often noticed in the products of ancient art-industry. In our museums, every one admires the candelabra brought from the villas of wealthy Romans, which were destroyed by the eruption of Vesuvius. From light bronze branches, whose leaves seem to flutter in every breath of air, are suspended by slender chains a number of beautifully-fashioned lamps. By the light of these lamps Cæsar wrote his "Commentaries," Cicero rounded his periods, Horace gave the last polish to his "Odes." Each lamp is simply an oil-holder, into which dips a wick—a smoky affair, that no scullery-girl would tolerate nowadays. The idea of discovering the source of the light given by the lamp; of finding it in a more or less perfect combustion of a combination rich in carbon—a combustion carried only so far that, in the hot but not luminous flame produced by perfect combustion, some solid carbon-particles shall be brought to a white heat; of bringing about this degree of combustion by regulating the supply of air and oil; meantime, of protecting the flame from air-currents, saving the surrounding objects from smut, and guarding the organ of smell from the offensive odors of acrolein—such thoughts never once appear to have occurred to the minds of the artists of Magna Græcia. For them, the most perfect lamp was the one that was the most ornamental. If more light was needed, other smudgy lamps were added.

Thus the ancient culture resembled one of those coins on which a master-hand had stamped a noble countenance of some deity, but which he could not make round. We may, therefore, justly characterize this civilization as being essentially æsthetic, and the attitude of the ancients toward Nature as *speculative and æsthetic.*

The backwardness of the ancients in natural science was fruitful in most serious consequences to the human race. It was one of the chief reasons of the downfall of the old civilization. The greatest misfortune that ever befell humanity, namely, the overrunning of the Mediterranean countries by the barbarians, could have been prevented had the ancients possessed natural science as we understand that term.

This point has not, perhaps, been sufficiently noted hitherto. When Montesquieu and Gibbon described the fall of the Roman Empire, natural science had not attained its present importance in the minds of modern nations, and even to this day it is for the most part overlooked by writers of history. The numerous causes under the action of which the Roman Empire was destined to crumble to pieces, and to become the prey of the barbarians, have been again and again set forth with much learning and skill. No doubt the ancient world had grievous internal ills. Slavery, pretorianism, corruption of morals, and aversion to matrimony, decay of civic as also of military virtue, the enervation caused by over-refinement, which had exhausted every pleasure and profaned every ideal, and which could not find in itself the means of rising above itself—such are the oft-cited causes to which the inevitable downfall of the Roman domination is ascribed.

And yet the success which almost invariably attended the efforts of vigorous emperors is proof that the state of affairs was not entirely hopeless. Down even to a very late period of the empire's history, the course of events was tolerably amenable to control and regulation, and in the face of the enemy the legions did not altogether belie their hereditary valor and discipline. Even in the palmiest days of the Roman state they had not always been victorious. The introduction of Christianity did not move the ancient world out of the ruts so much as might have been expected. Though a portion of the ancient culture was then thrown overboard, it nevertheless, on the whole, remained intact. There yet stood, under the protection of the victorious cross, temples, theatres, baths, halls of justice; the multitude of the works of art baffled the fury of the destroyers, and the papyrus rolls of the libraries still preserved unscathed the treasures which a thousand years had collected. What was needed was to oppose to the inpouring barbarian hosts from the northeast a barrier which should last until the tide had begun to ebb, and these hordes had themselves come under the influence of civilization: then all would have been well.

It was the opinion of Liebig, who also contemplated the downfall of the ancient culture from the point of view of the natural sciences, that the case was hopeless, whatever might be done. As a result of his researches on mineral manures, Liebig taught that the Roman Empire fell like the Grecian communities at an earlier day, and like the Spanish domination later, because in the countries from which the Romans derived their grain the soil had become exhausted of the mineral matters requisite for growing wheat, especially of phosphoric acid and potash.[1] This doctrine was refuted by Conrad, who shows that the fact of the soil having been exhausted is not proved. In every instance where, according to Liebig, the soil was exhausted by improvident cropping, other reasons may be assigned for the decreased fertility; for instance, drought resulting from the decay of irrigation-works, or from reckless deforestation, and the production of marshes from the want of river-

[1] "Die Chemie in ihrer Anwendung auf Agricultur und Physiologie," "*Einleitung in die Naturgesetze des Feldbaues*," p. 86, *et seq.*

levees, or the sinking of the soil by volcanic action. Many a tract of waste-land in Italy, which in former times was thickly populated, would still be productive were it not that the dragon of malaria keeps watch on the golden fleece of the grain-harvest. The south of Spain did not become barren till after Christian intolerance had driven out the industrious Moors, and Gothic laziness had permitted their irrigation-canals to become choked up. Wherever, therefore, sterility was not produced by irresistible natural agencies, it was not the cause, but rather the result, of the decay of the state. Under more favorable political conditions, the ancient fertility of the soil might be restored, but the evils of deforestation, as we see in Provence, can hardly ever be repaired.

It was not because the soil of the Mediterranean countries was impoverished in phosphoric acid and potash that the ancient civilization went to ruin, but because that civilization was built on the quicksand of æsthetics and speculativism, which was quickly swept away by the tide of barbarian invasion. Suppose the legionaries had been armed with flint-lock muskets, instead of the *pilum*, and that, instead of the catapult and the *ballista*, the Romans possessed even such artillery as was employed during the sixteenth century. Would not all the migrant hordes, from the Cimbri and the Teutones down to the Vandals, have been sent back home with broken heads? True, the Romans beat back the Teutones with the *pilum* alone, for, even with equal arms on both sides, the superior military science, backed by higher mental and bodily development, ever prevails over undisciplined masses of men. But, had fire-arms taken the place of the *pilum*, the Romans would always have triumphed over the barbarians, even without a Marius, and without such terrible efforts as at Aquæ Sextiæ. It is vain to speculate in history about what would have happened under altered circumstances. So much, however, is clear, that, had not the ancients neglected to win for themselves that absolute mastery over brute force which the subjugation of Nature and the progressive improvement of industrial skill always insure, the two ethnic elements of the "Nibelungenlied," namely, Northern heroes and horsemen from the steppes of Asia, would have been powerless against the Roman Empire, though its rottenness stunk to heaven. And, had the ancients developed their inventiveness sufficiently to originate the art of printing, then, despite the invasions of the barbarians, we should not have to lament evermore the loss of so many a masterpiece of poet, orator, and historian.

IV.—The Scholastico-Ascetic Period.

But the ancient culture succumbed. The night of the middle ages settled down upon those shores of the Mediterranean once illumined with the splendor of all that is grand and beautiful. To this was added a peculiar fatality which made the intellectual ruin more complete, and entirely checked for a long time the progress of natural science which under the ancients had been tardy enough.

With the fall of Roman power came, at the same time, the fall of polytheism, a system dating from the anthropomorphic period of the Philosophy of Nature. Christianity now came into possession of Olympus, crowded with barbaric gods, and banished its denizens to the region of demons and ghosts. Nor was it content with such purification of the temple as this. Sprung itself from Judaism, which possessed neither art nor science, but which was already characterized by an exclusive estimate of the value of moral effort, the new creed restricted the circle of ideas, which alone it recognized as profitable to man, within the categories of *good* and *bad*, and the relations between the sinful creature and his creator. In opposition to heathenism, which was languishing from sensuous excess, it enjoined on its adherents self-denial and contempt of earthly life, and bade them to tremble in constant expectation of the judgment which was to come both for them and for the whole world. This earth, with all its glory, appeared henceforth to man as a resting-place unworthy of notice, where the soul must prepare for a better state to come. Our body, given to us in love by father and mother, this crown and masterpiece of creation, Christianity despised as the perishable shell of the soul which alone was akin to God; nay, it hated the body as the accursed source of sin. Only with fear and trembling could the believer pluck the fruit of the tree of life. A celibate life within the walls of a cloister, and entirely occupied with prayer and penances, was held to be the best way, and the one most pleasing to God, of spending the time of trial here below; in recompense, the elect were assured of sempiternal beatitude *post mortem*.

That this new mode of looking at the universe was little favorable to natural science is obvious. Still it is only with difficulty that we can form to ourselves an idea of the attitude of the human mind toward Nature during the middle ages. A passage from the life of Francesco Petrarca will serve to throw light upon this point.

Petrarca, in whom the reminiscences of classic antiquity awoke and were strangely blended with the beliefs of his own day, daily had in sight, from Avignon, Mont Ventoux, that uttermost spur of the maritime Alps, swept by the *mistral*. Long had he wished to stand upon its summit. His longing was stimulated on reading in Livy that Philip of Macedon (the enemy of the Romans) ascended Mount Hæmus, in Thrace,[1] in order to view simultaneously the Adriatic and the Euxine. At last, on the 26th of April, 1336, the plan was carried into execution, and, as the weather was very favorable, Petrarca and his younger brother, Gherardo, enjoyed the broad prospect. The clouds beneath his feet proved to him the possibility of what he had often read of before with incredulity with regard to Athos and Olympus. The distant chain

[1] Titi Livii, "Hist. Rom.," lib. xxx., 21, 22. Petrarca falls into the error, not before noted, as far as I am aware, of planting Mount Hæmus (the Balkans) in Thessaly.

of the Alps calls to his mind Hannibal, and beyond he descries, with the mind's (rather than the bodily) eye, the land for which he longed—Italy. But now he feels the fetters which bind him growing painfully tighter; the image of his mysterious lady below there in Avignon, and whom he had for the first time seen almost exactly nine years before, April 6, 1327, rises before his mind. Of the Ovidian verse which he uses to describe the state of his feelings—

"Odero si potero. Si non, invitus amabo"[1]—

we can hardly say that it expresses a great amount of passion. The grandeur of the surrounding spectacle, the Rhône at his feet, in the distance the flashing mirror of the Mediterranean between Marseilles and Aigues Mortes, bring him back again to the real world. While he abandons himself to these impressions, it occurs to him to open, as though it had been a "book of fate," a little copy of St. Augustine's "Confessions" which he always carried about with him. He read there this passage: "Men go to gaze on lofty mountains and the mighty waves of the sea, and the wide currents of rivers, and the vast extent of ocean, and the circling courses of the stars, and they overlook themselves."[2] Taken in connection with the context, the passage does not carry an ascetic meaning, but occurs in the course of a theoretical explanation of memory that rather does credit to the mystic Bishop of Hippo. But Petrarca sees in these words, so directly applicable to his surroundings at that moment, the very finger of God. Full of shame and remorse, and without uttering another word, he descends from the mountain, and that very night addresses to his confessor, Dionigi de' Roberti, the doleful letter from which we take this narrative. The poor fellow had for a moment, forgetful of his soul's welfare, indulged the harmless pleasure of looking out on the entrancing world of sense, when he should have been moodily contemplating his own inner state. So diseased were the intellectual faculties of man in Europe in that age, that this incident sufficed to bring a conscientious, fine-feeling, but not very strong-minded man like Petrarca into a state of intensely painful self-conflict.

Fortunately, the "Decamerone" shows that not all minds were so delicately strung. But in the "Divina Commedia" we curiously enough see a poetic imagination of the highest power, equipped with all the scientific lore of its day, clothing the ascetic view of the world in such a garb of stern reality, that King John of Saxony has been able, from the description given in the "Inferno," to sketch a topographical plan of hell, as though Virgil had conducted, not a poet, but a scientific

[1] "Amores," lib. iii., Eleg. x., v. 35. "If I can, I will hate; if not, I shall love against my will."

[2] This incident occurred in the thirty-second year of the poet's life. The passage from Augustine is as follows in the original: "Et eunt homines admirari alta montium, et ingentes fluctus maris, et latissimos lapsus fluminum, et oceani ambitum, et gyros siderum, et relinquunt seipsos."

traveler—a Leopold von Buch, for instance—through the infernal regions.

It was not only by depreciating in the estimation of mankind the world of phenomena that Christianity, during this dreary period, discouraged the study of Nature, but also by proposing to them new and peculiar aims, before unheard of. Amid a darkness of their own procuring, men busied themselves with such problems that to them might well have been addressed the reproof of *Romeo* to *Mercutio:* "Peace, peace! thou talk'st of nothing." The best minds of the time expended no end of labor and ingenuity in distinguishing between absurdity and nonsense. Like a plant in the dark, the ancient philosophy put forth colorless and weakly sprouts which sought the light mainly in two directions, platonistic tendencies finding expression in an insane gnosticism, and Aristotelian tendencies in barren scholasticism. Scholasticism held the ground longest, and the *scholastico-ascetic period* will always remain as a warning to show to what length the unaided human mind, divorced from the world of reality, and without the revelation of Nature, can go astray.

V.—The Rise of Modern Science.

Inasmuch as humanity recovered from this madness through the study of the ancients, revived by Petrarca and Boccaccio, the next ensuing stage of development is called the stage of humanism. In the dusty codices the mind of the Christian West, awakened as it were from a bewildering dream, got a glimpse of the grand old heathen world; and, hardly believing its own eyes, began to understand how deplorably narrow was the circle of ideas within which it had in some unaccountable way suffered itself to be confined for a thousand years. A flood of reawakened ideas coursed through school and castle and town, and even through the cloisters; and, as it might be increased, swept away the musty trumpery of mediæval hallucination. With the ideas of the ancients, their works of art, too, arose from the grave. To the newly-awakened antique spirit corresponded the new form of the beautiful; and in an instant, almost, art flourished as it never has flourished since, with a bloom which is to the bloom of Hellenic art what a flower, perhaps of less perfect form, but of heavenly sweet odor, is to a flower of perfect beauty but odorless.

This resurrection of the human mind, with its natural consequences —the reformation of the Church, and the new birth of philosophy and the other sciences of mind—has oftentimes been described at length. Still, one point has commonly been overlooked, which it is not so easy satisfactorily to deduce. As we have seen, the ancients knew nothing of natural science, in our sense of the term. Is it not, then, a very curious circumstance that the resuscitation of classical studies should have given the impulse to the development of modern natural science? —that the ancients, who themselves could not think scientifically, nor experiment, nor even observe, should now, by their teaching and by their ideas, produce a race in whom these faculties were to go on steadily and incessantly developing—a race bearing to the authors of its intellectual culture the same relation as subsists between a brood of ducks and the hen that has hatched them out? To what cause, then, do modern civilized peoples owe the victorious outburst of the instinct of causality which among the ancients found no adequate or methodical expression, or was satisfied with futile reasons? Must we say that among the Kelts and Germans, who soon vied with the Latin peoples in their ardor to share in this newly-awakened intellectual activity, this instinct was naturally stronger than among the Greeks and Romans? And was, perhaps, Keltic or Germanic blood mingled with Tuscan in the veins of the youth who, during mass, discovered the isochronism of the pendulum oscillations in Buschetto's cathedral?

The greater seclusion and introspection of northern life, the quiet and leisure of the monasteries, the exigencies of a ruder climate, are cited as conditions that would naturally dispose the modern civilized nations toward investigation of Nature and the manufacturing arts. But if we trace backward the course of modern science, we at last find many clews leading into the laboratories of the alchemists and the observatories of the astrologers; and here, as we know, we meet with Arabian philosophy as a new element of culture.

While beneath the sign of the Cross the night of barbarism was settled down on the Western world, in the East, under the green standard of the Prophet, an original form of civilization had been developed, which not only preserved what had been won by the classical peoples in mathematics, astronomy, and medicine, but even itself made no mean acquisitions in those sciences. Through the crusaders and the Spanish Moors, this civilization had in many ways reacted on Europe, and it is natural for us to seek here for the source of those new ideas which the mind of the Western nations, reawakened by the writings of the ancients, could not have drawn from those writings. The question arises, "Whence did the Arabs derive their stronger instinct of causality, as compared with the Greeks and Romans?" Was that intelligent race specially gifted for observation and investigation of facts? Such a supposition conflicts with all we know of Semitic habits of thought, which incline more toward the exercise of dialectical subtilty, fanciful imagining, and speculative meditation.

But for the momentary ascendency of natural science under the influence of Islam, as also for its development in the Christian West so soon as the ban of the scholastic philosophy had been broken, a profounder reason can with some probability be assigned, and one which covers both of these cases. This reason, it is true, is ultimately based on an ethno-psychological peculiarity of the Semitic race. That race, not only directly, through the labors of its Arabic branch, had a part in the creation of modern science, but indirectly, too, the Semites were founders of modern science, owing to the fact that with them originated the monotheistic religions. Modern natural science, paradoxical as the statement is, owes its origin to Christianity.

Between polytheism and monotheism there is this difference, that the former is essentially tolerant, the latter essentially intolerant. Socrates apparently fell the victim of religious zeal, but, as we know, political considerations, and his uncomplying behavior toward his judges, had most influence in procuring his condemnation. At the time of the Acts of the Apostles the Athenians paid worship even to unknown gods, lest any deity should be slighted. The Roman Pantheon admitted all gods, even the gods of conquered nations. The Christians were persecuted by the Roman emperors solely because they were esteemed to be dangerous to the state. On the other hand, Judaism, Christianity, and Islam, have imagined that they each alone possessed the saving faith, and, in a measure, the idea of an absolute truth only came into the world through them. As the Greeks and Romans recognized all sorts of strange gods in addition to their own, and as the Semitic parable of the three rings would have been amiss among them, so, too, with regard to scientific truth, they were not over-particular. Their undeveloped instinct of causality was satisfied when they could assign for a phenomenon some ingenious explanation which pleased the fancy; and their researches of ultimate causes consisted really only of delightful conversations about what appeared admissible. "What is truth?" asked the Roman magistrate, in derision. "I came into the world to bear witness to the truth," said Jesus, and allowed himself to be crucified.

The idea of a God who suffers no other gods beside him, who appears not as a human invention involved in unworthy fables, but as the highest, the absolute Being, who is the centre of all man's moral aspirations, and who with unerring omniscience notes every transgression—this idea of God, entertained for hundreds of years by generation after generation of men, accustomed the mind of man, even in scientific matters, to the thought that throughout the universe the cause of things is one only, and inspired him with the wish to know this cause. Faust's heart-felt cry—

"Du musst, du musst, und kostet' es mein Leben!" [1]

is one quite foreign to the spirit of the ancient world. The fearful earnestness of a religion which claimed for itself all knowledge, which threatened its adversaries with everlasting torture in the next world, and claimed the right even in this life of visiting them with the most horrible punishment, imparted to humanity in the lapse of centuries that character of sobriety and of profundity which certainly fitted them better for patient research than did the light-hearted joy of life favored by the heathen religions. Where so many martyrs were teach-

[1] "Thou must, thou must, though it cost me my life!"

ing men how they should die for their creed, there must also be those who were ready for science' sake to lead a life of self-denial, or even, if need were, to die for it. In inspiring man with the ardent longing for absolute knowledge, Christianity made atonement for the wrongs its asceticism had for so long done to science.

RECENT EXPERIMENTS ON FOG-SIGNALS.

By Professor JOHN TYNDALL, F.R.S.

OUR most intense coast-lights, including the six-wick lamp, the Wigham gaslight, and the electric light, being intended to aid the mariner in heavy weather, may be regarded, in a certain sense, as fog-signals. But fog, when thick, is intractable to light; the sun cannot penetrate it, much less any terrestrial source of illumination. Hence the necessity of employing sound-signals in dense fogs. Bells, gongs, horns, guns, and sirens, have been used for this purpose; but it is mainly, if not wholly, explosive signals that I have now to submit to the notice of the Society. During the long, laborious, and, I venture to think, memorable series of observations conducted under the auspices of the Elder Brethren of the Trinity House at the South Foreland in 1872 and 1873, it was proved that a short 5½-inch howitzer, firing 3 pounds of powder, yielded a louder report than a long 18-pounder firing the same charge. Here was a hint to be acted on by the Elder Brethren. The effectiveness of the sound depended on the shape of the gun, and as it could not be assumed that in the howitzer we had hit accidentally upon the best possible shape, arrangements were made with the War Office for the construction of a gun specially calculated to produce the loudest sound attainable from the combustion of 3 pounds of powder. To prevent the unnecessary landward waste of the sound, the gun was furnished with a parabolic muzzle, intended to project the sound over the sea, where it was most needed. The construction of this gun was based on a searching series of experiments executed at Woolwich with small models, provided with muzzles of various kinds. The gun was constructed on the principle of the revolver, its various chambers being loaded and brought in rapid succession into the firing position. The performance of the gun proved the correctness of the principles on which its construction was based.

It had been a widely-spread opinion among artillerists, that a bronze gun emits a specially loud report. I doubted from the outset whether this would help us; and in a letter dated April 22, 1874, ventured to express myself thus: "The report of a gun, as affecting an observer close at hand, is made up of two factors—the sound due to the shock of the air by the violently expanding gas, and the sound derived from the vibrations of the gun, which, to some extent, rings like a bell. This latter, I apprehend, will disappear at considerable distances." The result of subsequent trial, as reported by General Campbell, is,

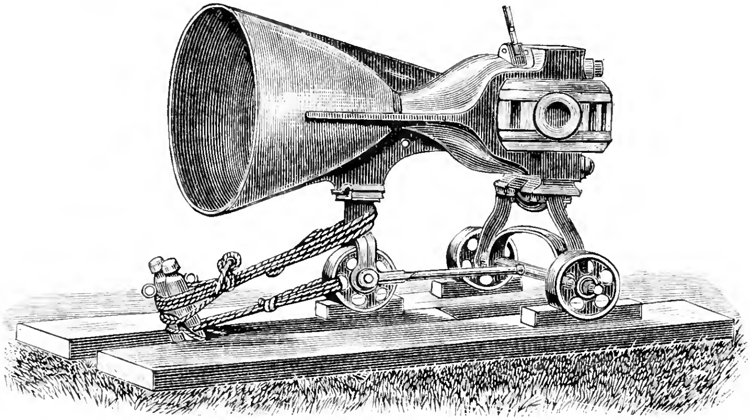

FIG. 1.—BREECH-LOADING FOG-SIGNAL GUN, WITH BELL-MOUTH, PROPOSED BY MAJOR MAITLAND, R. A., ASSISTANT SUPERINTENDENT.

that "the sonorous qualities of bronze are greatly superior to those of cast-iron at short distances, but that the advantage lies with the baser metal at long ranges."[1]

Coincident with these early trials of guns at Woolwich, gun-cotton was thought of as a probably effective sound-producer. Theoretic considerations caused me to fix my attention persistently on this substance; for the remarkable experiments of Mr. Abel, whereby its rapidity of combustion and violently explosive energy are demonstrated, seemed to single it out as a substance eminently calculated to fulfill the conditions necessary to the production of an intense wave of sound. What those conditions are we shall now more particularly inquire, calling to our aid a brief but very remarkable paper, published by Prof. Stokes in the *Philosophical Magazine* for 1868.

The explosive force of gunpowder is known to depend on the sudden conversion of a solid body into an intensely heated gas. The work which the artillerist requires the expanding gas to perform is the displacement of the projectile. Such, however, is not the work that we want our gunpowder to perform. We wish it to transmute its energy not into the mere mechanical translation of the shot, but into vibratory motion. We want *pulses* to be formed which shall propagate themselves to vast distances through the atmosphere, and this requires a certain choice and management of the explosive material.

[1] General Campbell assigns a true cause for this difference. The ring of the bronze gun represents so much energy withdrawn from the explosive force of the gunpowder. Further experiments would, however, be needed to place the superiority of the cast-iron gun at a distance beyond question.

A sound-pulse consists essentially of two parts—a condensation and a rarefaction. Now, air is a very mobile fluid, and, if the shock imparted to it lack due promptness, the pulse is not produced. Consider the case of a common clock-pendulum, which oscillates to and fro, and which therefore might be expected to generate corresponding pulses in the air. When, for example, the bob moves to the right, the air to the right of it might be supposed to be condensed, while a partial vacuum might be supposed to follow the bob. As a matter of fact, we have nothing of this kind. The air-particles in front of the bob retreat so rapidly, and those behind it close so rapidly in, that no sound-pulse is formed. A tuning-fork which executes 256 complete vibrations in a second, if struck gently on a pad and held in free air, emits a scarcely audible note. It behaves to some extent like the pendulum-bob. This feebleness is due to the prompt "reciprocating flow" of the air between the incipient condensations and rarefactions, whereby the formation of sound-pulses is forestalled. Stokes, however, has taught us that this flow may be intercepted by placing the edge of a card in close proximity to one of the corners of the fork. An immediate augmentation of the sound of the fork is the consequence.

The more rapid the shock imparted to the air, the greater is the fractional part of the energy of the shock converted into wave-motion. And, as different kinds of gunpowder vary considerably in their rapidity of combustion, it may be expected that they will also vary as producers of sound. This theoretic inference is completely verified by experiment. In a series of preliminary trials conducted at Woolwich on the 4th of June, 1875, the sound-producing powers of four different kinds of powder were determined. In the order of size of grain they bear the names respectively of Fine-grain (F. G.), Large-grain (L. G.), Rifle Large-grain (R. L. G.), and Pebble-powder (P.), (Fig. 2). The charge in each case

FIG. 2.

amounted to $4\frac{1}{2}$ pounds.; four 24-pound howitzers being employed to fire the respective charges. There were eleven observers, all of whom, without a single dissentient, pronounced the sound of the fine-grain powder loudest of all. In the opinion of seven of the eleven the large-grain powder came next; seven also of the eleven placed the rifle large-grain third on the list; while they were again unanimous in pronouncing the pebble-powder the worst sound-producer. These differences are entirely due to differences in the rapidity of combustion. All who have witnessed the performance of the 80-ton gun at Woolwich must have been surprised at the mildness of its thunder. To avoid the strain resulting from quick combustion, the powder employed is composed of lumps far larger than those of the pebble-powder above referred to. In the long tube of the gun these lumps of solid matter gradually resolve themselves into gas, which on issuing from the muzzle imparts a kind of push to the air, instead of the sharp shock necessary to form the condensation of an intensely sonorous wave.

These are some of the physical reasons why gun-cotton might be regarded as a promising fog-signal. Firing it as we have been taught to do by Mr. Abel, its explosion is more rapid than that of gunpowder. In its case the air-particles, alert as they are, will not, it might be presumed, be able to slip from places of condensation to places of rarefaction with a rapidity sufficient to forestall the formation of the wave. On *a priori* grounds, then, we are entitled to infer the effectiveness of gun-cotton, while in a great number of comparative experiments, stretching from 1874 to the present time, this inference has been verified in the most conclusive manner.

On the 22d of February, 1875, a number of small guns, cast specially for the purpose—some with plain, some with conical, and some with parabolic muzzles, firing 4 ounces of fine-grain powder—were pitted against 4 ounces of gun-cotton, detonated both in the open and in the focus of a parabolic reflector.[1] The sound produced by the gun-cotton, reënforced by the reflector, was unanimously pronounced loudest of all. With equal unanimity, the gun-cotton detonated in free air was placed second in intensity. Though the same charge was used throughout, the guns differed not among themselves, but none of them came up to the gun-cotton, either with or without the reflector. A second series, observed from a different distance on the same day, confirmed to the letter the foregoing result.

As a practical point, however, the comparative cost of gun-cotton and gunpowder has to be taken into account, though considerations of cost ought not to be stretched too far in cases involving the safety of human life. In the earlier experiments, where quantities of equal price were pitted against each other, the results were somewhat fluctuating. Indeed, the perfect manipulation of the gun-cotton required some preliminary discipline—promptness, certainty, and effectiveness of firing, augmenting as experience increased. As 1 pound of gun-cotton costs as much as 3 pounds of gunpowder, these quantities were compared together on the 22d of February. The guns employed to discharge the gunpowder were a 12-pound brass howitzer, a 24-pound cast-iron howitzer, and the long 18-pounder used at the South Foreland. The result recorded is, that the 24-pound howitzer, firing 3 pounds of

[1] For charges of this weight the reflector is of moderate size, and may be employed without fear of fracture.

gunpowder, had slight advantage over 1 pound of gun-cotton detonated in the open; while the 12-pound howitzer and the 18-pounder were both beaten by the gun-cotton. On the 2d of May, on the other hand, the gun-cotton is reported as having been beaten by all the guns.

Meanwhile, the parabolic muzzle gun (Fig. 3), expressly intended for fog-signaling, was pushed rapidly forward, and on the 22d and 23d of March, 1876, its power was tested at Shoeburyness. Pitted against it were a 16-pounder, a 5½-inch howitzer, 1½ pound of gun-cotton detonated in the focus of a reflector, and 1½ pound of gun-cotton detonated

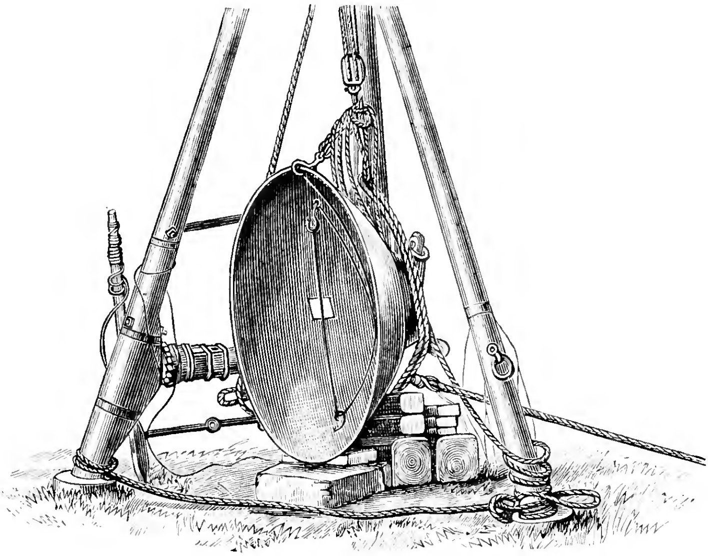

Fig. 3.—Gun-Cotton Slab (1½ lb.) detonated in the Focus of a Cast-iron Reflector.

in free air. On this occasion, nineteen different series of experiments were made, when the new experimental gun, firing a 3-pound charge, demonstrated its superiority over all guns previously employed to fire the same charge. As regards the comparative merits of the gun-cotton fired in the open, and the gunpowder fired from the new gun, the mean values of their sounds were found to be the same. Fired in the focus of the reflector, the gun-cotton clearly dominated over all the other sound-producers.[1]

The whole of the observations here referred to were embraced by an angle of about 70°, of which 50° lay on the one side and 20° on the other side of the line of fire. The shots were heard by eleven observers on board the Galatea, which took up positions varying from 2 miles to 13½ miles from the firing-point. In all these observations, the reënforcing action of the reflector, and of the parabolic muzzle of the gun, came into

[1] In this case the reflector was fractured by the explosion, but it did good service after fracture.

play. But the reënforcement of the sound in one direction implies its withdrawal from some other direction, and accordingly it was found that at a distance of $5\frac{1}{4}$ miles from the firing-point, and on a line including nearly an angle of 90° with the line of fire, the gun-cotton in the open beat the new gun; while behind the station, at distances of $8\frac{1}{2}$ miles and $13\frac{1}{2}$ miles respectively, the gun-cotton in the open beat both the gun and the gun-cotton in the reflector. This result is rendered more important by the fact that the sound reached the Mucking Light, a distance of $13\frac{1}{2}$ miles, against a light wind which was blowing at the time.

Most, if not all, of our ordinary sound-producers send forth waves which are not of uniform intensity throughout. A trumpet is loudest in the direction of its axis. The same is true of a gun. A bell, with its mouth pointed upward or downward, sends forth waves far denser in the horizontal plane passing through the bell than at an angular distance of 90° from that plane. The oldest bell-hangers must have been aware of the fact that the sides of the bell, and not its mouth, emitted the strongest sound, their practice being determined by this knowledge. Our slabs of gun-cotton also emit waves of different densities in different parts. It has occurred in the experiments at Shoeburyness that when the broad side of a slab was turned toward the suspending wire of a second slab six feet distant, the wire was cut by the explosion, while, when the edge of the slab was turned to the wire, this never occurred. To the circumstance that the broad sides of the slabs faced the sea is probably to be ascribed the remarkable fact observed on the 23d of March, that in two directions, not far removed from the line of fire, the gun-cotton detonated in the open had a slight advantage over the new gun.

Theoretic considerations rendered it probable that the shape and size of the exploding mass would affect the constitution of the wave of sound. I did not think large rectangular slabs the most favorable shape, and accordingly proposed cutting a large slab into fragments of different sizes, and pitting them against each other. The differences between the sounds were by no means so great as the differences in the quantities of explosive material might lead one to expect. The mean values of eighteen series of observations made on board the Galatea, at distances varying from $1\frac{3}{4}$ mile to 4.8 miles, were as follows:

Weights..........	4-ounce	6-ounce	9-ounce	12-ounce	7-ounce rocket.
Value of sound....	3.12	3.34	4.0	4.03	3.35

These charges were cut from a slab of dry gun-cotton about $1\frac{3}{4}$ inch thick; they were squares and rectangles of the following dimensions: 4 ounces, 2 inches by 2 inches; 6 ounces, 2 inches by 3 inches; 9 ounces, 3 inches by 3 inches; 12 ounces, 2 inches by 6 inches.

The numbers under the respective weights express the recorded value of the sounds. They must be simply taken as a ready means of expressing the approximate relative intensity of the sounds as estimated by the ear. When we find a 9-ounce charge marked 4, and a 12-ounce charge marked 4.03, the two sounds may be regarded as practically equal in intensity, an addition of 30 per cent. in the larger charges producing no sensible difference in the sound. Were the sounds estimated by some physical means, instead of by the ear, the values of the sound would not, in my opinion, show a greater advance with the increase of material than that indicated by the foregoing numbers. Subsequent experiments rendered still more certain the effectiveness, as well as the economy, of small charges of gun-cotton.

It is an obvious corollary from the foregoing experiments that on our "nesses" and promontories, where the land is clasped on both sides for a considerable distance by the sea—where, therefore, the sound has to propagate itself rearward as well as forward—the use of the parabolic gun, or of the parabolic reflector, might be a disadvantage rather than an advantage. Here gun-cotton, exploded in the open, forms a most appropriate source of sound. This remark is especially applicable to such lightships as are intended to spread the sound all round them as from central foci. As a signal in rock-lighthouses, where neither siren, steam-whistle, nor gun, could be mounted, and as a handy fleet-signal, dispensing with the lumber of special signal-guns, the gun-cotton will prove invaluable. But in most of these cases we have the drawback that local damage may be done by the explosion. The lantern of the rock-lighthouse might suffer from concussion near at hand, and though mechanical arrangements might be devised, both in the case of the lighthouse and of the ship's deck, to place the firing-point of the gun-cotton at a safe distance, no such arrangement could compete, as regards simplicity and effectiveness, with the expedient of a *gun-cotton rocket*. Had such a means of signaling existed at the Bishop's Rock Lighthouse, the ill-fated Schiller might have been warned of her approach to danger ten, or it may be twenty, miles before she reached the rock which wrecked her. Had the fleet possessed such a signal, instead of the ubiquitous but ineffectual whistle, the Iron Duke and Vanguard need never have come into collision.

It was the necessity of providing a suitable signal for rock lighthouses, and of clearing obstacles which cast an acoustic shadow, that suggested the idea of the gun-cotton rocket to Sir Richard Collinson, Deputy Master of the Trinity House. That idea was to place a disk or short cylinder of the gun-cotton in the head of a rocket, the ascensional force of which should be employed to cary the disk to an elevation of 1,000 feet or thereabouts, where, by the ignition of a fuse associated with a detonator, the gun-cotton should be fired, sending its sound in all directions vertically and obliquely down upon earth and sea. The first attempt to realize this idea was made on the 18th of July, 1876, at the firework manufactory of the Messrs Brock, at Nunhead. Eight rockets were then fired, four being charged with 5 ounces and four with 7½ ounces of gun-cotton. They ascended to a great height, and exploded with a very loud report in the air. On the 27th of July, the rockets were tried at Shoeburyness, the most noteworthy result on this occasion being the hearing of the rockets at the Mouse Lighthouse, $8\frac{1}{2}$ miles east by south, and at the Chapman Lighthouse, $8\frac{1}{2}$ miles west by north; that is to say, at opposite sides of the firing-point. It is worthy of remark that, in the case of the Chapman Lighthouse, land and trees intervened between the firing-point and the place of observation. "This," as General Younghusband justly remarked at the time, "may prove to be a valuable consideration if it should be found necessary to place a signal-station in a position whence the sea could not be freely observed." Indeed, the clearing of such obstacles was one of the objects which the inventor of the rocket had in view.

On the 13th of December, 1876, and again on the 8th of March, 1877, comparative experiments on firing at high and low elevations were executed. The gun-cotton near the ground consisted of $\frac{1}{2}$-pound disks suspended from an horizontal iron bar about $4\frac{1}{2}$ feet above the ground. The rockets carried the same quantity of gun-cotton in their heads, and the height to which they attained, as determined by a theodolite, was from 800 to 900 feet.

The latter day was cold, with occasional squalls of snow and hail, the direction of the sound being at right angles to that of the wind. Five series of observations were made on board the Vestal, at distances varying from 3 to 6 miles. The mean value of the explosions in the air exceeded that of the explosions near the ground by a small but sensible quantity. At Windmill Hill, Gravesend, however, which was nearly to leeward, and $5\frac{1}{2}$ miles from the firing-point, in nineteen cases out of twenty-four the disk fired near the ground was loudest, while in the remaining five the rocket had the advantage. Toward the close of the day the atmosphere became very serene. A few distant cumuli sailed near the horizon, but the zenith and a vast angular space all round it were absolutely free from cloud. From the deck of the Galatea a rocket was discharged, which reached a great elevation, and exploded with a loud report. Following this solid nucleus of sound was a continuous train of echoes, which retreated to a continually greater distance, dying gradually off into silence after seven seconds' duration. These echoes were of the same character as those so frequently noticed at the South Foreland in 1872–'73, and called by me "aërial echoes."

On the 23d of March the experiments were resumed, the most noteworthy results of that day's observations being that the sounds were heard at Tillingham, 10 miles to the northeast; at West Mersea, $15\frac{3}{4}$ miles to the northeast by east; at Brightlingsea, $17\frac{1}{2}$ miles to the northeast; and at Clacton Wash, $20\frac{1}{2}$ miles to the northeast by $\frac{1}{2}$ east. The wind was blowing at the time from the southeast. Some of these sounds were produced by rockets, some by a 24-pound howitzer, and some by an 8-inch maroon.

In December, 1876, Mr. Gardiner, the managing director of the Cotton-Powder Company, had proposed a trial of this material against the gun-cotton. The density of the cotton, he urged, was only 1.03, while that of the powder was 1.70. A greater quantity of explosive material being thus compressed into the same volume, Mr. Gardiner thought that a greater sonorous effect must be produced by the powder. At the instance of Mr. Mackie, who had been in communication previously with the Deputy Master of the Trinity House and myself, a committee of the Elder Brethren visited the cotton-powder manufactory, on the banks of the Swale, near Faversham, on the 16th of June, 1877. The weights of cotton-powder employed were 2 ounces, 8 ounces, 1 pound, and 2 pounds, in the form of rockets and of signals fired a few feet above the ground. The experiments throughout were arranged and conducted by Mr. Mackie. Our desire on this occasion was to get as near to windward as possible, but the Swale and other obstacles limited our distance to 1½ mile. We stood here east-southeast from the firing-point, while the wind blew fresh from the northeast.

The cotton-powder yielded a very effective report. The rockets in general had a slight advantage over the same quantities of material fired near the ground. The loudness of the sound was by no means proportional to the quantity of the material exploded, 8 ounces yielding very nearly as loud a report as 1 pound. The "aërial echoes," which invariably followed the explosion of the rockets, were loud and long-continued, shading off, as in all previous cases, by imperceptible gradations, into silence.

On the 17th of October, 1877, another series of experiments with howitzers and rockets was carried out at Shoeburyness. The charge of the howitzer was 3 pounds of L. G. powder. The charges of the rockets were 12 ounces, 8 ounces, 4 ounces, and 2 ounces, of gun-cotton respectively. The gun and the four rockets constituted a series, and eight series were fired during the afternoon of the 17th. The observations were made from the Vestal and the Galatea, positions being assumed which permitted the sound to reach the observers with the wind, against the wind, and across the wind. The distance of the Galatea varied from 3 to 7 miles, that of the Vestal, which was more restricted in her movements, being 2 to 3 miles. Briefly summed up, the result is that the howitzer, firing a 3-pound charge, which it will be remembered was our best gun at the South Foreland, was beaten by the 12-ounce rocket, by the 8-ounce rocket, and by the 4-ounce rocket. The 2-ounce rocket alone fell behind the howitzer.

It is worth while recording the distances to which some of the sounds were heard on the day now referred to:

1. Leigh	6½	miles	west-northwest	24	out of 40	sounds heard.
2. Girdler Light-vessel	12	"	southeast by east	5	"	"
3. Reculvers	17½	"	southeast by south	18	"	"
4. St. Nicholas	20	"	southeast	3	"	"
5. Epple Bay	22	"	southeast by east	19	"	"
6. Westgate	23	"	southeast by east	9	"	"
7. Kingsgate	25	"	southeast by east	8	"	"

The day was cloudy, with occasional showers of drizzling rain; the wind about northwest by north all day; at times squally, rising to a force of 6 and 7 and sometimes dropping to a force of 2 or 3. The station at Leigh excepted, all these places were to leeward of Shoeburyness. At four other stations to leeward, varying in distance from 15½ to 24½ miles, nothing was heard, while at eleven stations to windward, varying from 8 to 26 miles, the sounds were also inaudible. It was found, indeed, that the sounds proceeding against the wind did not penetrate much beyond 3 miles.

On the following day, viz., the 18th of October, we proceeded to Dungeness with the view of making a series of strict comparative experiments with gun-cotton and cotton-powder. Rockets containing 8 ounces, 4 ounces, and 2 ounces of gun-cotton had been prepared at the Royal Arsenal; while others, containing a similar quantity of cotton-powder, had been supplied by the Cotton-Powder Company at Faversham. With these were compared the ordinary 18-pounder gun, which happened to be mounted at Dungeness, firing the usual charge of 3 pounds of powder.

From these experiments it appeared that the gun-cotton and cotton-powder were practically equal as producers of sound.

The effectiveness of small charges was also illustrated in a very striking manner, only a single unit separating the numerical value of the 8-ounce rocket from that of the 2-ounce rocket. The former was recorded as 6.9 and the latter as 5.9, the value of the 4-ounce charge being intermediate between them. These results were recorded by a number of very practised observers on board the Galatea. They were completely borne out by the observations of the coast-guard, who marked the value of the 8-ounce rocket 6.1, and that of the 2-ounce rocket 5.2. The 18-pounder gun fell far behind all the rockets, a result probably to be in part ascribed to the imperfection of the powder. The performance of the siren was, on the whole, less satisfactory than that of the rockets. The instrument was worked, not by steam of 70 pounds pressure, as at the South Foreland, but by compressed air, beginning with 40 pounds and ending with 30 pounds pressure. The trumpet was pointed to windward, and in the axis of the instrument the sound was about as effective as that of the 8-ounce rocket. But in a direction at right angles to the axis, and still more in the rear of this direction, the siren fell very sensibly behind even the 2-ounce rocket.

These are the principal comparative trials made between the gun-cotton rocket and other-fog signals; but they are not the only ones. On the 2d of August, 1877, for example, experiments were made at Lundy Island, with the following results: At 2 miles distant from the firing-point, with land intervening, the 18-pounder, firing a 3-pound charge, was quite unheard. Both the 4-ounce rocket and the 8-ounce rocket, however, reached an elevation which commanded the acoustic shadow, and yielded loud reports. When both were in view, the rockets were still superior to the gun. On the 6th of August, at St. Ann's, the 4-ounce and 8-ounce rockets proved superior to the siren. On the Shambles Light-vessel, when a pressure of 13 pounds was employed to sound the siren, the rockets proved greatly superior to that instrument. Proceeding along the sea-margin at Flamborough Head, Mr. Edwards states that at a distance of $1\frac{1}{4}$ mile, with the 18-pounder gun hidden behind the cliffs, its report was quite unheard, while the 4-ounce rocket, rising to an elevation which brought it clearly into view, yielded a powerful sound in the face of an opposing wind.

On the evening of February 9, 1877, a remarkable series of experiments was made by Mr. Prentice, at Stowmarket, with the gun-cotton rocket. From the report with which he has kindly furnished me I extract the following particulars. The first column in the annexed statement contains the name of the place of observation, the second its distance from the firing-point, and the third the result observed:

Stoke Hill, Ipswich	10 miles	Rockets clearly seen and sounds distinctly heard 53 minutes after the flash.
Melton	15 "	Signals distinctly heard. Thought at first that sounds were reverberated from the sea.
Framlingham	18 "	Signals very distinctly heard, both in the open air and in a closed room. Wind in favor of sound.
Stratford. St. Andrews	19 "	Reports loud; startled pheasants in a cover close by.
Tuddenham. St. Martin	10 "	Reports very loud; rolled away like thunder.
Christ Church Park	11 "	Report arrived a little more than a minute after flash.
Nettlested Hall	6 "	Distinct in every part of observer's house. Very loud in the open air.
Bildestone	6 "	Explosion very loud, wind against sound.
Nacton	14 "	Reports quite distinct—mistaken by inhabitants for claps of thunder.
Alboro	25 "	Rockets seen through a very hazy atmosphere; a rumbling detonation heard.
Capel Mills	11 "	Reports heard within and without the observer's house. Wind opposed to sound.
Lawford	15½ "	Reports distinct: attributed to distant thunder.

In the great majority of these cases, the direction of the sound inclosed a large angle with the direction of the wind. In some cases, indeed, the two directions were at right angles to each other. It is needless to dwell for a moment on the advantage of a signal commanding ranges such as these.

The explosion of substances in the air, after having been carried to a considerable elevation by rockets, is a familiar performance. In 1873 the Board of Trade actually proposed a light-and-sound rocket as a signal of distress, which proposal was subsequently realized, but in a form too elaborate and expensive for practical use. The idea of the gun-cotton rocket with a view to signaling in fogs is, I believe, wholly due to the Deputy Master of the Trinity House. Thanks to the skillful aid given by the authorities of Woolwich, by Mr. Prentice and Mr. Brock, that idea is now an accomplished fact; a signal of great power, handiness, and economy, being thus placed at the service of our mariners. Not only may the rocket be applied in association with lighthouses and light-ships, but in the navy also it may be turned to important account. Soon after the loss of the Vanguard, I ventured to urge upon an eminent naval officer the desirability of having an organized code of fog-signals for the fleet. He shook his head doubtingly, and referred to the difficulty of finding room for signal-guns. The gun-cotton rocket completely surmounts this difficulty. It is manipulated with ease and rapidity, while its discharges may be so grouped and combined as to give a most important extension to the voice of the admiral in command. It is needless to add that at any point upon our coasts, or upon any other coast, where its establishment might be desirable, a fog-signal station might be extemporized without difficulty.

I have referred more than once to the train of echoes which accompanied the explosion of gun-cotton in free air, speaking of them as similar in all respects to those which were described for the first time in my report on fog-signals, addressed to the Corporation of Trinity House in 1874.[1] To these echoes I attached a fundamental significance. There was no visible reflecting surface from which they could come. On some days, with hardly a cloud in the air, and hardly a ripple on the sea, they reached us with magical intensity. They came directly from the body of the air in front of the great trumpet which produced them. The trumpet-blasts were five seconds in duration, but long before the blast had ceased the echoes struck in, adding their strength to the primitive note of the trumpet. After the blast had ended the echoes continued, retreating farther and farther from the point of observation, and finally dying away at great distances. The echoes were perfectly continuous as long as the sea was clear of ships, "tapering" by imperceptible gradations into absolute silence. But when a ship happened to throw itself athwart the course of the sound, the echo from the broadside of the vessel was returned as a shock which rudely interrupted the continuity of the dying atmospheric music.

These echoes have been ascribed to reflection from the crests of the sea-waves. But this hypothesis is negatived by the fact that the echoes were produced in great intensity and duration when no waves existed —when the sea, in fact, was of glassy smoothness. It has been also shown that the direction of the echoes depended not on that of waves, real or assumed, but on the direction of the axis of the trumpet. Causing that axis to traverse an arc of 210°, and the trumpet to sound at various points of the arc, the echoes were always, at all events in calm weather, returned from that portion of the atmosphere toward which the trumpet was directed. They could not, under the circum-

[1] *See* also "Philosophical Transactions" for 1874, p. 183.

stances, come from the glassy sea; while both their variation of direction and their perfectly continuous fall into silence are irreconcilable with the notion that they came from fixed objects on the land. They came from that portion of the atmosphere into which the trumpet poured its maximum sound, and fell in intensity as the direct sound penetrated to greater atmospheric distances.

The day on which our latest observations were made was particularly fine. Before reaching Dungeness, the smoothness of the sea and the serenity of the air caused me to test the echoing power of the atmosphere. A single ship lay about half a mile distant between us and the land. The result of the proposed experiment was clearly foreseen. It was this: The rocket being sent up, it exploded at a great height; the echoes retreated in their usual fashion, becoming less and less intense as the distance of the surfaces of reflection from the observers increased. About five seconds after the explosion, a single loud shock was sent back to us from the side of the vessel lying between us and the land. Obliterated for a moment by this more intense echo, the aërial reverberation continued its retreat, dying away into silence in two or three seconds afterward.

I have referred to the firing of an 8-ounce rocket from the deck of the Galatea, on March 8, 1877, stating the duration of its echoes to be seven seconds. Mr. Prentice, who was present at the time, assured me that, in his experiments with rockets, similar echoes had been frequently heard of more than twice this duration. The ranges of his sounds alone would render this result in the highest degree probable.

To attempt to interpret an experiment which I have not had an opportunity of repeating is an operation of some risk; and it is not without a consciousness of this that I refer here to a result considered adverse to the notion of aërial echoes. When the trumpet of a siren is pointed toward the zenith, it is alleged that when the siren is sounded no echo is returned. Now, the reflecting surfaces which give rise to these echoes are for the most part due to differences of temperature between sea and air. If, through any cause, the air above be chilled, we have descending streams—if the air below be warmed, we have ascending streams as the initial cause of atmospheric flocculence. A sound proceeding vertically does not cross the streams, nor impinge upon the reflecting surfaces, as does a sound proceeding horizontally across them. Aërial echoes, therefore, will not accompany the vertical sound as they accompany the horizontal one. The experiment, as I interpret it, is not opposed to the theory of aërial echoes which I have ventured to enunciate. But, as I have indicated, not only to see, but to vary such an experiment, is a necessary prelude to grasping its full significance.

In a paper published in the "Philosophical Transactions" for 1876, Prof. Osborne Reynolds refers to these echoes in the following terms: "Without attempting to explain the reverberations and echoes which have been observed, I will merely call attention to the fact that in no case have I heard any attending the reports of the rockets,[1] although they seem to have been invariable with the guns and pistols. These facts suggest that the echoes are in some way connected with the direction given to the sound. They are caused by the voice, trumpets, and the siren, all of which give direction to the sound; but I am not aware that they have ever been observed in the case of a sound which has no direction of greatest intensity."

The reference to the voice and other references cause me to think that, in speaking of echoes, Prof. Osborne Reynolds and myself are dealing with different phenomena. Be that as it may, the foregoing observations render it perfectly certain that the condition as to direction here laid down is not necessary to the production of the echoes.

There is not a feature connected with the aërial echoes which cannot be brought out by experiments in the laboratory. I have recently made the following experiment: A rectangle, 22 inches by 12, is crossed by 23 brass tubes, each having a slit along it from which gas can issue. In this way, 23 low, flat flames are obtained. A sounding reed, fixed in a short tube, is placed at one end of the rectangle, and a sensitive flame at some distance beyond the other end. When the reed sounds, the flame in front of it is violently agitated, and roars boisterously. Turning on the gas, and lighting it as it issues from the slits, the air above the flames becomes so heterogeneous that the sensitive flame is instantly stilled by the aërial reflection, rising from a height of 6 inches to a height of 18 inches. Here we have the acoustic opacity of the air in front of the South Foreland strikingly imitated. Turning off the gas, and removing the sensitive flame to some distance behind the reed, it burns there tranquilly, though the reed may be sounding. Again lighting the gas as it issues from the brass tubes, the sound reflected from the heterogeneous air throws the sensitive flame into violent agitation. Here we have imitated the aërial echoes heard when standing behind the siren-trumpets at the South Foreland. The experiment is extremely simple, and in the highest degree impressive.

WATER-SUPPLY OF RIVERS.

By GEORGE CHAHOON.

IN the year 1871, three kilns were built on lot 54, Jay Tract, town of Wilmington, Essex County, New York, for the purpose of burning wood into charcoal, to be used in making iron in the Catalan forges, on the Ausable River. At the time these kilns were built, the side of the mountain upon which they are located was covered with a heavy

[1] These carried 12 ounces of gunpowder.

growth of spruce-timber. Near the top of the mountain there is a pond, covering about one acre of ground. This pond was undoubtedly scooped out on the southeast side of the mountain during the Glacial period, and at the outlet the water is confined by a wide, low moraine dam, such as, upon a larger scale, distinguish all our moraine lakes. This pond, some 2,000 feet above the level of the sea, forms the head or source of a small trout-brook that flows down the side of the mountain past where the kilns have been erected.

I first visited this pond in August, 1874, and was very curious to know where the water came from, for I could not understand how the small extent of country drained could supply so much water during such a warm, dry time.

In the summer of 1876, after a thousand acres of timber had been cut, a fire broke out in the woods, not only killing the standing timber, but destroying the corded wood in the kiln-yard, and doing considerable other damage.

It was part of my business to prevent this destruction, as far as possible. Men were sent to the fire, and worked there for several days. In going to the kilns, the road leads up the mountain, by the side of the brook. The season was very dry, and the water in the rivers unusually low; but, in going up the mountain, I was surprised to notice that there was as much water in this brook as I had ever seen, except after some long, heavy rains, and my judgment in this matter was confirmed by all the men working at the kilns, with whom I spoke on the subject.

The fire was very fierce, and, after leaving the standing timber, spread across the cleared ground, burning the soil as far down as it was dry; and it actually ran through a field of potatoes freshly hoed, leaving the half-grown, scorched, and burned potatoes, lying upon the top of the ground. This fire lasted several days, and I was at the kilns every day during its continuance, and was every day surprised that the brook, fed largely from the drainage of the burning land, seemed to increase with the fierceness and extent of the fire. In some places, when cleared land had been burned over and dried under the scorching sun, in one or two days afterward the fire ran over it again, taking off another shaving of soil. This continued until the fire was finally quenched by rain.

Afterward, in making an examination of the soil, I found that it consisted of from two to four feet of what is known among the woodsmen of Northern New York as "spruce-duff," which is composed of rotten spruce-trees, cones, needles, etc. This "duff" has the power of holding water almost equal to the sponge, and, when it is thoroughly dry, burns, like punk, without a blaze.

I was told by Mr. Cooper, who has the direct charge of the kilns, that, in sledding wood down the mountain, the sleds frequently wore off the "duff," and came to ice.

On June 30, 1876, while the fire was still burning, I tested the water and soil, as far down as I could conveniently dig with my hands, with a thermometer, and found a temperature of from 37° to 40° Fahr. I afterward dug down, in several places, through the "duff," and in each place found ice or frozen ground.

After this, it was perfectly clear to my mind that this "duff" became thoroughly saturated with water during the fall rains, and that it was frozen to the bottom during the long, severe winters of this climate. It is not an uncommon thing for the ground in the valleys, hundreds of feet below the level of these kilns, to freeze to the depth of four feet during the winter.

The "duff" being frozen at the bottom accounts for the brook increasing in size with the increase of the fire, for the heat from the burning of the top "duff" would cause the ice to melt, and the water would find its way into the brook. This "duff," like all woody substances, is a poor conductor of heat, and when once frozen and protected, as it is in its natural state by the shade of the timber, would thaw out very slowly, and would continue to furnish a supply of water all summer; and very hot weather, causing low water in other places, would tend to increase the supply from this source.

During the latter part of the summer of 1877 I examined "duff" in several places, but did not find any ice; but found the "duff," in every instance, thoroughly saturated with water. It should be remembered that the summer of 1877 was unusually wet, and that water is an excellent conductor of heat, and that water from the rains, running over the ice, would melt it much sooner than it could be melted by what heat could be communicated from the sun, through its woody covering, in a dry season. At most, this would tend to show that the ice lasts only part of the summer, but, if that is a fact, the frozen "duff" would furnish a reservoir as long as the ice lasted, and, during the rest of the summer, would act as an absorbent, taking up and holding the showers, and gradually letting the water down into the streams, tending to prevent floods after heavy rains by holding back the water, and preventing scarcity of water during droughts by gradually releasing the water gathered from the storms.

In addition to the "duff," the sides of many of our mountains are covered with a heavy moss, which also acts as a sponge in the manner described above, in preventing floods and supplying water during dry seasons; and this moss, like the "duff," entirely disappears when the land is cleared, and, like the "duff," does not form again under the pines and deciduous trees that follow the spruce. The spruce-timber affords a dense shade, and, as long as the timber is left standing, this "duff" seldom gets dry enough to burn, but, when the timber is cut, the top of the "duff" dries, and is burned, as far down as it is dry enough to burn, by the forest-fires that are so common in this part of the country. This is repeated, year after year, until the "duff" is all burned off, and the sand and bowlders appear upon the surface; after this, white poplar and white birch spring up, which, however, are liable to be burned at any time, as the fire runs freely through all deciduous timber in the spring, before the leaves are out, or during a very dry time in summer.

It is generally understood that the clearing away of the forests has the effect of causing low water during the summer season, and the reasons given for it are, the more rapid evaporation of water from the soil, on account of the greater exposure to the sun in cleared than in timbered land, and to this may be added the more rapid drainage, particularly in sandy soils, after the rotten logs, leaves, and other absorbents, have been removed; and it is also claimed that more rain falls upon a section of country when it is timbered than after the land has been cleared. The first of these reasons is undoubtedly correct, and there is a great deal to show that the second is correct also, though I do not think we know enough about the subject to justify us in stating, as a scientific fact, that the amount of rainfall is affected by the growth of timber.

I have never known the existence of the spruce "duff" to be recognized, as a fact of any importance, in governing our water-supply during dry seasons; but, unless I am greatly in error, it is a matter of the greatest importance, and the destruction of the "duff," with the destruction of the forests, will prove as damaging to our streams as the increased evaporation caused by the greater exposure of the land to the sun.

The waters from this immediate section of country flow into Lake Champlain, and thence into the St. Lawrence River. The country around the principal feeders of the Hudson River is almost identical with the country described above, and the same causes that affect the water-supply of the Saranac and Ausable govern the water-supply of the Hudson.

The water-supply of the Hudson is a matter of very great importance to the people of New York, and any facts tending to throw light upon the natural laws governing it should be received with interest by the intelligent people whose health, comfort, and prosperity, are partially dependent upon the quantity and purity of the water in this noble river. Hundreds of square miles of the country upon whose drainage the Hudson is dependent for its supply of water is covered with this "spruce-duff," which, in the early spring, is a solid body of ice, holding untold millions of gallons of the purest water, to be slowly thawed out and given up to this river during the summer. In many places, and in most seasons, part of this ice lasts through the whole summer; in most places it lasts well into the summer, and even after the ice is gone the "duff" absorbs and stores away the rain, and, like a prudent housewife with her confections, gives up her treasures in such a way as not to injure the health of her children with her lavishness, nor exhaust her larder before a fresh supply can reasonably be expected.

I am convinced that careful investigation will demonstrate that the preservation of the "duff" is another and a very important reason why the destruction of the forests around the head-waters of the Hudson should be discontinued.

EVOLUTION OF CEREMONIAL GOVERNMENT.

By HERBERT SPENCER.

VI. FORMS OF ADDRESS.

WHAT the obeisance implies by acts, the form of address says in words. If the two have a common root, this is to be anticipated; and that they have a common root is demonstrable. Instances occur in which the two are used indifferently, as being the one equivalent to the other. Speaking of Poles and Slavonic Silesians, Captain Spencer remarks:

"Perhaps no distinctive trait of manners more characterizes both than their humiliating mode of acknowledging a kindness, their expression of gratitude being the servile "Upadam do nog" (I fall at your feet), which is no figure of speech, for they will literally throw themselves down and kiss your feet for the trifling donation of a few halfpence."

Here, then, the attitude of the conquered man beneath the conqueror is either actually assumed or verbally assumed; and, when used, the oral representation is a substitute for the realization in act. Other cases show us words and deeds similarly associated: as when a Turkish courtier, accustomed to make humble obeisances, addresses the sultan, "Centre of the Universe! Your slave's head is at your feet;" or as when a Siamese, whose servile prostrations occur daily, says to his superior, "Lord Benefactor, at whose feet I am;" to a prince, "I the sole of your foot;" to the king, "I a dust-grain at your sacred feet." Still better when a Siamese attendant on the king says, "High and excellent lord of me thy slave, I ask to take the royal commands, and to place them on my brain, on the top of my head," we have verbally indicated that absolutely-subject attitude in which the head is under the victor's foot.

Nor are there wanting instances from nearer countries showing this substitution of professed for performed obeisances. In Russia, even in these days of moderated despotism, a petition begins with the words, "So-and-so strikes his forehead" (on the ground); and petitioners are called "forehead-strikers." At the court of France, as late as 1577, it was the custom of some to say, "I kiss your grace's hands," and of others to say, "I kiss your lordship's feet." Even at the present time in Spain, where Orientalisms descending from the past still linger, we read: "When you get up to take leave, if of a lady, you should say, 'My lady, I place myself at your feet;' to which she will reply, 'I kiss your hand, sir.'"

From what has gone before, such origins and such characters of forms of address might, indeed, be anticipated. Along with other ways of propitiating the victor, the master, and the ruler, will naturally come speeches which, beginning with confessions of defeat by verbal assumption of its attitude, will develop into varied phrases acknowledging the state of servitude. The implication, therefore, is that forms of address in general, descending as they do from these originals, will express, clearly or vaguely, ownership by, or subjection to, the person addressed.

Of propitiatory speeches, there are some which, instead of describing the prostration entailed by defeat, describe the resulting state of being at the mercy of the person addressed. One of the strangest of these occurs among the cannibal Tupis. While on the one hand a warrior shouts to his enemy, "May every misfortune come upon thee, my meat!" on the other hand the speech required from the captive Hans Stade on approaching a dwelling was, "I, your food, have come." A verbal surrender of life takes other forms in other places. It is asserted that, during ancient times in Russia, petitions to the czar commenced with the words, "Do not order our heads to be cut off, O mighty lord, for presuming to address you, but hear us!" And, though I do not get direct verification for this statement, it receives indirect support from the still-current saying, "Whoso goes to the czar risks his head," as also from the lines—

"My soul is God's,
My land is mine,
My head's the Czar's,
My back is thine!"

Then, again, instead of professing to live only by permission of the superior, actual or pretended, who is spoken to, we find the speaker professing to be personally a chattel of his, or to be holding property at his disposal, or both. Africa, Polynesia, and Europe, furnish examples. "When a stranger enters the house of a Serracolet (inland negro), he goes out and says, 'White man, my house, my wife, my children, belong to thee.'" In the Sandwich Islands a chief, asked respecting the ownership of a house or canoe possessed by him, replies, "It is yours and mine." In France, in the fifteenth century, a complimentary speech made by an abbé on his knees to the queen when visiting a monastery was, "We resign and offer up the abbey with all that is in it, our bodies, as our goods." And at the present time in Spain, where politeness requires that anything admired by a visitor shall be offered to him, "the correct place of dating [a letter] from should be . . . . from this *your* house, wherever it is; you must not say from this *my* house, as you mean to place it at the disposition of your correspondent."

But these modes of addressing a real or fictitious superior, indirectly asserting subjection to him in body and effects, are secondary in importance to the direct assertions of slavery and servitude; which, beginning in barbarous days, have persisted during civilization down to the present time.

Biblical narratives have familiarized us with the word "servant," as habitually applied to himself by a subject or inferior, when speaking to a ruler or superior. In our days of freedom, the associations established by daily habit have obscured the fact that "servant," as used in translations of old records, means "slave"—implies the condition fallen into by a captive taken in war. Consequently, when, as frequently in the Bible, the phrases "thy servant" or "thy servants" are uttered before a king, they must be taken to signify that same state of subjugation which is more circuitously signified by the phrases quoted in the last section. Clearly this self-abasing word was employed, not by attendants only, but by conquered peoples, and by subjects at large; as we see when the unknown David, addressing Saul, describes both himself and his father as Saul's servants. And kindred uses of the word to rulers have continued down to modern times.

Very early, however, professions of servitude, originally made only to one of supreme authority, came to be made to those of subordinate authority. Brought before Joseph in Egypt, and fearing him, his brethren call themselves his servants or slaves; and not only so, but speak of their father as standing in a like relation to him. Moreover, there is evidence that this form of address extended to the intercourse between equals, where a favor was to be gained; as witness Judges xix. 19. How among European peoples a like diffusion has taken place, need not be shown further than by exemplifying some of the stages. Among French courtiers in the sixteenth century it was common to say, "I am your servant and the perpetual slave of your house;" and among ourselves in past times there were used such indirect expressions of servitude as—"Yours to command," "Ever at your worship's disposing," "In all serviceable humbleness," etc. While in our days, rarely made orally save in irony, such forms have left only their written representatives—"Your obedient servant," "Your humble servant:" mostly reserved for occasions when distance is to be maintained, and for this reason often having inverted meanings.

That for religious purposes the same propitiatory words are used, is a familiar truth. In Hebrew history men are described as servants of God, just as they are described as servants of the king. Neighboring peoples are said to serve their respective deities just as slaves are said to serve their masters. And there are sundry cases in which these relations to the visible ruler and to the invisible ruler are expressed in parallel ways ; as where we read that "the king hath fulfilled the request of his servant," and elsewhere that "the Lord hath redeemed his servant Jacob." Hence, as now used in worship, the expression "thy servant" has a history parallel to the histories of all other elements of religious ceremonial.

And here, perhaps, better than elsewhere, may be noted the fact that the phrase "thy son," used to a ruler, or superior, or other person, is originally equivalent to "thy servant." When we remember that in the rudest societies children exist only on sufferance of their parents, and that in patriarchal groups, whence the civilized societies of Europe have descended, the father had life and death power over his children, we see that professing to be another's son was like professing to be his servant or slave. There are ancient instances showing us the equivalence ; as when "Ahaz sent messengers to Tiglath-pileser, King of Assyria, saying, I am thy servant and thy son : come up, and save me." And we are not without more modern instances, furnished by those mediæval times when, as we have seen, rulers offered themselves for adoption by more powerful rulers : so assuming the condition of filial servitude and calling themselves sons ; as did Theodebert I. and Childebert II. to the Emperors Justinian and Maurice. Nor does there lack evidence that in some places this expression of subordination spreads like the rest, until it becomes a complimentary form of speech. "A Samoan cannot use more persuasive language than to call himself the son of the person addressed."

From those complimentary phrases which express abasement of self, we pass to those which exalt another person. Either kind taken alone is a confession of relative inferiority ; and this confession becomes the more emphatic when the two kinds are joined, as they ordinarily are.

At first it does not seem likely that words of eulogy may, like other propitiations, be traced back to the behavior of the conquered to the conqueror ; but we are not without proof that they do thus originate, certainly in some cases. To the victorious Rameses II. his defeated foes preface their prayers for mercy by the laudatory words—"Prince guarding thy army, valiant with the sword, bulwark of his troops in day of battle, king mighty of strength, great Sovran, Sun powerful in truth, approved of Ra, mighty in victories, Rameses Miamon." Obviously there is no separation between such praises uttered by the vanquished and those subsequently coming from them as a permanently-subjugated people, or those commonly made by subjects to their militant and despotic rulers. We pass without break to glorifying words like those addressed to the King of Siam—"Mighty and august lord! Divine Mercy!" "The Divine Order!" "The Master of Life!" "Sovereign of the Earth!" etc. : or like those addressed to the sultan —"The Shadow of God!" "Glory of the Universe!" or like those addressed to the Chinese Emperor—"Son of Heaven!" "The Lord of

Ten Thousand Years!" or like those some two years since addressed by the Bulgarians to the Emperor of Russia—"O blessed Czar!" "Blissful Czar!" "Orthodox powerful Czar!" or like those with which, in the past, speeches to the French monarch commenced—"O very benign! O very great! O very merciful!" And then along with these propitiations by direct flattery there go others in which the flattery is indirectly conveyed by affected admiration of whatever the ruler says: as when the courtiers of the King of Delhi held up their hands, crying, "Wonder, wonder!" after any ordinary speech: or in broad day, if he said it was night, responded, "Behold the moon and the stars!" or as when Russians in past times exclaimed, "God and the prince have willed!" "God and the prince know!"

Eulogistic phrases, first thus used to supreme men, of course descend to men in less authority, and so downward. Illustrations are supplied by those current in France during the sixteenth century—to a cardinal, "the very illustrious and very reverend;" to a bishop, "the very reverend and very illustrious;" to a duke, "the very illustrious and very reverend lord, my much-honored master;" to a marquis, "my very illustrious and much-honored lord;" to a doctor, "the virtuous and excellent." And from our own past days may be added such complimentary forms of address to those of lower rank as—"the right worshipful," to knights and sometimes to esquires; "the right noble," "the honorable-minded," used to gentlemen; and, even to aldermen and men addressed as Mr., such laudatory prefixes as "the worthy and worshipful," "the worshipfull, vertuous, and most worthy." Along with flattering epithets there spread flatteries more involved in form, especially observable in the East, where both are extreme. On a Chinese invitation-card the compliment, gravely addressed to an ordinary person, is—"To what an elevation of splendor will your presence assist us to rise!" Tavernier, from whom I have quoted the above example of scarcely credible flattery from the court of Delhi, adds, "This vice passeth even unto the people;" and, instancing the way in which he was himself classed with ancient men of the most transcendent powers, adds that even his military attendant, compared to the greatest of conquerors, was described as making the world tremble when he mounted his horse: a description harmonizing with the instance Mr. Roberts gives of Oriental compliment to an ordinary person—"My lord, there are only two who can do anything for me: God is the first, and you are the second."

On reading that in Tavernier's time a usual expression in the East was—"Let the king's will be done," recalling the parallel expression—"Let God's will be done," we are reminded that various of the glorifying speeches addressed to kings are identical with those addressed to deities. Where the militant type is highly developed, and where divinity is ascribed to the monarch, not only after death but before, as of old in Egypt and Peru, and as now in Japan, China, and Siam, it naturally results that the words of eulogy addressed to the visible ruler and the ruler who has become invisible are substantially the same. Having reached the extreme of hyperbole to the king when living, they cannot go further to the king when dead and deified. And the substantial identity thus initiated continues through subsequent stages with deities whose origins are no longer traceable.

Into the complete obeisance we saw that there enter two elements, one implying submission and the other implying liking; and into the complete form of address there enter two analogous elements. With words which seek to propitiate by abasing self or elevating the person addressed, or both, are joined words suggestive of attachment to the person addressed—wishes for his life, health, and happiness.

Professions of interest in another's well-being and good fortune are, indeed, of earlier origin than professions of subjection. Just as those huggings and kissings and pattings which indicate liking are used as complimentary observances by ungoverned or little-governed savages, who have no obeisances that signify submission, so friendly speeches precede speeches alleging subordination. Among the Snake Indians of North America, a stranger is accosted with the words, "I am much pleased, I am much rejoiced;" and in South America, among the Araucanians, whose social organization, though more advanced, has not yet been developed by militancy into the coercive type, the formality on meeting, which "occupies ten or fifteen minutes," consists of detailed inquiries about the welfare of each and his belongings, joined with elaborate felicitations and condolences.

Of course this element of the salutation persists while there grow up the acts and phrases expressing subjection. Along with servile obeisances we saw that good wishes and congratulations are addressed to a superior among negro nations, alike of the coast and the interior; and among the Fulahs and the Abyssinians inquiries concerning personal welfare and the welfare of belongings are elaborate. It is in Asia, however, where militant types of society are more highly developed, that the highest developments of these speeches occur. Beginning with such hyperbolic utterances as—"O king, live forever!" we descend to addresses between equals which, in like exaggerated ways, signify great sympathy; as among the Arabs, who indicate their anxiety by rapidly repeating, "Thank God, how are you?" for some minutes, and who, when well-bred, occasionally interrupt the subsequent conversation by again asking, "How are you?" or as among the Chinese, who thus directly assert their affection, on an ordinary visiting billet presented to the porter when making a call, "The tender and sincere friend of your lordship, and the perpetual disciple of your doctrine, presents himself to pay his duty and make his reverence even to the earth." Among Western peoples, in whose social organizations personal power has never reached so great a height, professions of liking and solicitude have been less exaggerated; and they have decreased as freedom has increased. In the fourteenth century, in France, at the royal table, "every time the herald cried, 'The king drinks!' every one made vœux and cried, 'Long live the king!'" And, though both abroad and at home the same or an allied form of wish is still used, it recurs with nothing like the same frequency. So, too, is it with the good wishes expressed in social intercourse. Though the exclamation, "Long life to your honor!" may still be heard, it is heard among a race who, till late times under personal rule, are even now greatly controlled by their loyalty to representatives of old families; while in parts of the kingdom longer emancipated from feudal forms, and disciplined by industrialism, the ordinary expressions of interest, abridged to "How do you do?" and "Good-by," are uttered in a manner that conveys not much more feeling than is entertained. It is interesting to note that along with these phrases, very generally diffused, in which divine aid is invoked on behalf of the person saluted—as in the "May God grant you his favors" of the Arab, "God keep you well" of the Hungarian, "God protect you" of the negro; and along with those which express interest by inquiries after state of health and strength and fortune, which are also wide-spread—there are some which take their character from surrounding conditions. One is the Oriental "Peace be with you," descending from turbulent times when peace was the great *desideratum;* another is the "How do you perspire?" alleged of the Egyptians; and a still more curious one is, "How have the mosquitoes used you?" which, according to Humboldt, is the morning salutation on the Orinoco.

There remain to be noted those modifications of language, grammatical and other, which, by implication, exalt the person addressed or abase the person addressing. These have certain analogies with other elements of ceremony. We have seen that, where subjection is extreme, the ruler, if he does not keep himself invisible, must, when present, not be looked at, on pain of death; and, from the idea that it is an unpardonable liberty to gaze at an exalted person, there has arisen in some countries the usage of turning the back on a superior. Similarly the practice of kissing the ground before a reverenced person, or kissing some object belonging to him, implies that the subject person is so remote in station that he may not take the liberty of kissing even the foot or the dress. And in a kindred spirit the linguistic forms used in compliment have, in part, the trait that they avoid direct relations with the person addressed.

Special modifications of language, having, as their common result, the maintenance of a distance between superiors and inferiors, are widely diffused, and make their appearance in some comparatively early social stages. Of the superior people among the Abipones we read that "the names of men belonging to this class end in *in;* those of the women, who also partake of these honors, in *en*. These syllables you must add even to substantives and verbs in talking with them." Again, "the Samoan language contains 'a distinct and permanent vocabulary of words which politeness requires to be made use of to superiors, or on occasions of ceremony.'" Among the Javans, "on no account is any one, of whatever rank, allowed to address his superior in the common or vernacular language of the country." And of the ancient Mexican language we are told by Gallantin that there is "a special form called Reverential, which pervades the whole language, and is found in no other. . . . this is believed to be the only one [language] in which every word uttered by the inferior reminds him of his social position."

The most general of the indirectnesses which etiquette introduces into forms of address appears to have its root in the primitive superstition respecting proper names. Conceiving that a man's name forms part of his individuality, and that possession of his name gives some power over him, savages almost everywhere are reluctant to disclose names, and consequently avoid that use of them in speech by which they are made known to hearers. Whether this is the sole cause, or whether, apart from this, utterance of a man's name is felt to be a kind of liberty taken with him, the fact is that among all races names acquire a kind of sacredness, and taking a name in vain is interdicted: especially to inferiors when addressing superiors. One curious result is that, as, in early stages, personal names are derived from objects, the names of objects have to be disused and others substituted. Among the Caffres "a wife may not publicly pronounce the *i-gama* [the name given at birth] of her husband or any of his brothers; nor may she use the interdicted word in its ordinary sense. . . . The chief's *i-gama* is withdrawn from the language of his people." Again, "the hereditary appellation of the chief of Pango-Pango [in Samoa] being now Maunga, or Mountain, that word must never be used for a hill in his presence, but a courtly term . . . substituted." And then, where there exist proper names of a developed kind, there are still kindred restrictions on the general use of them; as in Siam, where "the name of the king must not be uttered by a subject: he is always referred to by a periphrasis, such as 'the master of life,' 'the lord of the land,' 'the supreme head;'" and as in China, where "the 'old man of the house,' 'excellent honorable one,' and 'venerable great prince,' are terms used by a visitor to designate the father of his host."

Allied with avoidance of the proper name in addressing a superior, there is, as sundry of the above instances show, avoidance of the personal pronouns; which also establish with the individual addressed a relation too direct to be allowed where distance is to be maintained. In Siam, as already exemplified, when asking the king's commands the pronominal form is, as much as possible, evaded; and that this usage is general among the Siamese is shown by the remark of Père Bruguière, that "they have personal pronouns, but rarely use them." Among the Chinese, also, this style of address descends into ordinary intercourse. "If they are not intimate friends, they never say I and You, which would be a gross incivility. But instead of saying, I am very sensible of the service you have done me, they will say, The service that the Lord or the Doctor has done for his meanest Servant, or his Scholar, has greatly affected me."

We come next to those perversions in the uses of pronouns which serve to exalt the superior and abase the inferior. "'I' and 'me' are expressed by several terms in Siamese; as (1) between a master and slave; (2) between a slave and master; (3) between a commoner and a nobleman; (4) between persons of equal rank; while there is, lastly, a form of address which is only used by the priests." Still more developed is this system among the excessively ceremonious Japanese. "In Japan all classes have an 'I' peculiar to themselves, which no other class may use; and there is one exclusively appropriated by the Mikado . . . and one confined to women. . . . There are eight pronouns of the second person peculiar to servants, pupils, and children." Though in the West the distinctions established by abusing pronominal forms have not been so much elaborated, yet they have been sufficiently marked. In Germany "in old times . . . all inferiors were spoken to in the third person singular, as 'er':" that is, an oblique form by which the inferior was not directly addressed, but merely referred to, as though in speaking to another person served to disconnect him from the speaker. And then we have the converse fact that "inferiors invariably use the third person plural in addressing their superiors:" a form which, while dignifying the superior by pluralization, increases the distance of the inferior by its relative indirectness; and a form which, beginning as a propitiation of those in power, has, like the rest, spread till it has become a general propitiation. In our own speech, lacking such misuse of pronouns as serves to humiliate, there exists only that substitution of the "you" for the "thou," which, once a complimentary exaltation, has now by diffusion through all ranks wholly lost its ceremonial meaning. Evidently it retained some ceremonial meaning at the time when the Quakers persisted in using "thou;" and that in still earlier times it was employed to ascribe dignity is inferable from the fact that during the Merovingian period in France, when the habit was but partially established, the kings ordered that they should be addressed in the plural. Whoever fails to think that calling him "you" once served to exalt the person addressed, will be aided by contemplating this perversion of speech in its primitive and more emphatic shape; as in Samoa, where they say to a chief, "Have *you two* come?" or, "Are *you two* going?"

Since they state in words what obeisances express by acts, forms of address, of course, have the same general relations to social types. The parallelisms must be briefly noted.

Speaking of the Dakotas, who are politically unorganized, and who had not even nominal chiefs till the whites began to make distinctions among them, Burton says, "Ceremony and manners, in our sense of the word, they have none;" and he instances the entrance of a Dakota into a stranger's house with a mere exclamation meaning "Well!" Bailey remarks of the Veddahs, that in addressing others "they use none of the honorifics so profusely common in Singhalese; the pronoun '*to*,' 'thou,' being alone used, whether they are addressing each other, or those whose position would entitle them to outward respect." These cases will sufficiently indicate the general fact that where there is no subordination, speeches which exalt the person spoken to and abase the person speaking do not arise. Conversely, where personal government is absolute, verbal self-humiliations and verbal exaltations of others assume exaggerated forms. Communities such as we find in Siam, where every subject is a slave of the king, are those in which the inferior calls himself dust under the feet of the superior, while ascribing to the superior transcendent powers, and where the forms of address, even between equals, avoid naming the person addressed. It is in social organizations like that of China, where there is no check on the power of the "Imperial Supreme," that the phrases of adulation and humility, first used in intercourse with rulers and afterward spreading, have elaborated to such extremes that in inquiring another's name the form is, "May I presume to ask what is your noble surname and your eminent name?" while the reply is, "The name of my cold (or poor) family is ——, and my ignoble name is ——." Or, again, if we ask where occur the most elaborate misuses of pronouns initiated by ceremony, we find them among the Japanese, over whom chronic wars long ago established a despotism which acquired divine prestige.

So, too, on comparing the Europe of past times, characterized by social structures developed by, and fitted for, perpetual fighting, with modern Europe, in which, though fighting on a large scale occurs, it is the temporary rather than the permanent form of social activity, we observe that complimentary expressions, now less used, are also less exaggerated. Nor does the contrast fail when we put side by side the modern European societies that are organized in greater degree for war, like those of the Continent, and our own society, not so well organized for war; or when we put side by side the regulative parts of our own society, which are developed by militancy, with the industrial parts. Flattering superlatives and expressions of devotion are less profuse here than they are abroad; and, much as the use of complimentary language has diminished among our ruling classes in recent times, there still remains a greater use of it than among the industrial classes—especially those of the industrial classes who have no direct relations with the ruling classes.

These connections are obviously, like previous ones, necessary. Should any one say that along with the enforced obedience which military organization implies, and which characterizes the whole of a society framed for military action, there naturally go forms of address not expressing submission, and if, conversely, he should say that along with the active exchanging of produce, money, services, etc., freely carried on, which characterizes the life of an industrial society, there naturally go exaggerated eulogies of others and servile depreciations of self, his proposition would be manifestly absurd; and the absurdity of this hypothetical proposition serves to bring into view the truth of the actual proposition opposed to it.

EDUCATION AS A SCIENCE.[1]

By ALEXANDER BAIN, LL. D.,

PROFESSOR IN THE UNIVERSITY OF ABERDEEN.

IV.

IN education there has to be encountered at every turn the play of motives. Now, the theory of motives is the theory of sensation, emotion, and will; in other words, it is the psychology of the sensitive and the active powers.

1. THE SENSES.—The pleasures, the pains, and the privations of the senses, are the earliest and the most unfailing, if not also the strongest, of motives. Besides their bearings on self-preservation, they are a principal standing dish in life's feast.

It is when the senses are looked at on the side of feeling, or as pleasure and pain, that the defectiveness of the current classification into five is most evident. For, although, in the point of view of knowledge or intellect, the five senses are the really important approaches to the mind, yet, in the view of feeling or pleasure and pain, the omission of the varied organic susceptibility leaves a wide gap in the handling of the subject. Some of our very strongest pleasures and pains grow out of the region of organic life—the digestion, circulation, respiration, muscular and nervous integrity or derangement.

In exerting influence over human beings this department of sensibility is a first resource. It can be counted on with more certainty than perhaps any other. Indeed, almost all the punishments of a purely physical kind fall within the domain of the organic sensations. What is it that makes punishment formidable, but its threatening the very vitals of the system? It is the lower degree of what, in a higher degree, takes away life.

For example, the muscular system is the seat of a mass of sensibility, pleasurable and painful: the pleasures of healthy exercise, the

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pains of privation of exercise, and the pains of extreme fatigue. In early life, when all the muscles, as well as the senses, are fresh, the muscular organs are very largely connected both with enjoyment and with suffering. To accord full scope to the activity of the fresh organs is a gratification that may take the form of a rich reward; to refuse this scope is the infliction of misery; to compel exercise beyond the limits of the powers is still greater misery. Our penal discipline adopts the two forms of pain: in the milder treatment of the young, the irksomeness of restraint; in the severe methods with the full-grown, the torture of fatigue.

Again, the nervous system is subject to organic depression; and certain of our pains are due to this cause. The well-known state denominated "tedium" is nervous uneasiness; and is caused by undue exercise of any portion of the nervous system. In its extreme forms it is intolerable wretchedness. It is the suffering caused by penal impositions or tasks, by confinement, and by monotony of all kinds. The acute sufferings of the nervous system, as growing out of natural causes, are represented by neuralgic pains. It is in graduated artificial inflictions, operating directly on the nerves by means of electricity, that we may look for the physical punishments of the future, that are to displace floggings and muscular torture.

The interests of nourishment, as against privation of food, are necessarily bound up with a large volume of enjoyment and suffering. Starvation, deficiency and inferiority of food, are connected with depression and misery of the severest kind; inspiring the dread that most effectually stimulates human beings to work, to beg, or to steal. The obverse condition of a rich and abundant diet is in itself an almost sufficient basis of enjoyment. The play of motives between those extremes enables us to put forth an extensive sway over human conduct.

An instructive distinction may be made between privation and hunger; likewise between their opposites. Privation is the positive deficiency of nourishing material in the blood; hunger is the craving of the stomach at its usual times of being supplied, and is a local sensibility, perhaps very acute, but not marked by the profound wretchedness of inanition. There may be plenty of material to go on with, although we are suffering from stomachic hunger. Punishing, for once, by the loss of a meal out of the three or four in the day, is unimportant as regards the general vigor, yet very telling as a motive. Absolutely to diminish the available nutriment of the system is a measure of great severity; to inflict a pending hunger is not the same thing.

When we unite the acute pleasures of the palate with stomachic relish and the exhilaration of abundance of food-material in a healthy frame, we count up a large mass of pleasurable sensibility. Between the lowest demands of subsistence and the highest luxuries of affluent means there is a great range, available as an instrumentality of control in the discipline of the young. The usual regimen being something considerably above necessaries, and yet beneath the highest pitch of indulgence, room is given to operate both by reduction and by increase of luxury, without either mischief or pampering; and, the sensibility in early years being very keen in those heads, the motive power is great. Having in view the necessities of discipline with the young, the habitual regimen in food should be pitched neither too low nor too high to permit of such variations. It is the misfortune of poverty that this means of influence is greatly wanting; the next lower depth to the delinquent child is the application of the stick.

These are the chief departments of organic sensibility that contain the motives made use of in reward and punishment. The inflictions of caning and flogging operate upon the organ of the sense of touch, yet, in reality, the effect is one to be classed among the pains of organic life, rather than among tactile sensations; it is a pain resulting from injury or violence to the tissue in the first instance, and if carried far is destructive of life. Like all physical acute pains it is a powerful deterring influence, and is doubtless the favorite punishment of every age and every race of mankind. The limitations to its use demand a rigorous handling; but the consideration of these is mixed up with motives afterward to be adverted to.

The ordinary five senses contain, in addition to their intellectual functions, many considerable sensibilities to pleasure and pain. The pleasures can be largely made use of as incentives to conduct. The pains might of course be also employed in the same way; but with the exceptions already indicated they very rarely are. We do not punish by bad odors, nor by bitter tastes. Harsh and grating sounds may be very torturing, but they are not used in discipline. The pains of sight reach the highest acuteness, but as punishment they are found only in the most barbarous codes.

Postponing a review of the principles of punishment generally, we approach the most perplexing department of motives—the higher Emotions. Few of the simple sensational effects are obtained in purity, that is, without the intermingling of emotions.

2. The Emotions.—One large department of psychology is made up of the classification, definition, and analysis of the Emotions. The applications of a complete theory of Emotion are numerous, and the systematic expansion must be such as to cope with all these applications. We here narrow the subject to what is indispensable for the play of motives in education.

First of all, it is necessary to take note of the large region of Sociability, comprising the social emotions and affections. Next is the department of Anti-social feeling—Anger, Malevolence, and Lust of Domination. Taking both the sources and the ramifications of these two leading groups, we cover perhaps three-fourths of all the sensibility that rises above the senses proper. They do not indeed exhaust the fountains of emotion, but they leave no other that can rank as of first-class importance, except through derivation from them and the senses together.

The region of Fine Art comprises a large compass of pleasurable feeling, with corresponding susceptibilities to pain; some of this is sensation proper, being the pleasures of the two higher senses; some is due to associations with the interests of all the senses (Beauty of Utility); a certain portion may be called Intellectual, the perception of unity in variety; while the still largest share appears to be derived from the two great sources above described.

The Intellect generally is a source of various gratifications and also of sufferings that are necessarily mixed up with our intellectual education. Both the delights of attained knowledge and the pains of intellectual labor have to be carefully counted with by every instructor.

The pleasures of Action or Activity are a class greatly pressed into the educational service, and therefore demand special consideration.

The names Self-Esteem, Pride, Vanity, Love of Praise, express powerful sentiments, whose analysis is attended with much subtilty. They are largely appealed to by every one that has to exercise control over human beings. To gratify them is to impart copious pleasure, to thwart or wound them is to inflict corresponding pain.

Mention has not yet been made of one genus of emotion, formidable as a source of pain, and as a motive to activity, namely, Fear or Terror. Only in the shape of reaction or relief is it a source of pleasure. The skillful management of this sensibility has much to do with the efficient control of all sentient creatures, and still more with the saving of gratuitous misery.

Our rapid review of these various sources of emotion, together with others of a minor kind, proposes to deal once for all, and in the best manner, with the various educational questions that turn upon the operation of motives. We shall have to remark upon prevailing exaggerations on some heads and the insufficient stress laid on others; and shall endeavor to unfold in just proportions the entire compass of our emotional susceptibilities available for the purposes of the teacher.

3. The Emotion of Terror.—The state of mind named Terror or Fear is described shortly as a state of extreme misery and depression, prostrating the activity and causing exaggeration of ideas in whatever is related to it. It is an addition to pain pure and simple—the pain of a present infliction. It is roused by the foretaste or prospect of evil, especially if that is great in amount, and still more if it is of uncertain nature.

As far as education is concerned, terror is an incident of the infliction of punishment. We may work by the motive of evil without producing the state of terror, as when the evil is slight and well defined; a small understood privation, a moderate dose of irksomeness, may be salutary and preventive, without any admixture of the quakings and misery of fear. A severe infliction in prospect will induce fear; the more so that the subject does not know how severe it is to be.

In the higher moral education, the management of the passion of fear is of the greatest consequence. The evils of operating by means of it are so great that it should be reserved for the last resort. The waste of energy and the scattering of the thoughts are ruinous to the interests of mental progress. The one certain result is to paralyze and arrest action, or else to concentrate force in some single point, at the cost of general debility. The tyrant, working by terror, disarms rebelliousness, but fails to procure energetic service, while engendering hatred and preparing for his overthrow.

The worst of all modes and instruments of discipline is the employment of spiritual, ghostly, or superstitious terrors. Unless it were to scourge and thwart the greatest of criminals—the disturbers of the peace of mankind—hardly anything justifies the terrors of superstition. On a small scale, we know what it is to frighten children with ghosts; on a larger scale is the influence of religions dealing almost exclusively in the fear of another life.

Like the other gross passions, terror admits of being refined upon and toned down, till it becomes simply a gentle stimulation; and the reaction more than makes up for the misery. The greatest efforts in this direction are found in the artistic handling of fear, as in the sympathetic fears of tragedy, and in the passing terrors of a well-constructed plot. In the moral bearings of the emotions, its refined modes are shown in the fear of giving pain or offense to one that we love, respect, or venerate. There may be a considerable degree of the depressing element even in this situation; yet the effect is altogether wholesome and ennobling. All superiors should aspire to be feared in this manner.

Timidity, or susceptibility to fear, is one of the noted differences of character; and this difference is to be taken into account in discipline. The absence of general vigor, bodily and mental, is marked by timidity; and the state may also be the result of long bad usage, and of perverted views of the world. In the way of culture, or of high exertion in any form, little is to be expected from thoroughly timid natures; they can be easily governed, so far as concerns sins of commission, but their omissions are not equally remediable.

The conquest of superstitious fears is one of the grandest objects of education taken in its widest compass. It cannot be accomplished by any direct inculcation; it is one of the incidental and most beneficial results of the exact study of Nature—in other words, science.

4. The Social Motives.—This is perhaps the most extensive and the least involved of all the emotional influences at work in education.

The pleasures of love, affection, mutual regard, sympathy, or sociability, make up the foremost satisfaction of human life; and as such are a standing object of desire, pursuit, and fruition. Sociability is a wholly distinct fact from the prime supports of existence and the pleasures of the five senses, and is not, in my opinion, resolvable into those, however deeply we may analyze it, or however far back we may trace the historical evolution of the mind. Nevertheless, as the supports of life, and the pure sense agreeables and exemptions, come to us in great part through the medium of fellow-beings, the value of the social regards receives from this cause an enormous augmentation, and, in the total, counts for one paramount object of human solicitude. It would appear strange if this motive could ever be overlooked by the educator, or by any one ; yet there are theories and methods that treat it as of inferior account.

The vast aggregate of social feeling is made up of the intenser elements of sexual and parental love, and the select attachments in the way of friendship, together with the more diffused sentiments toward the masses of human beings. The motive power of the feelings in education may be well exemplified in the intense examples ; we can see in these both the merits and defects of the social stimulus. The "Phædrus" of Plato is a remarkable ideal picture of the study of philosophy prompted by Eros, in the Grecian form of attachment. The ordinary love of the sexes, in our time, does not furnish many instances of the mutual striving after high culture; it may be left out of account in the theory of early education. We frequently find mothers applying to studies that they feel no personal attraction for, in order to assist in the progress of their children. This is much better than nothing ; a secondary end may be the initiation and discovery of a taste that at last is self-subsisting.

The intense emotions, from the very fact of their intensity, are unsuited to the promptings of severe culture. The hardest studious work, the laying of foundations, should be over, before the flame of sexual and parental passion is kindled; when this is at its height the intellectual power is in abeyance, or else diverted from its regular course. The mutual influence of two lovers is not educative for want of the proper conditions. No doubt considerable efforts are inspired; but there is seldom sufficient elevation of view on the one side, or sufficient adaptability on the other, to make the mutual influence what Plato and the romancists conceive as possible. By very different and inferior compliances on both sides, the feeling may be kept alive ; if more is wanted, it dies away.

The favorable conjunction for study and mental culture in general is friendship between two, or a small number, each naturally smitten with the love of knowledge for its own sake, and basing their attachment on that circumstance. A certain amount of mutual liking in other respects perfects the relationship ; but the overpowering sensuous regards of the Platonic couple do not furnish the requisite soil for high culture. As a matter of fact, those attachments, as they existed in Greece, prompted to signal instances of self-devotion in the form of surrendering worldly goods and life itself; and this is the highest fruit that they have yielded in later times.

The remaining aspect of sociability—the influence of the general multitude—holds out the most powerful and permanent motive to conduct, and is largely felt in education. In the presence of an assembly the individual is roused, agitated, swayed ; the thrill of numbers is electric; in whatever direction the influence tends, it is almost irresistible. Any effort made in the sight of a host is totally altered in character ; and all impressions are very much deepened.

Having in view this ascendency of numbers, we can make a step toward computing the efficacy of class-teaching, public schools, and institutions where great multitudes are brought together. The power exercised is of a mixed character and the several elements admit of being singled out. The social motive, in its pure form of gregarious attraction and mutual sympathy, does not stand alone. Supposing it did, the effect would be to supply a strong stimulus in favor of everything that was supported by common consent; the individual would be urged to attain the level of the mass. The drill of a regiment of soldiers corresponds very nearly to this situation; every man is under the eye of the whole, and aspires to be what the rest are and not much, if anything, beyond; the sympathetic coöperation of the mass, guides, stimulates, and rewards the exertion of the individual. Even if it were the destination of a soldier to act as an isolated individual, still his education would be most efficaciously conducted in the mass system, being finished off by a certain amount of separate exercise to prepare for the detached or independent position.

In every kind of education in classes, the social feeling, in the pure form now assumed, is frequently operative, and the results are as stated. The tendency is to secure a certain approved level of attainment: those that are disinclined of themselves to work up to that level are pushed on by the influence of the mass. If there were no other strong passions called out in society, the general result would be a kind of communism or socialism characterized by mediocrity and dead level; everything correct up to a certain point, but no individual superiority or distinction.

The influence of society as the dispenser of collective good and evil things, in addition to its operation in the affections and sympathies, is necessarily all-powerful in every direction. If this stimulus were always to coincide with high mental culture, the effect would be something that the imagination hardly dares to shadow forth. It is, however, a power that may be propitiated by many different means, including shams and evasions, and the bearing upon culture is only occasional. Nevertheless, the social rewards have often served to foster the highest genius—the oratory of Demosthenes, and the poetry of Horace and Virgil—a form of genius notoriously allied with toil and perseverance of the most arduous kind. The same influence, working by disapprobation and approbation combined, is, as I contend, the principal generating source of the ordinary moral sentiments of mankind, and the inspiration of exceptional virtues.

5. The Anti-social and Malign Emotions.—The emotions of Anger, Hatred, Antipathy, Rivalry, Contumely, have reference to other beings, no less than Love or Affection, but in an opposite way. In spite of the painful incidents in their manifestation—the offense in the first instance, and the dangers of reprisal—they are a source of immediate pleasure, often not inferior, and sometimes superior, in amount to the pleasures of amity and gregarious coöperation. In numerous instances people are willing to forego social and sympathetic delights to indulge in the pleasures of malignity.

In the work of discipline the present class of emotions occasions much solicitude. They can in certain ways be turned to good account; but, for the larger part, the business of the educator and the moralist is to counterwork them as being fraught with unalloyed evil.

Being a fitful or explosive passion, anger should, as far as possible, be checked or controlled in the young; but there are no adequate means, short of the very highest influence of the parent or teacher. The restraint induced by the presence of a dread superior at the time does not sink deep enough to make a habit; opportunities are sought and found to vent the passion with safety. The cultivation of the sympathies and affections is what alone copes with angry passion, both as a disturber of equanimity and as the prompter of wrong. The obverse of ill-temper is the disposition that thinks less of harm done to self and more of harm done to other people; and, if we can do anything to foster this disposition, we reduce the sphere of malignant passion. The collateral incentives to suppress angry passion include, besides the universal remedy of disaprobation, an appeal to the sense of personal dignity and to the baneful consequences of passionate outbursts.

The worst form of malignant feeling is cold and deliberate delight in cruelty; all too frequent, especially in the young. The torturing of animals, of weak and defenseless human beings, is the spontaneous outflow of the perennial fountain of malevolence. This has to be checked, if need be, at the expense of considerable severity. The inflictions practised on those that are able to recriminate, generally find their own remedy; and the discipline of consequences is as effectual as any. By having to fight our equals, we are taught to regulate our wrathful and cruel propensities.

The intense pleasure of victory contains the sweetness of malevolence, heightened by some other ingredients. The prostration and destruction of an enemy or a rival is, no doubt, the primary situation where malevolent impulses had their rise; and it continues to be, perhaps, the very strongest stimulant of the human energies. Notwithstanding its several drawbacks, we are obliged to give it a place among motives to study and mental advancement. In the fight and struggle of party contests the pleasure of victory enters in full flavor; and in the competitions at school the same motive is at work.

The social problem of restraining individuals in their selfish grasping of good things—the mere agreeables and exemptions of the senses—is rendered still more intractable by the craving for the smack of malevolent gratification. Total repression has been found impossible; and ingenuity has devised a number of outlets that are more or less compatible with the sacredness of mutual rights.

One chief outlet for the malevolent impulses is the avenging of wrong, whether private or public. A convicted wrong-doer is punished by the law, and the indignation roused by the crime turns to gratification at the punishment. In the theory of penal retribution some allowance is claimed for the vindictive satisfaction of the public. To think only of the prevention of crime, and the reformation of criminals, and suppressing all resentful feeling, is a severe and ascetic view, beyond human nature as at present constituted. The privacy of the punishments of criminals, in our modern system, is intended to keep the indulgence within bounds.

A wide ideal scope is given to our resentful pleasures in history and in romance; we are gratified by the retribution inflicted upon the authors of wrong. Narratives of evil-doers and of their punishment are level to the meanest capacity; this is the sort of history that suits the imagination even of children.

The highest refinement of the malevolent gratification I take to be the creation called the ludicrous and the comic. There is a laugh of vindictiveness, hatred, and derision, which carries the sentiment as far as it can be carried without blows. But there is also the laugh expressed by playfulness and humor, in which the malignant feeling seems almost on the point of disappearing in favor of the amicable sentiment. It is of some importance to understand that in play, fun, and humor, there is a delicate counterpoise of opposing sentiments, an attempt to make the most of both worlds—love and anger. The great masterpieces of humor in literature, the amenities of every-day society, the innocent joyousness of laughter—all attest the success of the hazardous combination. Nothing could better show the intensity of the primitive charm of malevolence than the unction that survives after it is attenuated to the condition of innocent mirthfulness. When the real exercise of the destructive propensity is not to be had, creatures endowed with emotions still relish the fictitious forms. This is seen remarkably in the amicable "play" of puppies and kittens. Not being endowed with much compass of the caressing acts, they show their love by snarling and sham biting; in which, through their fortunate self-restraint, they seem to enjoy a double pleasure. In the play of children there is the same employment of the forms of destructive malevolence, and, so long as it is happily balanced, the effect is highly piquant. By submitting in turn to be victimized, a party of children can secure, at a moderate cost to each, the zest of the malevolent feeling; and this I take to be the quintessence of play.

The use of this close analysis is to fix attention upon the precarious tenure of all these enjoyments, and to render a precise reason for the well-known fact that play or fun is always on the eve of becoming earnest; in other words, the destructive or malevolent element is in constant danger of breaking loose from its checks, and of passing from fictitious to actual inflictions. The play of the canine and the feline kind often degenerates in this fashion; and in childish and youthful amusements it is a perpetual rock ahead.

It is no less dangerous to indulge people in too much ideal gratification of the vindictive sentiments. Tales of revenge against enemies are too apt to cultivate the malevolent propensity. Children, it is true, take up this theme with wonderful alacrity; nevertheless it is a species of pampering supplied to the worst emotions instead of the best.

One other bearing of irascibility on education needs to be touched. When disapproval is heightened with anger, the dread inspired is much greater. The victim anticipates a more severe infliction when the angry passion has been roused; hence the supposition is natural that anger is an aid to discipline. This, however, needs qualifying. Of course, any increase of severity has a known deterrent effect, with whatever drawbacks may attend the excess. But anger is fitful; and, therefore, its coöperation mars discipline by want of measure and want of consistency; when the fit has passed, the mind often relapses into a mood unfavorable to a proper amount of repression.

The function of anger in discipline may be something very grand, provided the passion can be controlled. There is a fine attitude of indignation against wrong that may be assumed with the best effect. It supposes the most perfect self-command, and is no more excited than seems befitting the occasion. Mankind would not be contented to see the bench of justice occupied by a calculating machine that turned up a penalty of five pounds, or a month's imprisonment, when certain facts were dropped in at the hopper. A regulated expression of angry feeling is a force in itself. Neither containing fitfulness, nor conducting to excess of infliction, it is the awe-inspiring personation of justice, and is often sufficient to quell insubordination.

SEA-SIDE STUDIES.

By Professor SANBORN TENNEY.

Among the thousands who visit the sea-shore in summer, there are many who, although not naturalists, are more or less interested in the various marine forms which there abound, and perhaps a brief notice of some of these forms will be acceptable to those who have not made a special study of life as it is revealed in the sea.

If an observer be on a rocky shore he will not fail to become interested in the "sea-anemones," those "flowers of the sea" which at first view appear to be on the border-land between plants and animals, so that one hardly knows whether to refer them to the vegetable or to the animal kingdom.

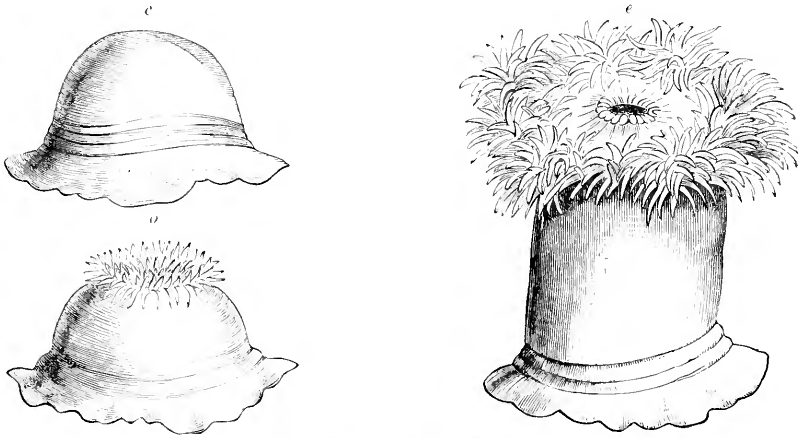


Fig. 1.—Actinia, or Sea-Anemone (*Metridium marginatum*, Milne-Edwards): *c*, closed; *o*, opening; *e*, expanded.

Although some sea-anemones live in the sand (Fig. 2), the home of the ordinary kinds is the pools and caverns among the rocks; here we may find and study them when the tide is out. Groups, sometimes in thousands, and standing so closely together that they cover the whole interior of the rocky cavern or grotto, are not uncommon. Some are expanded to their fullest extent, like a full-blown flower; others are only partly open; others are just opening; and others still are closed as tightly as the bud of a flower, which they more or less resemble.

Various are the colors which they exhibit, from pale or nearly white to the richest hues of pink, rose, red, and purple.

In the centre of the top there is an opening or mouth, which leads directly into a central sac or stomach, and around the mouth are rows of long and delicate hollow appendages, which the animal moves freely to and fro in the water, and with which it can bring the food to its mouth. As soon as a snail or other small animal falls among the fringes, these close around it and move it toward the mouth, where it is soon swallowed, the soft parts digested and the hard parts excluded. By means of its broad base or "foot," the sea-anemone attaches itself

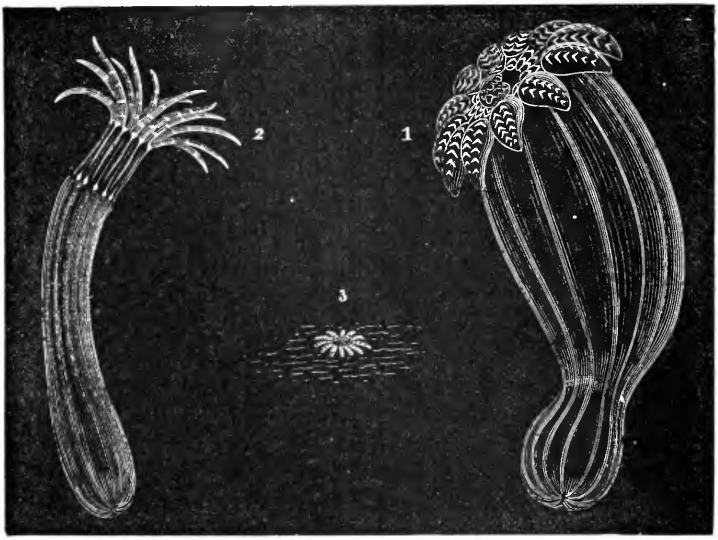


FIG. 2.—ACTINIÆ OR SEA-ANEMONES WHICH LIVE IN THE SAND AND ARE OFTEN UNATTACHED. 1. *Peachia hastata*, Gosse.—2. *Edwardsia callimorphia*, Gosse.—*Halocampa chrysanthellum*, Gosse—the last mostly buried in the sand.

firmly to the rock or shell on which it rests, and seldom moves from the spot which it has chosen, although it can effect locomotion by means of its "foot." By this it clings so firmly to the rock that it sometimes suffers itself to be torn in two rather than let go its hold.

The main cavity of the body in the sea-anemones is divided by septa or partitions, which run from the top to the bottom, and from the outer wall to the stomach. These partitions or septa are in pairs, and the number is some multiple of six. By what principle of selection this constant number was introduced we may be curious enough to inquire, but we must not expect to receive at once a perfectly satisfactory answer.

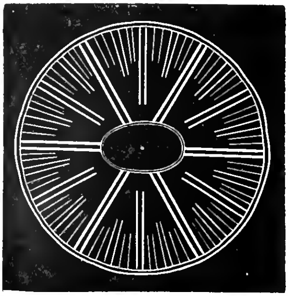


FIG. 3.—CROSS-SECTION OF A POLYP, OR SEA-ANEMONE, SHOWING THE SEPTA.

The partitions above mentioned are the infolding of the body-wall of the animal, and are essentially the same as the wall itself. Toward the top of each partition there is a hole, permitting free passage for the water to flow from one chamber to another.

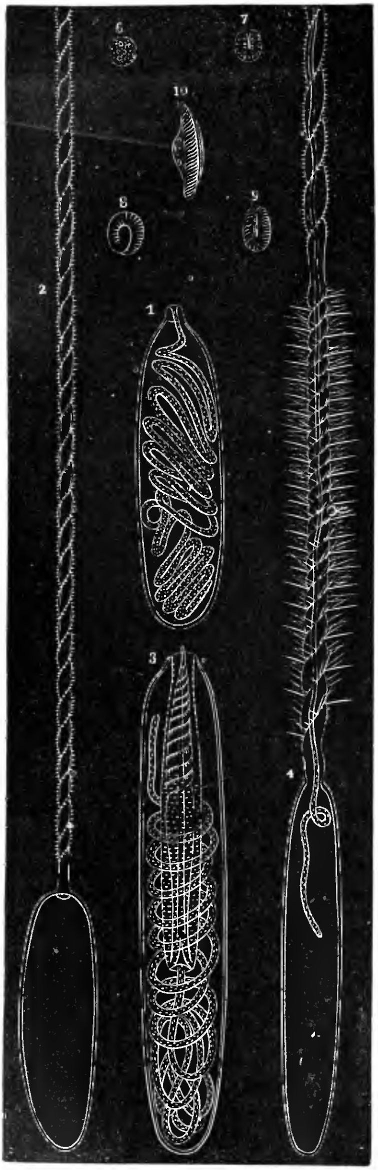


Fig. 4.—Cnidæ, or Lasso-Cells, some with the Lasso coiled within, and others with the Lasso extended; only a Part of the Length is shown. 1. Lasso-cells of an Actinia, with the lasso coiled within—its actual length $\frac{1}{350}$ of an inch. 2. The same as 1, with the lasso extended. 3 and 4 are alike—the former with the lasso coiled within, and the latter with the lasso extended. 6, 7, 8, 9, 10, a lasso-cell in different stages of development.

On various parts of the sea-anemones, and of all other polyps, especially on their tentacles or fringes, there are very remarkable objects called cnidæ, or lasso-cells, like those on jelly-fishes, each cell being less than one two-hundredths of an inch in length. In each there is a long, slender, coiled, and wonderfully-constructed thread, which can be instantly darted forth, paralyzing any little animal which it strikes; and thus the hungry polyp secures its food.

On the vertical partitions above mentioned the eggs are borne. These pass out into the water through the mouth. The newly-hatched anemone is oval in form, and swims freely about in the water by means of exceedingly delicate fringes called vibratile cilia. After a time it quits this roving life, attaches itself to the surface of the rocks, and grows into the form and size of the parent.

Sea-anemones have no proper nervous system. The sense of touch is distributed throughout the whole animal. It will, therefore, appear as a remarkable statement that some kinds have quite definitely-formed eyes. These are seen in some tropical species just outside of the tentacles, and according to Dana each of these eyes has a crystalline lens and an optic nerve!

Sea-anemones readily reproduce lost parts. If one is quickly torn from a rock, parts of the foot remain attached to the rock, and in many cases each portion thus left will become a perfect sea-anemone!

Sea-anemones vary greatly in size. Some species are only a fraction of an inch in diameter. Our most common kinds are from one to two inches, and expand from two to four inches. Some of the tropical kinds are a foot in diameter.

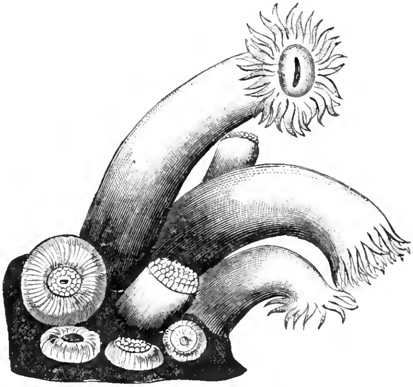


FIG. 5.—CLUSTER OF CORAL-POLYPS (*Asteroides calycularis*, Milne-Edwards)—in various stages of expansion.

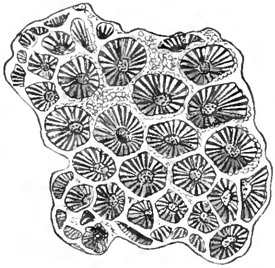


FIG. 6.—DEAD CORAL (*Asteroïdes calycularis*, Milne-Edwards.)—The coral of Fig. 5.

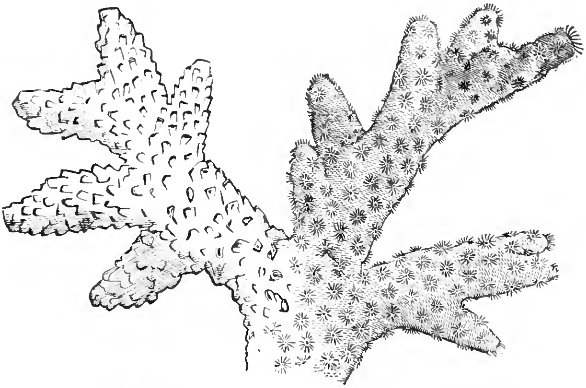


FIG. 7.—MADREPORE CORAL (*Madrepora aspera*, Dana). Right-hand branches alive; the left, dead.

The sea-anemones, whether in their natural home or in the aquarium, are exceedingly interesting objects; and in the latter place we can study them to the best advantage. Carefully remove a dozen of them

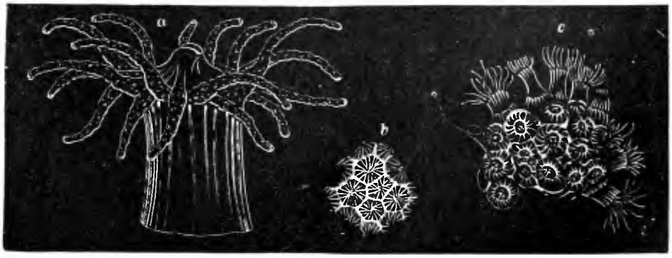


FIG. 8.—DANA'S ASTRANGIA (*Astrangia Danæ*, Agassiz): *c*, a growing cluster; *a*, a single polyp enlarged; *b*, the dead coral.

from the rocks; lay them in your basket, with plenty of wet sea-weeds; break from the rock some fragments with the sea-weeds still growing upon them; on your return to your studio put the whole into your aquarium, well supplied with pure sea-water. At first, the sea-anemones will appear like so many mere lumps of soft flesh, without definite form. But leave them there for a night; and, when you look again, you will find each one has established itself, and has expanded into a thing of beauty.

Those polyps which form the beautiful clusters of coral that adorn our mantels and museums, and which build up the vast coral-reefs and islands, differ in only one important respect from the sea-anemones.

Fig. 9.—*Sarsia* (*Coryne*) *mirabilis* (Agassiz). Cluster of Hydroids growing on sea-weeds.

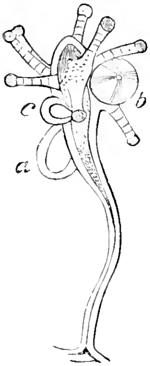


Fig. 10.—Single individual of Fig. 9 enlarged, showing *a b* just ready to become free jelly-fishes or Medusæ; Fig. 11, *c*, young bud.

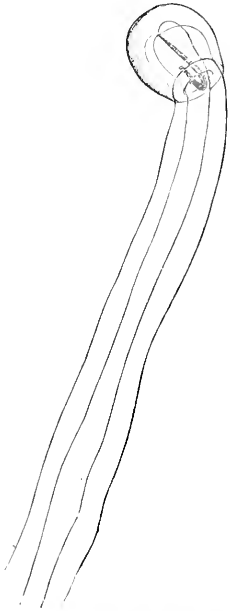


Fig. 11.—*Sarsia* (*Coryne*) *mirabilis* (Agassiz). Adult, Massachusetts Bay.

The sea-anemones are wholly soft; they secrete no skeleton, or only the merest particles of hard matter. On the other hand, the coral-producing polyps secrete a stony skeleton. The old notion that coral is something built by an insect is entirely erroneous. The coral-producing animal is in no sense an insect, nor does it toil to build the clusters and reefs of coral which it forms. The coral-polyp lives and eats, and the getting of its food is the only labor of its life.

Coral assumes a variety of shapes, imitating almost all forms of vegetation on the land.

Most of the coral-producing polyps are confined to the tropical parts of the ocean. A few kinds live in temperate waters. Dana's *Astrangia* lives and flourishes in Long Island Sound, where it occurs in little clusters upon stones and shells.

The visitor to the sea-shore will hardly fail to find among the growing sea-weeds little plant-like clusters like the one represented by Fig. 9. This is a cluster of hydroids, and its life-history is very interesting. The beginner may well be pardoned if he mistake these little clusters for plants, but they are indeed animals. From each little branch there arise buds (Fig. 10), which enlarge, till at length they become detached, float away, and grow into the beautiful jelly-fishes known as *Sarsia* or *Coryne;* it has been called by both names, the latter name meaning a club, and the former coming from Sars, the distinguished Norwegian naturalist, who was one of their earliest investigators.

Other hydroids, called *Campanularians*, will be found among sea-weeds. Here the minute jelly-fishes are formed in little bell-shaped organs (Fig. 12). At length they drop out into the water and become free jelly-fishes similar to *Tiaropsis* (Fig. 14).

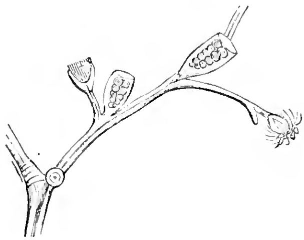


FIG. 12.—CAMPANULARIAN (*Obelia commissuralis*, McCready). The hydro-medusæ in the cups drop out and become free Medusæ, or jelly-fishes, similar to Fig. 14.

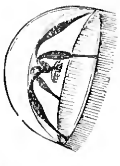


FIG. 14.—CAMPANULARIAN (*Tiaropsis diademata*, Agassiz).

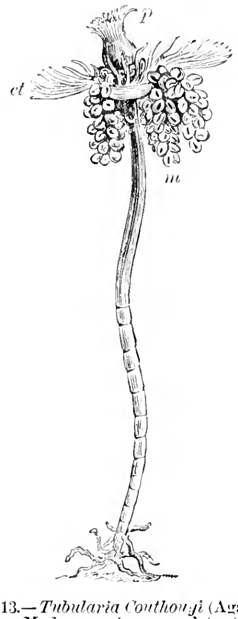


FIG. 13.—*Tubularia Couthouyi* (Agassiz). *m*, Medusæ; *ct*, coronal tentacles; *p*, proboscis.

The visitor will find other hydroids, which appear like miniature trees with all their foliage crowded to the top, and from beneath which there hang bunches, as it were, of grapes or other fruit. Such is *Tu-*

bularia, and the little fruit-like clusters are persistent jelly-fishes which develop and remain just beneath the row of tentacles (Fig. 13), instead of becoming free jelly-fishes as in *Sarsia* and in *Campanularia*.

In the Gulf of Mexico are communities of hydroids so organized that they seem to constitute but one animal. Such is the well-known "Portugese man-of-war" (Fig. 15). This community consists of an elegantly-crested air-sac floating upon the water, and giving off numerous long and variously-constructed appendages. According to Agassiz, the different parts are so many different kinds of members in the community, and fulfill widely-different offices, some catching and eating food for the whole, others producing buds, others being the locomotive or swimming members, and having tentacles that in some cases are twenty or thirty feet long. The air-sac itself is only a few inches in length.

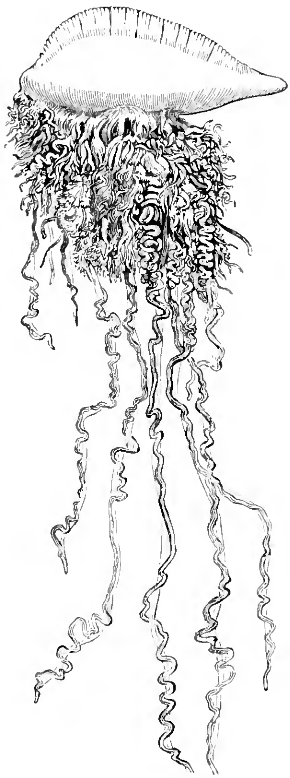


Fig. 15.—Portuguese Man-of-War (*Physalia arethusa*).

But the most common jelly-fishes are those which are more or less disk-shaped, and hence are called the *Discophoræ*. The "sunfish" is one of these. This name, we hasten to say, is rather indefinite when used without modification, for it is not only applied to a jelly-fish, but it is also given to our fresh-water bream, and to one of the large marine fishes—*orthogoriscus*. The "sunfish" of which we now speak attains a diameter of six to twelve inches (Fig. 19). In the early spring it may be seen in large schools near the surface of the water, and at this time is only a small fraction of an inch in diameter. It becomes full-grown by the middle of summer, and great numbers may then be seen swimming slowly by a sort of motion that may be likened to that of partly shutting and opening an umbrella. The motion is indeed effected by the contraction and expansion of the whole umbrella-like disk.

In the study of the sunfish (*Aurelia*) we are able to see plainly the prominent differences between jelly-fishes as a group and polyps as a group.

The natural attitude of the latter is with the mouth upward, or at least not turned downward, and the body is divided into vertical chambers, by vertical partitions, and the substance of the animal is flesh-like. On the other hand, the typical adult jelly-fishes have their mouth on the under surface, or at least not turned upward, their substance is jelly-like, and their body is traversed by tubes which radiate from the centre to the circumference.

The sunfish, and all the disk-shaped jelly-fishes especially, are remarkable for their stinging properties. When they come in contact

FIG. 16.—SCYPHISTOMA of *Aurelia flavidula* (Per. & LeS). Magnified about seven diameters.

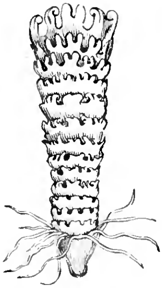


FIG. 17.—STROBILA of *Aurelia flavidula* (Per. & LeS). Magnified about seven diameters.

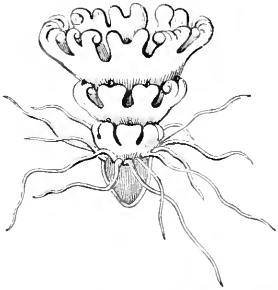


FIG. 18.—STROBILA of *Aurelia flavidula* (Per. & LeS). Magnified fifteen diameters.

with the flesh of the bather, they cause a stinging sensation, similar to that produced by nettles. This is why they are called sea-nettles, and why in scientific books they are called *Acalephæ*.

Toward the close of summer the sunfish lays numerous eggs, and in the autumn it perishes. The eggs hatch into little oval bodies,

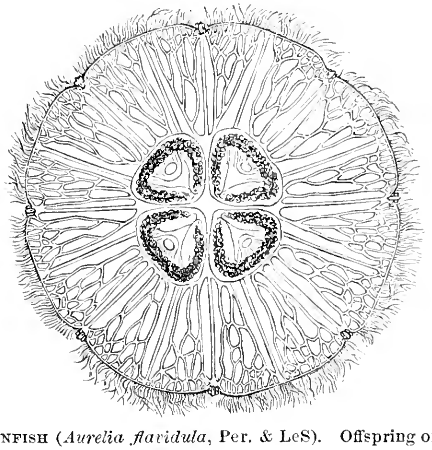


FIG. 19.—SUNFISH (*Aurelia flavidula*, Per. & LeS). Offspring of Figs. 16–18.

which swim freely about by means of minute hair-like appendages. After a time each one of these free-moving bodies attaches itself to a rock, shell, or sea-weed, and takes the form of a plant, and is then called *scyphistoma* (Fig. 16). As this goes on growing, it soon begins to divide into segments by horizontal constructions. By this process our little scyphistoma becomes a *strobila* (Figs. 17, 18). By continued growth the segments become more and more marked, more and more separated, and at length the uppermost one drops off, then the next one drops, then the next, and so each in its turn breaks away from the parent stalk ; and as each breaks away it assumes the natural attitude, mouth downward, and floats away to lead its independent life as a genuine sunfish. Here we have a good illustration of that strange mode of reproduction called "partheno-genesis" or "alternations of generations"—that is, the egg hatches into the *planula*, which soon becomes a *scyphistoma ;* that little plant-like body becomes a *strobila*, and this breaks into segments, each of which becomes a perfect jelly-fish, which produces the eggs.

The species of jelly-fishes of the disk, or partially hemispherical form, are very numerous and varied in details of structure, in form, and in size. Some have the appendages around the mouth and the margin greatly prolonged as in Fig. 20. A few kinds attain a diameter of two or three feet ; and these largest kinds have in some cases tentacles a hundred feet long.

Fig. 20.—Jelly-fish (*Pelagia cyanella*, Agassiz).

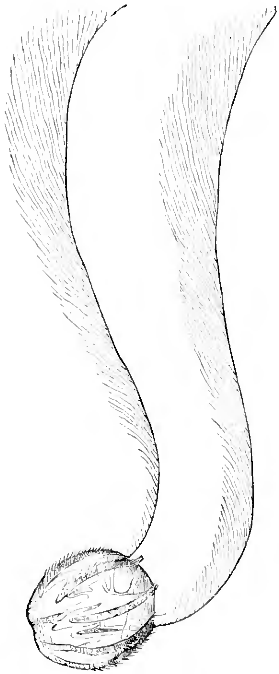


Fig. 21.—Pleurobrachia (*P. rhododactyla*, Agassiz).

One of the most beautiful of all the jelly-fishes is the rose-colored *idyia*. It is often seen near the shore, and is so transparent that it reveals almost its whole structure as it floats in the water. It is sometimes so abundant that it gives a rosy hue to considerable areas of the sea. It attains a length of three or four inches, and in form is not very unlike an elongated melon with one end cut square off.

Closely related to idyia is *pleurobrachia*, one of the commonest of the "comb-bearers," or *Ctenophoræ*, on the northern coast of the United States. This jelly-fish, less than an inch in length, like all other *Ctenophoræ*, has eight rows of locomotive fringes dividing the surface of the body into regions as the ribs divide the surface of a musk-melon. Besides these eight rows of fringes, or locomotive organs, it has two most extraordinary tentacles; and no form of expansion, or contraction, or curve, or spiral, can be conceived of, which these wonderfully constructed tentacles do not assume as this transparent jelly-fish moves freely through the water.

If the visitor to the sea-shore will go down among the big rocks left bare by the retiring tide, and will lift up the long sea-weeds which hang from their sides, he will find the curious "starfishes," or "sea-stars," in some cases in great profusion, and clinging to the surface of the rock so firmly that they often leave some of their locomotive suckers attached when too quickly lifted from their places.

The starfishes have the body so gradually merging into the arms

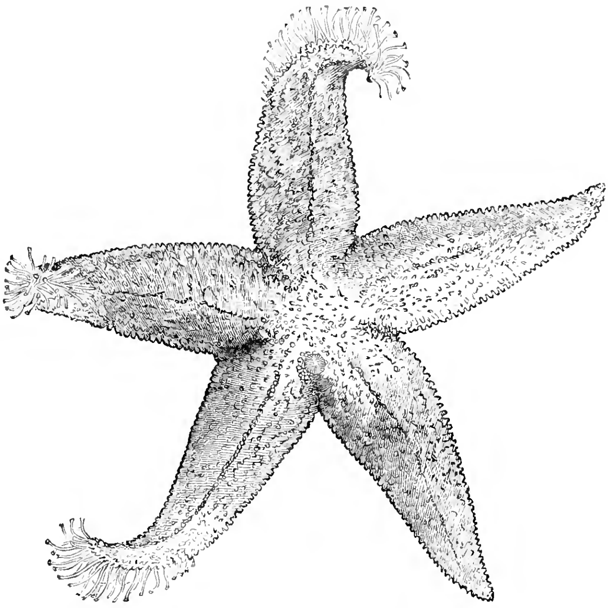


FIG. 22.—STARFISH (*Asteracanthion*).

or rays that one can hardly tell where the body ends and the arms begin; and this enables one to readily distinguish them at sight from the "serpent-stars," which are sometimes called star-fishes, and of which we will presently speak. The mouth is in the centre of the under side, and beneath each ray there are a large number of locomotive suckers. An eye is situated at the end of each ray; and on the back, near the junction of two arms, is a sort of water-filter called the madreporic body.

As in all similar cases, the dried specimens give us only a partial idea of the real starfishes, and those who have studied these animals in museums only have little idea of the readiness with which they make their way along the vertical and overhanging surfaces of rocks, and into holes and narrow fissures.

Starfishes are very voracious, and feed mainly on mollusks. They are exceedingly destructive to oysters in many places, and thus come in direct competition with man for the possession of this delicious bivalve. Instead of swallowing their food as other animals do, they turn the stomach out of the mouth and over the animal which they wish to devour!

Starfishes have a wonderful power of reproducing lost parts. If an arm is bitten off by a hungry fish, another grows in its place; and cases are known where all the arms but one have been detached, and the remaining arm and central portion of the body have lived on and reproduced all the destroyed parts. Examples of this may be seen wherever starfishes are abundant.

Starfishes are quite numerous in species, and vary greatly in form and size. The ordinary kinds are only three or four inches across, others a foot.

In the same localities where we find true starfishes, we may confidently expect to find the "serpent-stars" or serpent-tailed starfishes, so called because their arms taper like a snake's tail. They are also called "brittle-stars," because they break so easily.

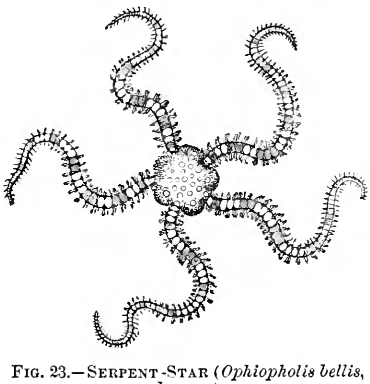


Fig. 23.—Serpent-Star (*Ophiopholis bellis*, Lyman).

Many visitors to the sea-shore come away without seeing a single living brittle-star, because the curious echinoderms which bear this name hide under the sea-weeds, and in the dark holes and crevices among the rocks, and are, therefore, found only by those who search carefully for them.

The long, gently-tapering arms, starting out abruptly from a well-defined disk, make the form of serpent-stars very distinct from that of the *Asteroidæ* or genuine sea-stars, already noticed. And, unlike the true starfishes, they have no interambulacral plates, but a series of large plates envelops the whole of each ray or arm, meeting in a ridge along its under surface. They have no genuine locomotive suckers like starfishes, but instead they have numerous tuberculated organs which pass out through holes in the sides of the arms. Their madreporic body is in one of the circular plates on the under side of the disk.

Allusion is made above to the brittleness of the serpent-stars. This sort of brittleness is not confined exclusively to these echinoderms: at least one species of starfish exhibits the same property. The lamented Prof. Edward Forbes tells a story of his experience with a starfish known as *Luidia*, which shows that it equals any serpent-star in brittleness. The professor went dredging for the *Luidia*. He brought up a fine specimen and laid it on one of the benches in the boat, and went on with his dredging. When he was ready to go home he found his *Luidia* in fragments. It had gone to pieces of its own accord—probably by contraction. Much disappointed by the loss of so desirable a specimen, he determined to take great precautions when he should capture another *Luidia*, that he might not again have to put up with pieces only. So, next time, he took the precaution to carry a bucketful of pure fresh-water, intending to plunge the *Luidia* into it, thus paralyzing and saving it before it should have time to break itself in pieces. Pulling up the dredge and seeing that he had a fine specimen,

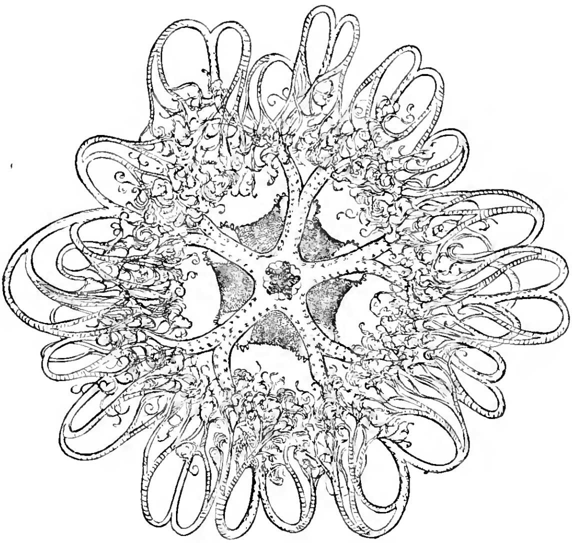


FIG. 24.—" BASKET-FISH " (*Astrophyton Agassizii*, Stimpson).

he let down his bucket of fresh-water so that its top was near the surface of the sea, intending, as soon as the dredge should reach the surface, to overturn it into the bucket; but, just when he would lift the dredge from the sea, the *Luidia*, as if apprehending the situation, went to pieces, and these began to disappear through the meshes;

and, as one of the last was vanishing, the professor imagined that the eye looked back at him with a peculiar and suggestive wink of derision!

The most remarkable representative of the serpent-stars or *Ophiurans*, as they are called in scientific books, is the "basket-fish," or *Astrophyton*. The ordinary kinds, as we have seen, have the arms simple; but one genus has the arms extensively branched (Fig. 24). This kind inhabits the deeper waters, and will not be readily obtained except through the aid of dredgers or fishermen, who sometimes bring it up attached to their lines. It attains a diameter of ten or more inches, and the arms go on dividing and subdividing until the divisions are said to number more than 80,000!

If we imagine the *Astrophyton* with its mouth turned upward, and its arms brought near together, and the ab-oral region furnished with a long, jointed, and flexible stem, we shall have a form not very unlike the *Pentacrinus caput-medusæ* (Fig. 25), of the West Indies, one of the few survivors of the order of *Crinoids* that was represented by a great number of species in the palæozoic ages of the earth's history.

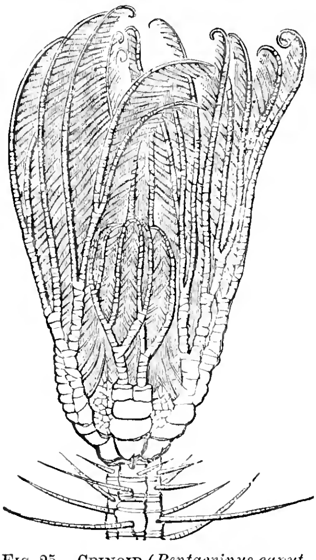


Fig. 25.—Crinoid (*Pentacrinus caput-medusæ*), West Indies.

Some kinds of crinoids, as the rosy feather-star of the European coast, have a stem in the young state, but at length become detached and live as free crinoids. They thus illustrate, in their embryonic stage, the permanent form of the living stemmed species and of those stemmed forms which fill the rocks in many regions, from the Silurian to the Triassic, inclusive.

It may be remarked here that in no place are fossil crinoids more abundant or varied, and beautiful, than in the sub-carboniferous rocks of this country, especially those in the Mississippi Valley; although larger species have been found in the Triassic rocks of Europe.

While the visitor to the sea-shore may hardly hope to secure a living crinoid, it is well to bear in mind that this form is a near ally of the starfishes, serpent-stars, and the *Astrophyton*, which he can secure.

It was the remark of one of the old students of Nature that there was nothing on the land that has not its counterpart in the sea. And, if we recall some of the names that have been given to marine forms, we shall see how men have been struck with the resemblances between animals of the land and those of the water. Among fishes we have "sea-vampires," "sea-eagles," "sea-wolves," "sea-hounds," "sea-robins," "sea-swallows," "sea-horses," etc. Among mammals we have "sea-elephants," "sea-lions," "sea-bears," "sea-cows," etc.

Among the lower forms we find sea-hedgehogs, that is, "sea-urchins," and "sea-cucumbers." It is of these I would now briefly speak, as they are among the interesting things which the visitor to the sea-side will be sure to find, if he search faithfully for them. But first as to the sea-urchins (Figs. 26, 27). If one would study these strange forms, he must seek for them in the deeper pools left by the tide. Nor is a casual glance into the pool sufficient to reveal the prize

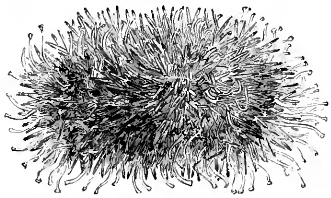


FIG. 26.—SEA-URCHIN (*Toxopneustes drobachiensis*, Agassiz).

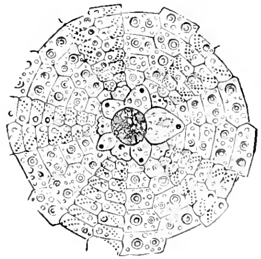


FIG. 27.—TOP-VIEW OF SEA-URCHIN, SPINES REMOVED. Shows ambulacral and interambulacral plates.

which he is in search of. The beginner may look into a clear pool where there are a hundred sea-urchins, and perhaps he will not see one until he has looked for some minutes; for sea-urchins not only resemble some of the sea-weeds in their color, but by means of their locomotive suckers they draw the sea-weeds closely about them, in many cases completely concealing themselves. If the collector reach down into the water the full length of his arm, and move his hand over the bottom among the sea-weeds, he will not be long in finding a sea-urchin. He will know when he touches one, as the sharp spines stand out on every side. Without moving from his position the collector will often secure a score or more of fine living specimens—some hardly exceeding a fraction of an inch in diameter, and others two inches or more; for he will find them of different ages, even if not of different species. Should he put them in a shallow pool while he goes on collecting, and then look for them again, he will at first think they have escaped into the sea or into some hole; for, true to their instincts, no sooner are they uncovered than they begin to conceal themselves again by drawing around them the sea-weeds by means of their long locomotive suckers. If we turn one over on his "back," that is, place the mouth upward, the urchin immediately begins to turn itself, and in a short time will regain its natural attitude, mouth downward.

The spines are very remarkable, not only in their appearance, but in their structure. A cross-section of one, under a microscope, reveals a structure so perfect and so beautiful that the richest mosaic is but rude masonry as compared with this natural mosaic.

Situated among the spines are curious three-pronged forceps, which have much puzzled the naturalists in days gone by; for it was doubtful what is their real function. But, at last, Agassiz—the younger Agassiz, I believe—discovered that these curious organs, called pedicillariæ, are for keeping the spines clean.

The mouth of the sea-urchin is provided with five pointed teeth, which shut together on a common centre; and these teeth can all be removed together, and, thus removed, they present quite a curious appearance, and are known among naturalists as "Aristotle's lantern."

The shell, which is composed of hundreds of pieces, presents a very beautiful sight when the spines are removed. It is made up of ten segments, radiating from the mouth, and converging to a central region on the top (Fig. 27). Every alternate segment is perforated for the numerous locomotive suckers to pass out, the intermediate segments being imperforate, and more prominently marked with tubercles, on which spines are borne. At the termination of the five perforated segments there is a triangular plate with a minute opening; here the eye is situated. Alternating with these five plates are five larger ones, each with a hole, through which the eggs are laid. The largest of these plates is the madreporic body, corresponding perfectly to that seen on the starfish, already spoken of, and which doubtless acts as a sieve or water-filter.

As sea-urchins do not shed the shell, as do crabs and lobsters, the inquiring mind will naturally ask how the animal can continue to enlarge when once it is invested with a hard shell. The answer is, that every piece of the shell grows at the same time, and in this way the whole shell enlarges together, and in a perfectly symmetrical manner.

As already indicated, the sea-urchin moves by means of its locomotive suckers. Extending these beyond the spines, it lays hold of the surface of the rock or sea-weed, and then, contracting the suckers, pulls itself along. And these suckers can be extended quite a distance beyond the spines. For example, a sea-urchin can extend a sucker from near the top of the shell, and bend it over, and lay hold of the surface upon which the animal is resting.

The sizes and forms of sea-urchins are very numerous. The ordinary kinds are two or three inches in diameter; some of the elongated kinds in the tropics have a diameter of five inches or more. Some are nearly hemispherical; others rise in the centre so as to be almost a cone; others are flat, and are known as cake-urchins (Fig. 28); others are more or less heart-shaped, etc. Some of the cake-urchins are curiously modified, as seen in Fig. 29.

On the coast of Maine especially, but also along both shores of the Atlantic, as well as in most other parts of the world, the sea-shore visitor will find the "sea-cucumber" appearing not very unlike a cucumber while it still retains the blossom upon its end. On the coast of Asia it is known as trepang, and is the animal which the Chinese use so extensively for food. Aristotle called it *Holothuria*, but for what reason he does not tell us, and we can only conjecture. The dead specimens give us but little idea of this animal. It must be seen and studied while in the sea or in the aquarium, in order to be appreciated. When dead, the suckers—which are like those of starfishes and sea-urchins—are retracted, and the tentacles are also in a mass, and the

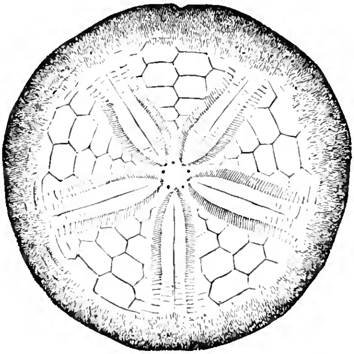


FIG. 28.—CAKE-URCHIN (*Echinarachnius parma*, Gray).

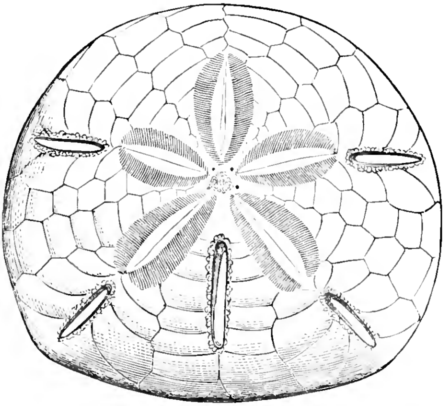


FIG. 29.—KEY-HOLE-URCHIN (*Mellita quinque-fora*, Agassiz).

whole form is shriveled. But in the water the form is full, and the fringed tentacles are extremely beautiful, and can properly be compared to the delicately-branched and beautifully-colored sea-weeds which we all so much admire.

The "sea-cucumber" has a wonderful power of changing its form. It elongates, contracts, enlarges at each end while it is small in the middle, and thus changes its appearance from time to time. In its power of going to pieces it almost excels the "brittle-star" and the

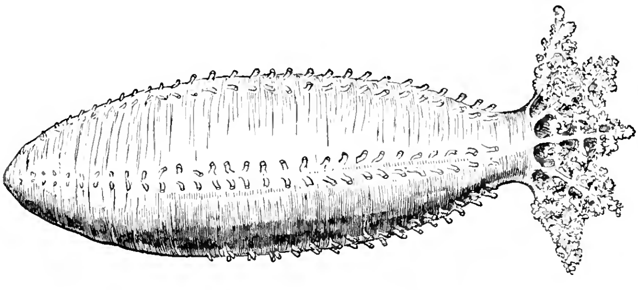


FIG. 30.—HOLOTHURIAN, OR "SEA-CUCUMBER" (*Pentacta frondosa*), North Atlantic.

starfish, *Liudia*, already noticed. It breaks off its tentacles, and yields up other parts, at will; and it has been known, when disturbed, to eject all its internal organs, thus leaving itself only an empty sac!

The "sea-cucumber" has no hard parts, excepting the merest calcareous particles imbedded in the thick, leather-like covering. These are of various and remarkable shapes, and are very interesting objects when seen under the microscope. They are the representatives of the calcareous plates which make up the hard shell of the sea-urchin.

Unlike as are the crinoid, brittle-stars, star-fishes, sea-urchins, and sea-cucumbers, in their form and general appearance, they are but different expressions of one and the same fundamental idea. They are all radiates, all possess calcareous plates—though these are at their minimum in the sea-cucumbers—and are covered with spines, tubercles, or a rough skin. They are all constructed according to a reigning number, the principal parts being in fives, or some multiple of five. If we imagine the sea-cucumber to be placed with its mouth downward and the tentacles to be replaced with teeth, the long body to be shortened upon itself so as to assume nearly the form of a hemisphere, and the microscopic calcareous particles to be enlarged so that they should touch one another, then we should have essentially the form and structure of the sea-urchin.

And if we imagine the sea-urchin with its segments spread out into a star-like form, instead of being brought near together, each perforated segment taking half of the imperforate one, and at the same time the spines to be reduced to tubercles and the plates to a network, then we should have essentially the form of a starfish.

Again, if the starfish had its body reduced to a well-defined disk, and its arms starting out abruptly from this disk, we should have all the most prominent features of the serpent-star.

And if the serpent-star had its mouth placed upward, its arms multiplied by branching, and its ab-oral region elongated into a stem, we should have the plant-like form of the crinoid.

And so it is in all parts of the material world. Nature has but comparatively few great types, but the forms included under these types are almost endlessly varied. Unity in diversity is a great law which prevails not only in the animal kingdom, but throughout the whole realm of Nature.

THE SCIENTIFIC STUDY OF HUMAN TESTIMONY.

By GEORGE M. BEARD, M. D.

III.

OUTLINE OF THE RECONSTRUCTED PRINCIPLES OF EVIDENCE.—Even a qualified admission of the soundness of these views also compels the admission that the reconstruction of the principles of evidence is the crowning need of philosophy.

Such reconstruction will not be made on the base of Pyrrhonism, or the denial of the possibility of knowledge—for knowledge is possible, although it is relative to the human faculties. The revision of human testimony that physiological science now requires, and is qualified to undertake, is radical and revolutionary, but it is not suicidal; it is discriminating, not sweeping; not destructive, but constructive.

The demand is not for the rejection but for the reconstruction of human testimony; and the spirit with which this should be undertaken is not skeptical, but scientific.

This reform of logic, like all revolutions in science, should advance under the guidance of the *scientific method.* By the scientific method, I mean that method of obtaining and organizing knowledge which consists in defining, so far as is possible to expert human faculties, the *boundaries between the possible and the probable, between the known and the unknown.*

The scientific method can only be successfully used by those who are endowed with, or by discipline have acquired, what I am accustomed to call the *scientific sense,* by which phrase I mean the power of seeking truth through the intellect alone, uninfluenced by the emotions. For the tendency of truth, the scientific sense has no hopes and no fears, except so far as it may help to find the truth.[1]

The scientific method is a part of the evolution of culture, of science, and of civilization; to absolute savagery everything is absolutely known; all natural phenomena are pronounced supernatural; with the beginning of knowledge there is a recognition of ignorance, which, in time, gradually subdivides so as to include all phenomena that can be brought to the attention of the human mind in one of these four grand divisions—the *possible,* the *probable,* the *known,* and the *unknown.* The constant effect and sign of progress in knowledge is the narrowing of the area of the known and the probable, and the extension of the areas of the unknown and the possible.

I. *The corner-stone of the reconstructed edifice of the principles of evidence must be the recognition of the necessity of the testimony only of experts in all matters of science, and consequent absolute rejection of all testimony of non-experts, without reference to their number or the unanimity of their testimony.*

A few definitions are here needed:

Science is systematized knowledge.

An expert is one who can see all sides of a subject.

A non-expert is one who sees but one or a few sides of a subject that has many sides.

[1] The philosophy of the world has almost always been the servant of delusions. The most eloquent passage in Sir William Hamilton's "Logic" is that in which he enjoins on the philosopher the duty of seeking truth for its own sake, and there are few or no philosophers who would not in the abstract subscribe to this sentiment, but concretely and practically nearly all human reasoning on logic and the principles of evidence has been exercised for the special purpose of proving what is absolutely undemonstrable or absolutely untrue.

The tests of scientific expertness are—distrust of the senses; the recognition of the relation of induction to deduction; avoidance of all sources of error, in observation, experiment, or reasoning; the appreciation of the relative importance and non-importance of real or supposed facts; the ability to distinguish reality and its semblance, especially between the subjective and the objective; and, what indeed follows from the other three tests, the maintenance of mental equilibrium during experimental researches. The reputation of an expert is acquired primarily through other experts, and secondarily through the judgment of mankind. Expertness has its various degrees; there are experts, and experts, and experts: the highest experts are the originators, the explorers, the pioneers, the founders, the creators of science; the lowest experts are the followers, the gleaners, the treasurers, the curators of what others have discovered, and who simply repeat and retain the experiments of genius. The highest experts—the Newtons and Galileos, the Harveys and Jenners of science—must stand at first alone, with no other expert at hand, by which to estimate their relative heights and strength; it is their necessity and their glory to educate experts, by whom their own merits are to be tested; they must create the standard by which they are to be judged; their critics will be their own offspring. For many years Newton was the only man on this planet who understood the theory of gravitation, or was able to criticise it.

The tests of scientific non-expertness are, blind repose in the senses, the inability to eliminate or appreciate sources of error in observation, experiment, or reasoning; the non-appreciation of the relative importance of real or supposed facts; the confounding of semblance with reality, and particularly the subjective with the objective; liability to be entranced, or to have the emotions unduly excited, in the presence of genuine or supposed phenomena; and the use of induction when only deduction is valid, and *vice versa*.

Expertness in one branch of science not only does not qualify, but in various ways may disqualify, one to be an expert in another branch.

That skill in mathematics unfits one for the successful study of various other specialties was pointed out long ago, both by Abercrombie and Hamilton; but the antagonism of specialties may be traced, under recent experience, yet more minutely, for it is found that eminence in physics, or chemistry, or astronomy, may thoroughly unfit one for the study of physiology; and within a few years some of the greatest blunders recorded in the history of delusions have been made by naturalists, chemists, physicists, jurists, and astronomers of unquestioned honesty, real genius, and deserved eminence, making, or attempting to make, discoveries in the new and almost unexplored realm of cerebro-physiology—experiments with living human beings. The worst blunders in the world are scientific blunders—the unconscious slips of justly eminent men, who do not know that their very eminence in one sphere forbids them to undertake another.

Coöperation of Experts.—There are claims that can only be settled by a coöperation of experts, in different branches of science. In regard to the question of the relations of experts to each other in the investigations of claims, it is to be observed that a claim should *primarily* be referred to that *specialty that is best capable of dealing with it by deductive reasoning.* Claims that can be settled by the principles of logic, without the aid of special scientific knowledge—such as, from the limitations of the human faculties, can never be proved or disproved—are to be referred to logicians. If the known principles of any special science, to which a claim is referred, deductively disprove any claim, it is unscientific for any expert in that science to examine or discuss it, save as an amusement, or for the sake of the incidental facts that an investigation may develop. If the claim refer to an open question, the primary expert is to judge whether the coöperation of experts in other branches of science is needed. If the claim belong to a department not yet organized into science—the territorial or preëxploratory stage—in which there are no experts, there are none to decide upon its merits, and the world must remain in ignorance until the experts appear; but the world, in its impatience and ignorance of logic, practically refers such claims to leaders in various branches of science, or to men of general ability and honesty, who almost always reach erroneous, if not ludicrous, conclusions. Such was the origin of the delusions of "animal magnetism," and "odic" and "psychic" *force*—claims that belong to cerebro-physiology, a department of science that is now but just passing out of the territorial into the organized stage.[1] When experts blunder, as they may, their conclusions should be revised, not by the people, but by other and better experts.

II. *The reconstructed principles of evidence require that the quality and quantity of evidence necessary for proof of any claim depends on the nature of the claim.*

The principles of evidence that have heretofore commanded the world's acceptance make no distinction in the quality or quantity of testimony for different varieties of claims; the discovery of a new planet is as credible as the daily rising of the sun; the introduction of a new force needs no more and no better auspices than the observation of the

[1] Mr. William Crookes, in his kindly and complimentary remarks on my theory of trance, as republished in the London *Quarterly Journal of Science*, January, 1878, observes that there may be a physical side to physiological experiments. The suggestion is so far forth a valid one; the reply is found in the above analysis. The question whether there is in the human body a new and unknown force belongs to cerebro-physiology, and, not being disproved deductively, should be referred to those experts in that specialty who understand how to experiment with living human beings; and it is for these primary experts to decide whether the experiments they may make require the coöperation of physics, or chemistry, or other branches of science. There may also be a physiological or pathological side to physical experiments; thus the "etheric force" of Mr. T. A. Edison was primarily a question of physics, but for its investigation needed and obtained the coöperation of physiologists.

established phenomena of an old one; the passing from death into life is to be received with as little question as the passing from life into death. Under this feature of current logic delusionists of all kinds have consistently and persistently found refuge.

The different classes of claims in regard to real or alleged phenomena, in their relation to the quality and quantity of evidence needed to prove them, may be thus presented in order of climax:

1. *Claims as to unsystematized knowledge or matters of every-day life.*

Under this head comes most of the testimony commonly given in courts of justice. For claims of this kind experts are not usually required, and the mistakes which are constantly made, every hour and every moment, are of comparatively trifling account, since they affect individuals and not general principles.

It is one of the innumerable proofs of the limitations of the human brain, that the rules of evidence in our courts of justice, although practically, on the average, as good, with some exceptions, as can be expected for the obtaining of legal justice, necessarily imperfect and uncertain, are yet, in many respects, to the last degree unscientific. The exclusion, for example, of hearsay testimony, and of the testimony of a wife against her husband, and the modes of questioning and cross-questioning of witnesses make it oftentimes impossible to obtain justice. The scientific man, desirous not of gaining a point but of ascertaining the truth, and recognizing the untrustworthiness or uncertainty of nearly all human testimony, would in many cases prefer hearsay to direct statements, and would give more for the evidence of a near relation or a wife than for that of all the world besides.

One needs but to follow the details of a few great causes, as the McFarland trial, the Beecher-Tilton, the Tichborne, and the Vanderbilt cases, to see that by the rules of evidence, or at least by the actual practice of courts, testimony which scientifically is valueless is admitted, while the only testimony that is, or promises to be, of any scientific value is systematically excluded.

The great advances in science have not been made in courts of justice. Even when on questions of science experts are called to testify, their testimony is obtained in such a way as to impair, if not destroy, its value, and to obscure more than to reveal the truth.

From the scientific point of view, a legal trial is really an experiment with living human beings, and, like all experiments of that kind, is liable to *six* sources of error, all of which must be guarded against if we are to find the exact truth. The science and art of experimenting with living human beings are not yet understood, even by physiology and pathology, to which department they belong.[1]

[1] That the art of experimenting with living human beings is now but in its early childhood is shown by the fact that all those who give special attention to the physiology

2. *Claims as to general or special facts of science that are already established by the investigations of experts.*

Here we rise in the scale of evidence, but do not require experts. What is bad or useless evidence for original demonstration may be satisfactory, or at least tolerable, for confirmation. The phonograph, prior to its invention, was credible only on expert authority; stories relating to it may now be received on the statements of non-experts, for, although they may be erroneous, they do not in any way affect science.

III. *Claims as to facts or phenomena which have not yet been established by experts in the special science to which they are to be referred, but which may yet be proved true by the experts of the future.*

Here we take a long step in the ascending scale of evidence; we come to claims that cannot be proved by any amount of non-expert evidence; which may be true, or may be untrue, as experts only shall determine. A type of this class of claims is that of the sea-serpent, of whose existence there is now no proof, but which zoölogists might possibly introduce into science. Testimony which is sufficient to arouse the attention of experts, and induce them to investigate claims that are made by non-experts, may yet of itself have no value in science.

Types of this class of claims are supposed new forces in Nature, the existence of which can only be established by the highest experts in the branches of science to which they respectively belong. The claims of "odic" force and "psychic" force, and of "animal magnetism," are excellent illustrations: although believed by thousands and thousands of people of average intelligence, and by a number of eminent non-experts in science, they are yet instinctively rejected, not because there is any positive deduction against them, but for the reason that experts have never been able to find a shadow of proof of their existence, but, on the contrary, have been easily and abundantly able to show that all the real phenomena supposed to indicate the presence of these unknown forces can be explained by the laws of forces already known. An illustration, belonging in part to a different branch of science, was that of the alleged new force, between light and heat on the one hand, and magnetism and electricity on the other, said to have been discovered

and pathology of the nervous system do not, in their experiments, even suspect the elements of error involved. During the past year one of the very ablest of neurologists—Charcot, of Paris—has published accounts of experiments in so-called "metalloscopy" and "metallotherapy," in the making of which, according to his own statements, one of the most important of the six elements of error (as indicated in a paper on "Mind-reading," in a previous number of this Monthly), mind acting on body, seems to have been ignored or ill understood, or at least not scientifically provided for. The experiments of the committees of the French Academy with "animal magnetism," "mesmerism," and "clairvoyance," of Crookes with Home, of Wallace and Zollner with Slade, are open to the same and also numerous other criticisms. From such accounts of such experiments, even an expert cannot tell what did or what did not happen; it is therefore unscientific to discuss them.

two or three years since by Mr. Edison, the renowned inventor of the phonograph. This claim belonged primarily to physics, and secondarily to physiology, and was carefully investigated by many physicists and some physiologists of this country and Europe, and by them it was decided, rightly or wrongly, that the claim was not proved, that the spark supposed to indicate a new force represented a hitherto undetected phase of induced electricity.[1]

IV. *Claims which, from the limitations of the human faculties, can never be proved or disproved.*

Claims of this kind may be indulged in as speculations, with the understanding that they are merely speculations; but to seriously discuss them, with the purpose of ascertaining their truth or falsity, is unscientific.

Under this head all supernatural claims must be included, for the reason that it is impossible for the human faculties to distinguish between what is unknown in Nature and what is above Nature. The narrow limitations of our knowledge of Nature all will admit. What expert professes to exhaustively know Nature even in his own department? What, indeed, is all our knowledge but an infinitesimal fraction of our ignorance; a flower or so plucked from a boundless garden; a few ores dug from measureless mines; a slight clearing in an infinite wilderness; "a film on the ocean of the unknown?" Leaving out of view all questions of supernaturalism and all the phenomena of life, what do we know, or, in this world, have we reason to expect to know, of inorganic Nature? What is light? What is heat? What is gravity? Why should one mode of motion make one form of force and not another? Toward the solution of these primal questions—that the infant can ask and the philosopher cannot answer—the sciences and reasoning of all the centuries have made, and are destined to make, no advance.

Even if an expert could be supposed who should exhaustively know Nature in his own department, how could he know that he knew it? Not knowing that he knew all Nature in his own realm, what tests would he have—could he have—to distinguish between the supernatural and what might be unknown in Nature? If, to go to the outermost verge of conceivability for illustration, the clock of the universe were turned back to-morrow, and the sun should thereafter rise in the west instead of the east, how would it be possible to prove, in a scientific sense, that a supernatural event had occurred?

Every phenomenon that can be brought to the attention of the human faculties must be referred to one of these three classes:

1. The known in Nature.
2. The unknown in Nature.

[1] Mr. Edison's views, as he writes me, are unchanged. His experiments, and my own made in coöperation with him, as well as a discussion of the bearings of the claim on the principles of evidence, were published two years since.

3. The supernatural, or above Nature.

In investigating any new claims whatever, experts—consciously or unconsciously—keep this order in mind: they first inquire whether the claims can be explained by laws already known to experts; if not so explained, then they are referred to the second order—the unknown in Nature—and attempts are made to bring them into the first order, or the known in Nature: such is the philosophy of all human progress in science. But when men go further, and assert that these unknown phenomena are of supernatural character, they bid good-by to the scientific method; for what is it that constitutes the differential diagnosis between the unknown in Nature and the supernatural? It matters not, in its bearings on this question, how the supernatural is defined, as the unusual action of natural laws or interference with natural law. The supernatural manifested becomes, relatively to the human faculties, the natural. For all that we know, or can know, every great or minute phenomenon in Nature may be a direct, immediate, and special act of a power above Nature: the movement of every star, each vibration of the infinite ether, the shock of earthquakes, and the silent meaning of protoplasm, may all be manifestations of a power above Nature; but, whether they are so or not, the human mind is powerless to prove or disprove. The universe might swarm with demons and angels; ghosts might inhabit the earth and sky, in numbers compared with which the population of the globe is as the seen to the unseen stars; spirits might speak, might rap, might materialize—and yet the human mind would be unable to scientifically prove the supernatural, for still the question, how to distinguish what is above Nature from what is unknown in Nature, would remain unanswered and unanswerable.

Science has not, cannot have, any absolute deduction against the existence of ghosts, or of spirits, evil or good, or of any imaginable supernatural shapes whatsoever; the world might be embraced and permeated by an infinite spiritual ocean, as the air is believed to be penetrated by a luminiferous ether; but science would not have, and could not find, either through induction or deduction, any way of demonstrating its existence. In the realm of the supposed supernatural all things are possible and all things are undemonstrable.[1] Under this class of claims, that from the limitations of the human brain can neither

[1] Although it hardly comes within the scope of the present outline to point out all the practical bearings of this reform in logic, one thought may perhaps be briefly suggested. For the cause of religion, it is fortunate that it cannot be scientifically proved. Religion, being a recognition through the emotions of a spiritual universe and of our relations to it, cannot and should not appeal to the intellect. A religion scientifically proved would be a religion no longer, but a fact of science, like the Copernican theory, or gravitation, and, like these and other scientific facts, would be taken cognizance of by the intellect alone, consequently it would lose entirely the leverage of the emotions, by which it has so powerfully influenced the destinies of mankind. The scientific demonstration of religion would be the destruction of religion.

be proved nor disproved, are the conventional definitions of matter, and accepted distinctions between matter and mind, or other forms of force.

The qualities that for ages have been attributed to matter, as inertia and extension, apply correctly enough to that limited portion and form of matter that the senses can appreciate; but, as has been shown, all but an infinitesimal portion of Nature is permanently sealed against the senses. What warrant have we, beyond undemonstrable probability, that the attributes of that portion of matter that can be reached by the senses belong also to all that portion of which the senses can directly teach us nothing? How do we know that the familiar forces, as light, heat, electricity, and gravity, may not be as truly matter as the Atlantic Ocean or Mont Blanc?

Standing on the outermost verge of conceivable science, and casting the line of probability into the dark unknown, as far as it is possible for human weakness, will it, can it reach any more rational generalization than this, that all Nature is unity? Whether the common axioms of human reasoning—such as the whole is greater than a part, every effect must have an adequate cause, every thought must have a thinker, a thing cannot be and not be at the same time—do or do not apply to the supernatural, the mind of man is powerless to determine.

Under this head come all conceivable questions relating to the existence and nature of other universes than ours.

A question of great interest, or would be if it could be answered, is that of spontaneous generation, which from the limitations of the human senses can neither be proved nor disproved.

How is it possible for the human faculties to determine what degree of heat any supposable living substance, or intermediate substance between living and non-living, beyond the reach of the microscope, may bear? There are gradations of endurance in living things that are accessible to the senses. What are the limits of this gradation through the realm of the infinitely little? If, therefore, all experts in this branch of inquiry should agree that fluids subjected to a very much higher degree of heat than has yet been employed in experiments of this kind shall yet, when every conceivable precaution against sources of error has been taken, develop some of the lower forms of life, the question of spontaneous generation would still be an open one.

The present and prospective state of the spontaneous generation question is, then, as follows:

1. Science has no absolute deduction for or against it.

2. It is impossible by present deduction or by conceivable induction to either positively prove or disprove it.

Discussions on the subject, like that between Tyndall and Bastian, are on both sides unscientific, as they are unsatisfactory, and would not be indulged in by those who have correct ideas of the limitations of the senses.

V. *Claims which are absolutely disproved by deductive reasoning, and which therefore the special sciences to which they belong know to be false without any examination.*

Among the more prominent of claims of this kind are those that relate to squaring the circle, flatness of the earth, perpetual motion, including "Keeley" and "Winter" motors, alchemy, astrology, "four dimensions of space," levitation, mind or thought reading, clairvoyance or second-sight, including prevision and retrovision.

To examine or discuss claims of this kind, for the purpose of determining their truth or falsity, is not only useless, but unscientific. In science there are three unpardonable sins—trusting the senses, non-experts attempting to do the work of experts, and using deduction for induction, or, *vice versa*, induction when only deduction should be used, as in the class of claims here under consideration.

The reconstructed principles of evidence explain the following problems in psychology, to which hitherto, so far as I know, no solution has been offered:

1. *Why the logic of the schools has always been on the side of delusions.*

For those who accept non-expert testimony science is the only delusion: everything is true except the truth. In the long discussion relating to various modern delusions between Mr. Wallace and Dr. Carpenter, Mr. Wallace, according to the rules of evidence, has throughout the best of the argument: his reasoning, for those who trust their senses, who believe that non-experts can do the work of experts, and who use induction when only deduction should be used, is unanswerable.

Likewise in all, or nearly all, the world's memorable contests between science and delusions, the truth has prevailed, not by virtue of logic, but in spite of it; the instincts of mankind—the one saving clause in the constitution of the human brain—rising up in their unconscious majesty, and vindicating their rights and their power against the tyranny of the senses and the cruelty of the syllogism. Logically, Copernicus and Galileo were wrong; and their accusers, backed by the concurring testimony of the eyes of all mankind through all the generations, have to this hour never been answered. Only on the side of error is there consistency; during all these recent days, when science sets its forces in array against any dominant delusion, as "animal magnetism," or "odic" force, or "psychic" force, or "spiritualism," it first closes its books of logic and forgets all the teachings of the university.

2. *Why men of culture and genius, and especially of logical attainments, are more easily and profoundly deceived by delusions than men of ordinary ability.*

The history of all delusions, so far as known, establishes the wisdom of the maxim of the father of modern conjurers—the famous Houdin: "It is easier to dupe a clever man than a fool." Jugglers, and illusionists, and sleight-of-hand performers of every grade, prefer examining committees composed of leading citizens—the ablest jurists, physicians, merchants, clergymen, scientists, and men of letters that can be found—and instinctively dread the criticism of children and of day-laborers, who, being unable to read, or write, or to think, or to reason according to the books, are obliged to trust their instincts.

The world's greatest follies and darkest untruths, especially while in the process of dissolution, have always found some justly honored authority in theology, in literature, in philosophy, in law, and in science itself—a Matthew Hale, a Lord Bacon, a Wesley, a Cotton Mather, an Elliotson, a Hare, a Gregory, a Wallace, an Emerson, an Agassiz, a Zollner, committees of learned academies, professors in great colleges—to stand by their bedside, armed with syllogisms, trusting their senses, and conscientiously striving to nurse them back to vigorous life. This grotesque phenomenon of history—so universal as to command general observation—would seem to have this threefold explanation: 1. The fact here suggested, that clever natures trained in logic are obliged to reason logically, and, as the logic of the world is wrong, they arrive at the wrong conclusions, which, against the protestation of their instincts, they are forced to accept. The greater the man the greater his errors; the weakness of the world confounds its strength; ignorance is saved by its instincts, which science and logic dare not always trust. If the chart be wrong, the navigator who accurately steers by it is sure to go out of his course; while he who goes by blind reckoning may possibly float into harbor. 2. The social and professional position of men of genius and ability is constantly compelling them to undertake investigations in departments in which they are not authorities, and requires them to proclaim positive decisions which, like the results of all non-expert investigations, are almost inevitably erroneous. 3. The faculty of wonder that so often leads to credulity is not inconsistent with the highest scientific genius; it is, indeed, a powerful and determining element in the scientific character, and thus what has been called "the foundation of all philosophy" also becomes the foundation of all folly. Such, as it would appear, is the solution of the problem which for so many years has been the despair of the historian and the opprobrium of psychology.

Hence it is that there are no superstitions that are so superstitious as the superstitions of scientific men. Hence it is that all delusions in their decline cast their last shadows over the loftiest heights of science, of literature, and philosophy.

ON THE FORMATION OF NEBULÆ.

By WILLIAM M. DAVIS, Esq.

THE close proximity of the satellites of Mars to their primary has led me to investigate the lesson taught by them and other satellites of short periods.

This investigation has enabled me to demonstrate:

I. That the nebular hypothesis fails to account for the present condition of the solar system, without the additional hypothesis of a resisting medium in space.

II. It has enabled me to show, also, that, although this medium tends to bring the solar and all other systems to a state of quiescence, it has no such tendency on the material universe as a whole, provided that the ponderable matter thereof be of *infinite* extent. If, however, the ponderable matter—as distinguished from the ether—be of *finite* extent, it should come to rest, as will be shown in the sequel.

The first proposition will be established by taking the first satellite of Mars as an example, and proving that *it* must have been at least fifteen or twenty times as far as it now is from its primary when it was able to take on the globular form from the nebulous ring out of which it was made. This being established, it follows, as a necessity, that its orbit must have contracted into its present dimensions since it was thus formed; and the satellite during this time has condensed into its present condition.

As the same cause which contracts the orbits of the satellites should produce a like result upon those of the planets, it follows that *they, too,* must have been farther away from the centre of the system than they now are, when they took on the globular form from their nebulous rings.

The hypothesis of a resisting medium has been adopted to account for this contraction of orbits, as no other hypothesis seems competent to do so.

That this satellite of Mars and others in our system were much farther away from their primaries than they now are, will be proved, by proving that, if a nebulous satellite revolved around any primary in the short period in which most of the solid ones now do, the tidal energy—or tendency to elongation and disruption—which would, in that case, be generated on its opposite sides by such rapid revolution, would be sufficient to tear it into atoms. These atoms would be distributed around the primary in the form of a nebulous ring, which ring would be in a state of *stable equilibrium*, and therefore could not be reconverted into the globular form.

Permit me, then, to bring forward some imaginary experiments, for the purpose of illustrating certain dynamical principles (and methods) to be employed in proving the fact just stated.

Assuming the density of the earth to be $5\frac{1}{2}$ times that of ice, it follows that, if a globe of ice—say ten miles in diameter—be isolated in space, a small dense body, as a bullet, near its surface, should fall toward it—by the action of its gravity alone—through 160 inches during the first minute of its descent. Now, if this icy globe be made to revolve around any large planet in the short period of 5 hours and $42\frac{3}{4}$ minutes, and on its axis in the same time and in the same direction, then the tidal energy (which is, in this case, the difference between the force of the planet's attraction for the particles at the centre of the icy satellite and for those at the two opposite points of its surface which are nearest to and farthest from the planet, added to the difference of the tangential force on the particles)[1] would exactly counterbalance the icy satellite's interior gravity along this diameter; i. e., if the tidal energy could be made to act alone on the aforesaid bullet, at either end of this diameter, it would force it outward through 160 inches during the first minute of such action; hence, if a particle at either end of this diameter should be acted upon both by the gravity and the tidal energy at the same time, it would have no tendency to move in either direction; but if it were raised a few inches above the surface, then the tidal energy would prevail over the gravity and take it away.

To get a clear conception of the peculiar condition under which this icy globe is now placed, let us call this last-named diameter its axis of tension, and the plane passing through its centre and perpendicular to it the plane of compression.

Now, along this axis there is no force to prevent the elongation of the icy globe in that direction, except only the force of cohesion in the ice itself, as its gravity in that direction is exactly counterbalanced by the tidal energy.

Around the plane of compression, however, the case is different; here the interior gravity is unopposed by the tidal energy, and every atom is pressing inward on the central mass; and this pressure tends to force the tensible regions outward, and thus to make the tensile axis longer.

When this elongation begins, the disruptive energy rapidly increases in virtue of the increased diameter in that direction, and the diminution

[1] The above is the formula usually given for computing the tidal energy under the assumed conditions; but I incline to believe that the real disruptive power exerted on the satellite is just double that, for the following reasons:

One (1) pound of ice placed on the surface of this icy globe should press it with the force of 1.6 grain, of our standard.

Now, the tidal energy, as above calculated, causes the planet to pull the nearest pound with 1.6 grain greater force than it does the central pound, while, at the same time, it pulls the central pound with practically 1.6 grain greater force than it does the farthest pound; consequently the tensile pull between these two surface-pounds, which would be required to resist the tidal energy, must be equal to 2×1.6 grain, while they are drawn toward each other by the gravity of the satellite with the force of only 1.6 grain.

of the internal gravity, produced by the same operation. By such action as this the icy globe should be quickly torn into pieces and distributed around its primary in the form of a ring of fragments.

Prof. Daniel Vaughan has shown that such is the origin of the rings of Saturn, and ascribed the close approach of the two satellites which formed them to the action of a resisting medium.[1]

If this were a globe of water instead of ice, it is very evident that much less disruptive energy would be required to tear it to pieces, on account of the greater mobility of its parts; most probably not more than one-seventh of the above-named force would be required to accomplish this result.

If this force be sufficient, and the globe of water be made to revolve around any large planet in fifteen hours or less, the tidal energy will tear it into atoms by virtue of the following law:

It can be demonstrated—1. That the tidal energy generated on a spherical satellite of small but constant mass, when revolving around a large primary, varies *directly as its diameter;* 2. That it varies, also, *inversely as the square of its periodic time;* and 3. That the ability of the same satellite to resist the disruptive tendency of this tidal energy varies *inversely as the square of its diameter;* provided there be no cohesive force to aid in resisting this tendency, and in a nebulous satellite there would be none to do so.

As the first and third propositions relate to the diameter, they may be included in one, and then the law may be stated as follows:

The disruptive ability of the tidal energy of a primary planet on a nebulous satellite of small but unvarying mass varies directly as the cube of the diameter and inversely as the square of the periodic time. Let us apply this law to the case in hand. To do this it may be very safe to estimate that a ten-mile globe of water, while yet in the state of a nebulous satellite, would occupy the globular space of at least one hundred miles in diameter. This would give it a density of only $\frac{1}{1000}$ of that of water, which, however, would still be millions of times greater than that of the original nebula out of which the entire system was made.

According to the above law, the disruptive ability of the tidal energy on the nebulous satellite must be 10^3, or 1,000 times as effective as on the ten-mile liquid one, if revolving in the same time. Now, to find the shortest time by the above law in which this nebulous globe could revolve around its primary without disruption, we must multiply the fore-named fifteen hours by the square root of 10^3; the product of this multiplication amounts to about $19\frac{3}{4}$ days. As this is the shortest time in which *any* small nebulous satellite of this density can revolve around *any large primary* without disruption, it becomes very evident that nearly all the solid ones in our system must have been

[1] "Popular Physical Astronomy," by Prof. Daniel Vaughan. Cincinnati: Freeman & Spofford. 1858.

much farther than they now are from their primaries, when they were able to take on the globular form from the nebulous rings or collection of nodules out of which they were made.

Taking the above estimates, and applying the law to the case of Mars's nearest satellite, we find that its orbit must have been at least $17\frac{2}{3}$ its present diameter when it was able to take on its globular form from its nebulous ring.

This establishes beyond doubt the fact to be proved, and gives us some idea of the vast dimensions of the solar system when this last nebulous satellite of Mars was formed.

What, then, must have been the distance of the *first* nebulous planet from the centre of the system, when *it* was formed? This, of course, can be only vaguely guessed, as we have no reliable criterion to judge by.

The Resisting Medium.—The introduction of the hypothesis of a resisting medium to account for this contraction of planetary orbits seems at first sight to involve a condition fatal to the continued activity of the material universe; for, if there be a resisting medium, which is gradually bringing our system to a state of rest by its reaction on the bodies moving in it, it is but reasonable to suppose that it should produce like results on all other systems, and thus ultimately bring the entire universe of matter into the quiet sleep of death. But that this is not the normal tendency, however, when applied to the universe *as a whole*, we have the most abiding assurance, without any investigation of this kind; for, if such be the tendency now, it always would have been the tendency, in which case the end would have been accomplished during the eternities of the past, and we would not be here to-day to dread its approach.

Still the following question, or its equivalent, will press itself on many minds: How can the perfect conservation of force, which is so essentially necessary for the continued activity of the material universe, be reasonably accounted for, if there be a resisting medium in all space through which it must ever move? This pressing yet interesting question leads directly to the second division of our subject, which will now be discussed.

In order to give this question a suitable reply, as well as to show *how the perpetual activity of the material universe may be maintained*, while moving in this resisting medium, we will trace the history of some given solar system from its original nebulous state, down through its life-sustaining period, thence to its final destiny; and then discover, if possible, a means by which it may be reinvigorated or resurrected to a new planetary life. For this purpose it seems necessary to present —very briefly, however, for want of space—one illustration, reaching through the various stages in the grand round of successive changes through which all planetary systems seem to be passing. Our solar system will be taken as the illustrative example.

In tracing the history of the system from its nebulous state down to the present time, the path pointed out by the illustrious Laplace will be closely followed.

More recent writers have suggested other modes for the formation of such systems, some of which, however, would seem to be the exception instead of the rule here presented, as the sequel will show.

No definite explanation will be given in this paper as to how the out-thrown masses of nebulous matter—which will hereinafter be described—may be utilized in forming other systems; and no suggestion given as to the formation or structure of the globular or other clusters of stars, which are so bewildering to investigate, and yet so interesting to look upon; but the formation of these, and of that great galaxy of stars of which our sun seems to be a member, may be accounted for on the same dynamical principles that are employed in this discussion.

Following Laplace, it is assumed, then, that our planetary system began its evolutions as a great nebulous sphere of perfectly dissociated matter of almost inconceivable rarity, and of nearly uniform density.

At this time it was not quiescent, but most probably was agitated by the movement of internal currents and counter-currents, the resultant motion of which caused the entire mass to revolve around one of its diameters.

From the nature of the case, this rotation must have been very slow indeed, probably one rotation in millions of years. If its diameter were 500 times that of Neptune's present orbit, it would require more than 36,000,000 years to make one revolution; even this velocity would slightly flatten it at the poles.

During these revolutions it was radiating heat, not only from its surface, but, on account of its extreme rarity,[1] from regions far below its surface. This radiation, combined with the gravitation of its parts, caused contraction; and this contraction, by well-known mechanical laws, increased the rate of rotation, and a consequent further flattening at the poles, while a correspondingly greater increase of density in the central parts took place.

This process continued till the rate of rotation of the bulging equatorial belt generated sufficient tangential force, by virtue of the rapid rotation of those particles, to counterbalance the gravitating force of the disk-like mass within, at which time further contraction of the outer edge of this nebulous belt, or beginning of a ring, ceased, except that infinitesimal portion due to resistance alone; for, at this time, each particle in this outer belt revolved in its own orbit around the central mass.

As radiation continued, contraction also continued, thereby conferring a planetary character on each particle of the successive layers of the equatorial ring of particles thus left out by the contracting nebulous spheroid.

Let us now confine our attention to this out-left ring, for *its* conduct

[1] It should be here remarked that the heat thus radiated from the nebula is not lost, but continues as wave-motion in the ether, until it is again converted into molecular motion in ponderable matter.

will show how planets and satellites are formed from rotating nebulous masses:

As radiation still continued, the repulsive force between the particles diminished, which allowed them to approach nearer to each other; and this tendency to agglomeration resulted in the formation of small centres of local attraction near the surface of the ring, where radiation was most rapid.

As condensation continued, new centres of local attraction were formed within, while the outer and older nodules continued to increase in size, and to coalesce into larger masses; till, finally, the outer edge of this ring had changed from an homogeneous and continuous nebulous disk to a multitude of nebulous planetoids of great volume, but of small mass; while the succeeding interior particles, as fast as they were left out by the contracting spheroid, were preparing to undergo a like change.

Now, as these planetoids have various periods of revolution, they will occasionally come into conjunction, and then, on account of the great volume and small mass of each, they should coalesce without crash; till, finally, some preponderating mass should collect all the little ones exterior to its orbit into itself, together with as many of those within its orbit as its gravitating force could control.

In like manner will all succeeding rings be collected into nebulous planets; and, if the masses of these planets be sufficiently large, they too, in a like manner, will develop nebulous secondaries after their own likeness, both in form and motion.

It is the satellites so formed of the out-left rings of the condensing nebulous planets in our system that have been under discussion in this paper.

That the nebulous planet thus formed will be given a motion of rotation in the same direction as that of its primary is due to the fact that the exterior planetoids have a greater *virtual velocity* than the interior ones have. This will become evident from the following considerations:

Let us consider, first, the effect produced on its rotation by one of the outer planetoids as it coalesces with this preponderating mass. As the two bodies approach conjunction, the small one will be drawn inward to meet the larger one, and this contraction of its orbit so increases its orbital velocity that, at the time of meeting, this velocity is greater than that of the controlling mass, and on striking it will give the latter an impulse to rotate in the direction of its orbital motion; while, on the other hand, one of the interior planetoids, by being drawn outward, will have its motion diminished to such a degree that, on meeting, it will give the larger one an impulse to rotate in the same direction as that which the outer one gave to it.

Now, if this nebulous globe be not disturbed by some *external* force, it will form the outer planet of the then future solar system.

This is the general rule for the formation of secondary bodies in all systems. In our system there seems to have been one exception to this general rule, viz., the asteroids. From some cause—most probably from external disturbance—this ring did not collect into a single mass, or, if so, was dashed into many fragments afterward by some meteoric or cometary body which, thrown out from some previously-formed nebula, had been wandering through space till it reached our system.

There are indications in other parts of the system of such external disturbances, notably in the satellitious system of Uranus.

From the manner in which the solar system has been formed, it seems most probable that all the bodies in it should both revolve and rotate in the same plane and direction that the sun does, had there been no external disturbance to prevent it.

Having examined the mode in which a planet is formed, and thus learned how a solar system may be formed out of nebulous matter, and having discovered that the system must be contracting into smaller dimensions from some sufficient cause, let us next inquire what consequences are most likely to follow the operation of such cause.

Consequences of Contraction.—It has been shown, by the foregoing investigation, that our system is expending its life-giving energy on some resisting medium which causes this contraction.

This, at first sight, seems saddening to contemplate; but there may be another point from which to view it. For, while it is seemingly wasting its life-giving power in this struggle with resistance, it may, in reality, be storing up a new supply of potential energy, by which a future activity may be insured. Or, in other words, it may be forming a new bud, which, when properly vivified by another one, may blossom forth with the most brilliant rainbow hues, and finally ripen into planetary fruit which shall become the happy home of future intelligent races.

Modus Operandi of Conservation.—It is well known that the stars are not fixed, but that they are moving in various directions with various velocities, relatively to our galaxy, at least.

Now, if the stars be moving, it is very probable that some of them are moving in such directions that they will finally meet, either in pairs or otherwise.

Let us direct our attention to two of them which are very like our star in mass and attendants, or we may suppose our sun to be one of them, and that they are so moving as to approach each other at the very slow rate of one mile a week; and let us further suppose that, before meeting, each will have arrived at that state of quiescence to which all systems are tending.

The object of assuming such slow original motion for the meeting bodies is to make a test case, as it were, in order to show clearly that the gravitative force of two such large bodies is sufficient to convert them both into a nebulous mass, besides throwing large portions of this mass into the attracting spheres of surrounding stars, and thus beyond the possibility of return.

It may be proper, here, to point out the *modus operandi* by which such systems reach the state of quiescence alluded to above, which is, substantially, as follows:

The planets absorb their satellites by first converting them into fragmentary rings — as Saturn has already transformed two of his. These rings gradually approach the planets, till finally they fall upon their surfaces, and become part of them; while the planets themselves are approaching their primaries to succumb to a like fate.

Having absorbed their planetary attendants, and having cooled off so as to become cold, dark bodies, like the earth, they enter the sphere of each other's sensible attraction, and begin to approach with continually increasing velocity, till finally they meet, each arriving at the point of contact with a velocity of from 400 to 500 miles a second, depending on their mass and density.

Of the heat generated by such a collision, we can have no adequate conception. It may, however, be calculated, and written down in thermometric degrees;[1] still the figures are meaningless to us except as representing an inconceivable intensity of heat.

It may be stated as so many thousand times the heat generated by the explosion of an equal weight of gunpowder, still we are unable to form an idea of the unit of measure here given.

If the doctrine of the "correlation and conservation of forces" be true, then the heat thus generated, if it could all be applied in the form of moving force to these two bodies while yet intact, should be sufficient to throw them back again to the points at which their motions began to be accelerated, if there were no resistance; but, owing to the resistance met with, they will not rebound fully to those points.[2]

It will not, however, be expended in that manner, but in expanding the entire mass of these two globes into a thin, nebulous vapor; large portions of which, most probably, will be thrown out beyond the sphere of sensible attraction of that which remains, and into those of the surrounding stars.

This great probability will much resemble a certainty when we come to subject the question to the following speculative illustration:

[1] Assuming the average specific heat of cosmic matter to be one-fifth that of water, then the calculated temperature due to a velocity of 400 miles a second is equal to nearly 450,000,000° Fahr., or 250,000,000° Centigrade.

[2] It may be well to remark just here that the resistance here spoken of is assumed to be caused by the so-called ether of space, through which all bodies must move. Now, this resistance may be due to the inertia of the ether alone, in which case we must suppose that the ether is perfectly fluent, and receives a kind of mass-motion from the bodies moving through it. Or, on the other hand, we may conceive it to be a friction between the moving body and the ether. In this case the ether will be given a wave-motion of some kind, while the ponderable matter acquires a molecular motion. In either case there will be no motion lost.

If the entire nebulous mass could be preserved in the form of an expansible spherical shell, while the entire amount of heat-force should be acting upon its interior surface to force it outward, then, according to the above-named law of conservation, the entire mass would be thrown nearly to the limit of its sphere of sensible attraction; i. e., nearly to those points at which the motion of the two bodies began to be accelerated.

For the sake of convenient reference in the following difficult illustration, let us imagine the entire mass of expanding vapor to be divided into two equal parts, called respectively the *inner* mass and the *outer* mass; and let us imagine the heat-force to be divided into two equal parts also, called the *inner* force and the *outer* force.

Now, as these two forces are sufficient to drive these two masses very nearly to the aforesaid points of acceleration, and whereas only a part of the *inner force* can be expended in distributing the *inner mass* throughout the space surrounded by such limits, it follows that that part of the inner force so conserved will expend itself in helping the *outer force* to throw the *outer mass* beyond this sphere of sensible attraction, and, most probably, into those of the surrounding stars.

If such be the case, then some of these out-thrown masses may become cometary bodies and meteoric showers to the inhabitants of "other worlds than ours," besides forming abundant material for the "cosmical dust," so much discussed of late; and, possibly, some of the largest of these fragments may be able to produce asteroidal groups, in some ripening planetary system, by disrupting one of its planets while yet in the nebulous state. This seems to supply a deficiency in this hypothesis which has long been felt.

Density of the Newly-formed Nebula.—If, now, we fix our attention on the condition of this nebula at the moment when the explosive force had expended its last effort to throw these outside masses into surrounding space, we can readily see that it must have been of very nearly uniform density, in consequence of the tendency of the out-moving particles to continue their motions outward.

Confirmation.—It is very probable that many such explosions as that described above have been witnessed from our planet, and have been recorded in history as *temporary stars;* an interesting account of some of which may be found in Herschel's "Outlines of Astronomy."[1]

In May, 1866, such a phenomenon was observed in the Northern Crown. This collision, however, seems to have been, not with the star itself, but with one of its planets, or with some other dark body lying in that direction, which contained a large amount of water, the hydrogen of which, being dissociated from its oxygen, shone out with such brilliancy as to be seen at this distance.

That this was a *planetary* collision seems probable, from the fact that the star continued to shine with its normal light during the time

[1] Philadelphia edition, 1861, p. 472.

of, and after, this brilliant display of hydrogen, which is proved by the spectrum analyses of its light during that time.

The "new star'' lately discovered in the constellation of Cygnus seems to be a complete confirmation of this theory.

A very interesting account of this star, by Richard A. Proctor, may be found in THE POPULAR SCIENCE MONTHLY for December, 1877. From this account the star seems to have passed through all the various changes which should naturally be expected from such a collision; first, a very great augmentation of light, with a continuous, rainbow-tinted spectrum arising from the intense pressure to which the rapidly-expanding mass of gas was at first subjected; gradually passing through various changes and gradations, till, finally, it took on the "spectrum of a true nebula," which should naturally occur after a large part of the intense heat of percussion had taken on the form of latent heat of expansion.

"As the stars are moving with various velocities in various directions," it may be asked, "What would be the consequences if two of them should enter each other's sphere of sensible attraction with very great velocities?"

In order to secure definite results, in replying to this question let us assume definite conditions:

Suppose them to be equal, and of such mass and density that each would approach the point of meeting with a velocity of 400 miles a second, by virtue of their mutual gravitation alone; and, further, that each one had an original velocity of 300 miles a second toward that point, when they entered each other's sphere of sensible attraction.

Now, they would meet, not with a velocity of 700 miles a second, as might, at first, be supposed, but with the velocity represented by $\sqrt{300^2 + 400^2}$, or 500 miles a second.

According to a previous mode of reasoning, the heat-force generated by such a collision should be sufficient to throw these two bodies outward beyond the possibility of return; therefore, the greater portion of the resulting nebulous mass would be thrown out with a corresponding velocity, and be distributed among the surrounding stars, leaving but a small portion of it to occupy the place of meeting; which, consequently, without further additions, would make but a small solar system.

CONCLUSION.—Let us now consider what would most likely be the result of such collisions, if the matter of the universe were of finite instead of infinite extent.

For this purpose we may assume the last-named pair of stars to constitute the entire amount of ponderable matter in the universe. It is supposed, then, that they are both moving directly toward the point of future meeting with a velocity of 300 miles a second, when each begins to be affected by the other's accelerating force; which, consequently, increases that velocity to 500 miles a second at the time of meeting.

It will readily be seen, from previous considerations, that large masses of the resulting nebula will be thrown out from the sphere of sensible attraction of the remaining mass, with velocities exceeding 300 miles a second, while other portions will emerge with less and less velocities, till finally some portions barely reach those limits.

The remaining nebula should then begin to contract, and might, possibly, form a small planetary system. Of the out-thrown masses, those which moved with the greatest velocity would retire to the greatest distances; but even they must finally stop, because they could not overcome perpetual resistance.

The resistance which these masses have to contend with is of two kinds: first, the feeble, insensible attraction of the remaining mass; second, the resistance of the ether.

The first diminishes with the square of the increasing distance, but is never reduced to absolute zero; the second, however, diminishes with the diminishing speed, and finally becomes nothing, at which time the body stops.

Now, would these farthest masses return? Most certainly they would; for no distance can be named so great that the force of gravity shall become absolutely nothing.

If it took millions of years for the most distant body to move one inch, after it had stopped it would eventually return to the central mass, which would itself finally become quiescent.

It will be readily seen that if any number of such bodies were put in motion in the boundless ether, they, too, would finally come to rest.

Another very well-known and much shorter path leads to this same conclusion; it is this:

If the ponderable moving matter of the universe be limited, then, by constant collision, its motion would all be converted into heat and light, and be radiated into the outer realms of space, never to return again, leaving all the ponderable matter to collect into one great mass, and to cool off to a state of perfect quiescence.

But, if matter be infinite, then there can be no "outer realms" into which this heat-force can radiate; consequently there will be no motion lost, and matter, since it has ever been moving, will continue in motion forever.

THE QUESTION OF PAIN IN HANGING.

By ROGER S. TRACY, M. D.

IN executions it is the custom to drop the condemned man from a height, or (as in New York) to jerk him up from the ground by the fall of a heavy weight, so that there is a powerful concussion of the brain to start with. It used to be a common belief that the necks of criminals were broken by this means, and that the pressure of the fractured vertebræ on the spinal cord shortened the period of suffering. It is now known, however, that this rarely occurs, and the criminal dies of asphyxia or apoplexy, usually the former. In some persons, particularly in heavy or aged ones, the sharp and sudden violence of the shock is sufficient to burst some blood-vessel, and the gush of blood into the brain-substance renders the criminal immediately unconscious. But apoplexy rarely kills suddenly; even such persons really die of asphyxia. In feeble persons, the simple concussion of the brain may be sufficient to bring on insensibility, like a stunning blow on the head, without any visible lesion of the organ; so that, in a certain proportion of persons who are executed by authority of law, it is probable that insensibility is instantaneous.

Some men, however, with strong necks and coarse organizations, do not become unconscious from the shock of the fall, and suicides generally have no fall; so that, in such cases, death supervenes by asphyxia. But even here the process is not a simple one. It is complicated by a congestive apoplexy; i. e., such an overfilling of the blood-vessels of the brain as to produce unconsciousness by pressure on the brain-substance, but without the actual rupture of any artery. And in these cases, too, insensibility comes on so rapidly that death is really painless.

The fact that executed criminals suffer little has been known for a long time. Morgagni quotes Cesalpinus as saying that persons who have been hung and have not died have declared that "they were overcome with stupor at the instant of the tightening of the rope, to such a degree that they felt nothing." And he adds: "As for myself, I have learned from a sober and truthful man that a thief, whom the cord of the hangman had not killed, for the same reason that prevented the deaths of those individuals mentioned by Gardani in the Sepulcretum, told those who questioned him, that he at first saw sparks before his eyes, and soon after saw nothing and felt absolutely nothing, as if he had been asleep."

I once witnessed an execution at the Tombs, and observed the victim carefully, watch in hand. After the body fell to the length of the rope, it remained perfectly motionless, so far as I could see, and I was not more than twenty-five feet away. It swayed a little in the currents of air, and at the end of a minute and ten seconds there were three very slight drawings-up of the feet, and a peculiar quivering of the hands. Then all was still, and remained so until the body was taken down. In this case the neck was not broken, and death took place by asphyxia. It is probable that the shock of the fall caused an apoplexy, or the convulsions would have been more pronounced. It seemed evident to me at the time that the death of the victim was painless.

Devergie says: "A friend of Fodéré, after a long discussion with him on the phenomena of asphyxia, hung himself from his door, expecting to be able at will to stop the experiment. Luckily, some one came into the room and rescued him. Chancellor Bacon has reported the case of a gentleman who took a fancy to find out for himself whether those who are hung suffer any pain. He put a cord around his neck, and hung himself, stepping off from a small bench on which he had been standing, and expecting to be able to mount it again when he wished. This was impossible for him on account of the loss of consciousness, which supervened immediately. The experiment would have had a tragic ending, if a friend had not by chance entered and released him.

In the *New Yorker Allgemeine Zeitung* for May 14, 1877, was the following item: "In the village of Brunswick, a bet was made, by one of three young fellows, drinking together, that he could hang for a certain number of minutes. A ladder was brought, put against the wall, a noose placed around his neck, and the end thrown over a round of the ladder. A second drew on the rope, while the third stood by, watch in hand. Just then in came a servant-girl, who saw the situation. At her exclamation that the man was blue in the face, the man with the watch said the time was not up. At her shrieks, however, others rushed in, and the cord was loosened. The poor fellow fell insensible to the ground, and was with the greatest difficulty resuscitated."

Although nothing is said in this account about the young man's sensations, it is likely that he became unconscious immediately; for, if he had felt the pangs of suffocation, as ordinarily understood, he would have certainly either grasped the ladder and relieved himself, or in some way indicated to his companions that he was suffering and wished to be let down.

Two remarkable examples are on record of persons who allowed themselves to be hung for the entertainment of an audience. An account of one of them is given in the *Lancet* of April 17, 1847. The man's real name was John Harnshaw, but he performed throughout England under the high-sounding professional title of Monsieur Gouffe. He was an athlete, and among other feats it was customary with him to exhibit the process of hanging. In this performance he relied for security on the strength of the muscles of the neck and throat. He had a rope with a fixed knot which could not slip, and passed both ends of the loop up behind one ear. The whole act was so adroitly managed that he prevented any pressure of the rope on the windpipe or the jugular veins, and could even sustain a weight of one hundred and fifty pounds in addition to that of his own body.

On three separate occasions Harnshaw mismanaged the rope, and became unconscious, being luckily rescued each time. Dr. Chowne, who writes the account, says very truly: "It cannot be doubted that, as far as sensation and consciousness are concerned, Harnshaw passed through the whole ordeal of dying; and, had he been permitted to remain hanging until actually dead, he would have passed out of existence without further consciousness."

Now, this man stated, not with particular reference to either accident, but as common to all, that "he could hardly recollect anything that happened to him in the rope;" that "he lost his senses all at once; the instant the rope got in the wrong place he felt as if he could not get his breath—as if some great weight were at his feet; could not move only to draw himself up; felt as if he wanted to loosen himself, but never thought of his hands." And he added: "You cannot move your arms or legs to save yourself; you cannot raise your arms; you cannot think." He did not see sparks or light, but had in his ears a rattling sound.

This account is an interesting one, because it shows the absence of physical suffering, even when consciousness is for a short time retained. The benumbing effect of the venous blood on the brain is well shown by his remarks on the confusion of thought and mental helplessness.

In the second instance, which has been fully recorded, the show-man was not so fortunate. He hung himself once too often, and the circumstances of his last exhibition were very singular. He was known as Scott, the American diver, and he, like Harnshaw, had many times hung himself before an audience with safety. The last time, however, the rope slipped in such a way as to compress the throat and bring on asphyxia. He hung thirteen minutes, the spectators thinking that he was prolonging the experiment for their gratification. When he was taken down he was dead. It is just to those who were looking on to state that they thought he was safe, because he was still, and did not raise his feet and stand upon the scaffold, which his legs actually touched. This case shows with peculiar force the insidious manner in which death comes on in asphyxia.

While death in such cases has been supposed to occur in consequence of the lack of air, there are good reasons for believing, as previously stated, that it may be largely if not mainly due to the congestion of the vessels of the brain. Fleischmann tried some experiments on himself with the object of throwing light on this question. He says: "If a person puts a cord around the neck between the hyoid bone and the chin, he can draw it tight at the back or side, without the respiration being sensibly interfered with, and can for a long time continue to inspire and expire naturally enough, because in this situation compression is not made on any part of the air-passages. Notwithstanding this, the face grows red, the eyes become a little glaring, the head becomes hot, there comes on a feeling of weight, dizziness, a sort of distress, and then all in an instant a hissing and roaring in the ears. This last symptom should be especially noticed, for it is time then to stop the experiment. I confess that a second time I should hardly dare to push it so far. The same symptoms follow the application of a cord to the larynx. It seems to me, though, that then they come on more promptly, and that the respiration is a little interfered with. I have been able to prolong the first experiment for more than two minutes, while in the second trial a half-minute had barely passed when the noise in the ears and a peculiar sensation in the brain, difficult to describe, warned me to stop the experiment."

In the first experiment Fleischmann was on the very border of unconsciousness, and, as he himself says, did not stop a moment too soon. In the second, when the effects of asphyxia and cerebral congestion were combined, the result was reached much more rapidly.

Devergie states plainly, after considering all the facts, that hanging is a pleasant way of dying. His words are: "In suicide, at the moment of the application of the cord, or a few moments after, a feeling of pleasure manifests itself; then supervenes disordered vision; bluish flames appear before the eyes, and the loss of consciousness soon follows."

All the evidence goes to show that death by hanging is painless, and there is positively no fact or well-founded opinion to the contrary. If this be the case, then, what is the explanation of it? Simply this: That in every form of strangulation the blood-vessels of the neck are compressed, as well as the air-passages. A large part of the blood is returned from the head by the external jugular veins, which are very near the surface, and in which the current can be checked by slight pressure. Most of the blood from the brain itself comes back through the internal jugulars, which lie near, but a little outside of, the carotid arteries. The walls of veins are lax and yielding, so as to be easily compressed, while those of the arteries are firm and elastic, and it requires considerable force to approximate them. Pressure, then, which is sufficient to close the jugular veins only crowds the carotids a little farther inward, and the blood is still poured through them into the brain, whence it cannot escape. When this pumping process is going on at the rate of seventy strokes a minute, it is easy to understand how the engorgement of the vessels of the brain, in a very brief time, reaches a degree which causes insensibility. To explain why this congestion causes unconsciousness would involve a technical discussion which would here be out of place. It must suffice to say that it does; so that, as the cerebral congestion in a hanged person brings on insensibility within a minute, while the physical agony of suffocation does not begin until later, it follows that the victim does not feel any of the pangs of asphyxia. He first becomes insensible, with accompanying pleasurable feelings, from cerebral congestion, and then is choked to death while unconscious.

Drowning and hanging, then, are painless modes of dying, because the asphyxia which causes death is complicated by other circumstances which render the dying man so soon unconscious that the pangs of suffocation are unfelt. And the insensibility which results from hanging is so insidious and painless in its approach, that experiments on the subject are very dangerous for any one to make alone. It is probable that many persons, who are supposed to have committed suicide in this way, had really no intention of bringing about their own death. Some have been led, like the two gentlemen mentioned by Morgagni, to try the experiment out of curiosity. Others may have done it out of pique. It is not impossible, nor perhaps improbable, that high-spirited boys or girls, after a degrading punishment, should rush off, as we read of their doing, and hang themselves. The child puts a cord around his neck, and steps off from a chair, expecting to be followed, found choking, and released, by the anxious parents. If he is not followed and his absence not noticed, nothing can be easier for him than to step up on the chair again, loosen the rope, and no one will ever know of his folly. In the first case he would obtain his childish revenge for the wrong he had received, and in the second case he would lose nothing, for he is his only accomplice. But the laws of Nature are too stern. He experiences the fate of poor Scott, above related. Utterly ignorant of his danger, and intending only a prank of childish folly, he steps from his chair into eternity. Such a possibility should make us charitable, and in cases of suicide by hanging lead us to remember that, although the case may be evidently one of suicide, and the hanging plainly intentional, nevertheless the death may have been undesired and unlooked for.

THE RADICAL FALLACY OF MATERIALISM.

By R. G. ECCLES, Esq.

NOT many years ago the manifestations of energy were looked upon as mere conditions of matter. When a moving body came to rest, it was thought that the motion was obliterated from the universe, and, when a body at rest was put in motion, it was supposed to be a creation. The motion was looked upon as a *mere state* that had arisen and ceased. To-day, in the light of the new doctrine of the correlation and conservation of forces, the old notions are inconceivable, because of the rise of a new element of thought, namely, that force is caused by energy. Motion to us is the effect of a real though immaterial existence, called force or energy, acting upon matter. This energy persists in spite of every effort to destroy it. It is seen to leap from matter to matter as motion, when passing through a row of elastic collision-balls, as each successively gives up its energy to the next. Energy being seen to travel from matter to matter, persisting in one piece after eliminating the other, we are compelled to look upon it as having a real existence of its own. It may change its form many times, but through all the mutations there remains the identical energy. After repeatedly following it through such changes, we conclude that the universe contains a fixed quantity, never had more, and never can have less. While the form of this energy changes, the substance endures forever. In this respect it resembles matter. The forms of both matter and energy are fleeting, but the invisible substance endures. By their interactions they incessantly alter each other. The forms of energy determine the forms of matter, and the forms of matter determine the forms of energy. In this respect their interdependence is mutual. The form of matter determines whether energy shall be moulded into heat, light, sound, magnetism, chemical affinity, cohesion, or molar motion. The mode and amount of energy determine whether matter will be solid, liquid, or gas, opaque or transparent, colored or colorless, etc. As all matter must have some form, so all energy must have some mode.

Whatever form matter may assume, that form is built from the elements of form of which matter can never divest itself. While matter and energy have independent substantive existences, form has no existence apart from the matter with which it is found. One piece of matter cannot give up its form to another, as one collision-ball can give its energy to another. The failure to see this truth has led to serious mistakes among psychologists. The elements of form belonging to one piece of matter may be put together in the same order as found in another piece, so that the identical form may appear to have been transmitted. The elements of form belonging to matter may imitate or mimic each other, but this does not constitute identity. The two words R′O′S′E′, ROSE, may look alike, but each has its own form. If we transpose them as entire words, ROSE, R′O′S′E, they have not given up their own forms. If we transpose them letter by letter, as beneath, each still retains its own form, and has not appropriated that of its neighbor:

First change........................	RO′S′E′	R′OSE
Second "	ROS′E′	R′O′SE
Third "	ROSE′	R′O′S′E
Fourth "	ROSE	R′O′S′E′

When transposed as entire words, the entire forms are transposed at once, and, when transposed as letters, the forms are transposed in their elements. At the base of the left thumb of the writer there is a scar, made during boyhood. All the tissue has probably been removed several times, as in the transposition of the letters of our word ROSE; but because the material that supplied the waste has been the same in kind, and because these elements of form have been put up in the original order at every change, a scar is there to-day like the one of years ago. For convenience' sake we call it the same scar, yet it is no more the same than are our two words, when transposed, identical. By one set of the elements of form imitating another an illusion is established that makes it appear as if the identical form was transmitted from one mass of matter to another, just as the identical energy is transmitted. In this way are organized forms maintained during the lapse of years, despite the waste continually going on.

Now that the self-existence of energy has been substantiated, and motion is no longer considered merely a condition or state of matter in the old sense, the creation and annihilation theory is being shifted to consciousness or the ego feeling. This feeling is looked upon as a product of a certain mode of motion brought about by a certain form of matter, or it is said to be one side of energy. But few pause to consider what such expressions imply. If consciousness is a product of organization, then the proper amount, quality, and arrangement, of matter and motion constitute the ego. Let us consider this. If we put inactive matter together in any form we choose, the only thing we can conceive of its having is that form. Add energy to such an arrangement of matter, and the only conceivable result will be some mode of motion which the mode of arrangement directed. Whether we arrange atoms, molecules, or masses, in simple or complex order, the addition of energy will only give a mode of energy. Matter can direct energy, but we cannot conceive of its turning it into something that is not energy. We cannot conceive of a motion being a passion or sensation. No element of kinship can be detected between a kind of motion and love or hate. Conceive of any mode, speed, or direction of motion you choose, and they will never even suggest the possibility of their creating thought, will, hate, avarice, love, ambition, color, sound, taste, odor, or any other sensation. We can perceive that these are all forms of the one ego feeling, but that that could ever arise merely from a mode of motion is absolutely unthinkable. We can conceive of feeling COMING IN when certain forms of matter and modes of energy are present, but no alternative theory can for a moment be entertained. It must either *come in* under favorable circumstances or be their product. The law of excluded middle forbids a third possibility. The first of the only two alternatives is conceivable, the second inconceivable. If we here apply Mr. Herbert Spencer's test of truth, "the inconceivability of the opposite," we must admit that consciousness possesses an independent existence of its own. We can conceive of no form of matter and energy being the ego feeling. As it is absolutely impossible to think of any form of motion arising in matter without energy entering from some source, so it is equally as impossible to conceive of consciousness arising in any form of matter or motion without conceiving that a substance of consciousness was infused at some stage. We may, by refusing to think, give an indorsement to the verbal expression, and so deceive ourselves by imagining we believe it. Every proof that can be given of a substance of matter or energy will be equally telling when turned on consciousness. It is just as impossible to conceive of the substance of matter being energy or consciousness, of the substance of energy being matter or consciousness, as of the substance of consciousness being matter and energy. If we demand clear ideas, there is no other alternative than to view the three as distinct but incomprehensible existences. Consciousness *reveals itself* through matter and energy. Energy *reveals itself* through matter and consciousness. Matter *reveals itself* through energy and consciousness. Take away any one of the three and the other would be unknown. How could we know matter but for vibrations? How could we know energy but for matter? How could we know consciousness but for sensations induced by energy? No one of these can be known without the other. Mr. Fiske's world of pure consciousness is as inconceivable as a world of motion where there is nothing to move. We do not and cannot know what the substance of matter is. We only know the sensations it produces in us through its vibrations. The theory that assumes the existence of matter is accepted because no other will explain our experiences. We meet precisely the same difficulties when we assert that matter is the result of the combination of consciousness and energy, or that energy is the result of the combination of consciousness and matter, as when we declare that consciousness is the result of matter and energy. Let any person attempt to conceive of whatever pair he may choose of this trinity producing the third and he will find every effort in vain. Take them pair by pair, and the difficulty will be the same in every pair, thus revealing a common guarantee for the identity of each as distinct from the other. Men talk glibly of the production of consciousness by organization, but the words are mere meaningless jargon. When we see what is meant by such an expression, we shall learn that the idea has equal lucidity with that of a round square. Evolution deals only with the forms of this trinity. Forms evolve, but the substances are eternal. As dissolution follows evolution, the forms of each are resolved into their elements, to be refashioned again into new forms. Matter may form a tree, a crystal, a man, or a world; energy may form heat, light, electricity, or sound; and consciousness may be fashioned into memory, intellect, color, or emotion. These are the transient manifestations of the enduring verities.

Men in prescientific times lost sight of the persistence of matter because they looked upon the form as the reality. When fuel ceased to show a solid, compact form after combustion, they thought it was annihilated. Up to a later date they looked upon the form of energy as the reality, and when that form vanished they were content to declare it as swept from the universe. When motion changed to heat, they thought it was annihilated. The form being destroyed, as that form was mistaken for the reality, they thought the reality had vanished from existence. With broader and more enlightened views this method of reasoning on energy and matter became obsolete, but it still continues to be applied to consciousness. Intellect, memory, or emotion, being put forward for consciousness, how can we refrain from thinking that it goes when these go? As energy determines the form of matter, and matter determines the form of energy, so consciousness determines their form and they determine the form of consciousness. It is well known to the most superficial observer that the body affects the mind, and the mind affects the body. A man with toothache, drunk, or in a fever, in in a bad state to think. When mentally depressed or in great excitement, the body is affected, and disease or even death may be induced by a fright. A blow on the head may destroy memory for all past events or only part of them. How easy for men, who look upon memory as the substance of consciousness, to declare that that blow on the head suspended consciousness, because memory was a blank for some minutes or hours after it! As well might we talk of energy being suspended from the time motion ceases to be seen as such in the magneto-electric machine till it reappears as motion again in the electro-magnetic machine. While the body rests in sleep, the forms of consciousness are, to all intents and purposes, still, and we say the sleeper is unconscious. Give the alarm of fire, and see how quickly the so-called unconscious man will be aroused. Did he first hear that call and then awake, or did he awake first and then hear the call? If he heard the call before awakening, then consciousness was awake to hear it while the body slumbered. If he awoke before he heard the call, then the call did not awaken him. No matter how deep the slumber of the body, something remains awake to catch the signals from without.

Every form of consciousness being built of that form we call the ego feeling, or feeling of individual identity, that feeling may be expected to persist wherever consciousness persists. As the connections of matter and energy, so far as form is concerned, are perfectly continuous and complete in every form that each assumes, so the connections of mind and body from beginning to end will be found just as perfect and thorough-going throughout. Given the form of matter, and the form of energy can be at once inferred. The forms of matter, motion, and consciousness, have from beginning to end the most intimate relations with each other. Each moulds the other into the form in which it appears, and it would, indeed, be remarkable from this view of the case if our experiences of the power of bodily condition over mind were not as they are. Nerve-waves are not sensations. The nerve-matter is there and the wave and sensation are there, but by no effort of thought can we conceive them as less than three. Whether any one of these can exist independent of the others cannot be known. We know matter as possessing energy, and when the philosophic mind attempts to divest it of all energy it melts into inconceivability. In attempting to separate energy from matter we are foiled. We know consciousness as connected with matter through energy. When we attempt to remove consciousness in thought from this relationship, it slides out of thought completely. In an ultimate analysis each of the three appears with a substantive basis of its own, but the natures of these bases are totally beyond the range of knowledge. Our persisting symbol of matter is extension; of energy, motion; and of consciousness, feeling. We cannot reduce our conception of matter to unextended points of force, nor can we think of either energy or consciousness as latent. The words but cover a vacuity of thought.

Any system of philosophy that denies a substantive basis for the ego feeling, exclusive of the bases of matter and energy, virtually denies the existence of knowledge of every kind, and so stamps itself as false. Our only assurance of the existence of anything outside of ourselves is the effect produced on consciousness. If the perceiving consciousness is not real, how can we assert that the perceived matter is? Action and reaction are equal and opposite. If consciousness has not persistence and permanence of its own, how can it gauge persistence and permanence in matter and energy? But for consciousness we could know of the existence of nothing else. Is it logical to claim that our conclusions are permanent and real, while asserting that our premises are unsubstantial and unreal? Yet this is what every materialist is compelled to do. No theories of "double-faced entities," "results of organization," or "remodeled definitions of matter and energy," can ever be conceived to explain the facts.

One of the strongest proofs of the independent existence of the soul is seen in the fact that at no two consecutive moments of our lives does the ego feeling rest upon the same matter or energy. The systems of waves within my brain will all have radiated away many times before this paragraph is completed. The matter giving out, the energy will pass away as waste, and the arteries bring back a new supply. For days, weeks, months, and years, matter and energy will thus pass while the identical consciousness will persist, and can be traced through every change precisely as energy can be traced from matter to matter. To say that energy is a two-sided entity, one side of which constitutes sensation, is against the facts. The energy my body has to-day is not that of yesterday. Yesterday's energy has all radiated away and carried both its sides with it; but consciousness—the same consciousness—is still here. The closeness of analogy between the conduct of energy toward matter and of consciousness toward energy is remarkable. Let $M' \; M'' \; M''' \; M''''$ represent four pieces of elastic matter, and e a quantity of energy. By collision, e will travel from matter to matter thus:

First position .... $Me' \; M'' \; M''' \; M''''$
Second " .... $M' \; Me'' \; M''' \; M''''$
Third " .... $M' \; M'' \; Me''' \; M''''$
Fourth " .... $M' \; M'' \; M''' \; Me''''$

As e travels from M to M it can be no part of M, so must have a distinct existence of its own. Now let $E' \; E'' \; E'' \; E''''$ represent the brain-waves of as many consecutive moments and c our conscious identity.

As the waves follow each other in the order of time, *c* will travel from one to the other thus:

First moment	....	E*c*′ E″ E‴ E⁗
Second "	....	E′ E*c*″ E‴ E⁗
Third "	....	E′ E″ E*c*‴ E⁗
Fourth "	....	E′ E″ E‴ E*c*⁗

As *c* travels from E to E it can be no part of E, and must have a distinct existence of its own. The deportment of matter, energy, and consciousness, toward each other, is much like that of the three letters M, E, C, toward each other in our illustration. Let any person try to make these three letters one, as the ancients did by the entities for which they stand, or but two as the moderns do by them, and precisely the same muddle of inconceivability will arise with the letters as has arisen with the things. The materialist is not satisfied with trying to make himself and others believe that matter and energy produce consciousness, but he must believe that, no matter how often he changes his matter and energy, every new supply will produce the identical consciousness the old one did. If we wish a note of a certain pitch and timbre, we must have matter in a certain form; and, if we wish a sensation of a certain kind and quality, we must have energy of a certain mode. The tuning-fork or violin-string is not the energy of the vibrations, nor is the wave of motion the consciousness of sensation. It is necessary that the brain of to-day be like that of to-morrow if I get the same *form* of consciousness from it each time, but the brain is not the consciousness. To the form of brain there is not continuation of identity. The brain of to-day mimics that of days ago, because the elements of form are put together in the same order. The consciousness that appears is the identical consciousness, no matter what the form nor how much energy has escaped. If we declare matter and energy to be eternal, then we must declare the same of consciousness. We know matter as atomic, energy as rhythmic, and consciousness as individualized.

SKETCH OF PROFESSOR DU BOIS-REYMOND.

THE name of Du Bois-Reymond stands high among that group of illustrious scientific men of whom Germany may well be proud. He is known throughout the scientific world for his masterly researches in experimental physiology, having, while yet a young man, made a series of brilliant discoveries in electro-physiology, which at once placed him at the head of that delicate and important branch of investigation.

But the customary channels of international scientific communication have hitherto been so narrow that the public has not yet been able to recognize his greatness as a thinker on high questions of scientific philosophy. We do not say that Prof. Du Bois-Reymond is more than a scientist, for, in our view, that is a term of great breadth, but we do say that he is much more than a scientific specialist. He is a comprehensive and cultivated thinker. For largeness, originality, and independence of view, for depth of analysis and thoroughness of erudition, and for clearness, vividness, and vigor of style, he has no superior among his distinguished German contemporaries. His celebrated address on "The Limits of our Knowledge of Nature," which attracted great attention in Europe, was first presented to the English-speaking public in The Popular Science Monthly for May, 1874; and we now offer another of his productions to our readers, which is the subject of comment elsewhere. Prof. Du Bois-Reymond is in the vigorous maturity of his life, and, although he has done a great deal of valuable work, much more is still expected from him. We hope in due time to bring before the American public some other of his able productions that are suited to popular appreciation.

Emil du Bois-Reymond was born in Berlin, November 7, 1818. His father, a native of Neufchâtel, in Switzerland, had in his youth been a watch-maker, but subsequently entered upon a literary and official career in Berlin. Du Bois-Reymond's mother was descended from the Huguenots, who were driven from their country by Louis XIV. Among his maternal ancestors we must not omit to mention the celebrated artist and engraver, Daniel Chodowiecki, called by some the Hogarth of Germany.

After the fashion prevalent in Germany, Du Bois-Reymond first attended a primary school, then the Collége Français of his native town; but, when he was about eleven years old, his parents went to live several years in Switzerland, and during this period he was a pupil of the College of Neufchâtel. The French language, therefore, was from his childhood as familiar to him as German.

Later on, we again find Du Bois-Reymond in Berlin; and at the age of eighteen he became a student at the university of that town. It is said that, like many others who afterward distinguished themselves in natural science, he first devoted himself to theological studies, and that, during a session, he regularly attended Neander's lectures on ecclesiastical history. Chancing, however, to enter the lecture-room of the celebrated chemist Mitscherlich, he felt irresistibly drawn toward his true vocation. He now studied chemistry, natural philosophy, mathematics, and during the summer of 1838, which he spent at Bonn, on the Rhine, also geology, without any very definite aim.

This was eventually pointed out to him by a friend, the late Dr. Edward Hallmann, who, with greater scientific experience, convinced him that, of all the branches of science, the study of animated Nature affords the highest interest and includes the deepest problems, and that medicine is the proper road to that goal. A medical student, then, Du Bois-Reymond became, and as such, a pupil, and soon after an assistant of the great anatomist and physiologist, John Müller.

The connection with Müller decided, as it were, his fate. Humboldt at that time received a copy of Matteucci's "Essai sur les Phénomènes électriques des Animaux," and communicated it to Müller. Müller, knowing that Du Bois-Reymond possessed a share of physical and mathematical knowledge very unusual in a student of physiology, thought him qualified to take in hand the investigation of animal electricity, in which Matteucci had made but a poor advance since Nobili's discovery of the so-called current of the frog. Thus it happened that, in the spring of 1841, Du Bois-Reymond undertook to elucidate the problem proposed to science by Nobili, and for nearly forty years he has not ceased to work upon this subject, which, in his hands, and those of his numerous pupils, has marvelously expanded, so as to become one of the most important branches of physiology.

Du Bois-Reymond, after having in 1842 printed a short account of his first results, went on working patiently for seven years, and then published his celebrated book, "Researches in Animal Electricity" (Berlin, 2 vols., 1848–'49). This work, besides a complete history of what had previously been done upon the subject, contains an immense number of experiments, made after methods, and with the aid of apparatus, for the most part entirely new, invented by Du Bois-Reymond himself. In substance, the book is devoted to the exposition of his discoveries of the muscular and of the nervous current, of their law, and of the variations they undergo when the muscles and nerves are thrown into action.

To understand the importance of these discoveries, it must be borne in mind that, long before Du Bois-Reymond, in fact since the middle of last century, innumerable attempts had been made to observe electrical phenomena during the contraction of the muscle. They had all failed. Du Bois-Reymond, at the outset, perceived that one of the reasons of these failures was the transient nature of the contraction, and he invented the method of tetanizing the muscles in order to increase the duration of the contraction, and thereby facilitate the observation of what takes place in that state. He was thus fortunate enough to detect electrical phenomena concomitant with the act of contraction, and he even taught how to deflect the magnetic needle of the galvanometer by the voluntary contraction of the muscles in living man, or, as it were, by our will. The correctness of these facts having been doubted by MM. Despretz and Becquerel, of the Académie des Sciences, Du Bois-Reymond, in 1850, went to Paris with his apparatus, and triumphantly proved the truth of his statements.

As to the nerve, up to the date of Du Bois-Reymond's researches, no material change had ever been observed during its activity. In this case, too, a great many fruitless attempts had been made to discover some electrical phenomenon connected with that state. Du Bois-Reymond constructed with his own hands a galvanometer of 24,000 coils, by far the most sensitive ever made up to that time, and by its means succeeded in disclosing an electrical phenomenon in the tetanized nerve, which, for certain reasons we cannot here explain, he styled the *negative variation* of the nerve-current. In point of fact, he transmuted into a deflection of the galvanometer that molecular change in the nerve which, had it reached the muscles, would have convulsed them, and which, had it reached the brain, would have caused pain. He also decided the long-vexed question whether the nervous fibres conduct only in one direction, or in both, by showing that the negative variation is equally well transmitted in a motor nerve in the centripetal, and in a sensitive nerve in the centrifugal direction.

Soon after the publication of his "Researches," Du Bois-Reymond, then thirty years old, was elected a member of the Royal Academy of Sciences of Berlin. As already stated, he has ever since pursued and extended his investigations; but it is impossible, in the compass of this brief notice, more fully to detail their results. Moreover, those of our readers who may feel interested in the subject will find a conscientious *exposé* of most of Du Bois-Reymond's papers in the book of one of our countrymen, of whose talents science has been robbed by a premature death—Mr. Charles E. Morgan, author of "Electro-Physiology and Therapeutics" (New York, William Wood & Co., 1868). These results will also be found in Prof. Rosenthal's German treatise on the "Physiology of Muscles and Nerves," contributed to the "International Scientific Series," and soon to be published in this country. Du Bois-Reymond's papers have also been collected in two volumes, under the title "Gesammelte Abhandlungen zur allgemeinen Muskel- und Nervenphysik" (Leipsic, Veit & Co., 1875–'77).

Several of Du Bois-Reymond's papers bear merely upon electricity, without reference to physiology. We will only mention his experimental and theoretical researches on the aperiodic state of the magnetic needle induced, under certain circumstances, by high dampening powers; these researches are of the greatest practical importance. Du Bois-Reymond also showed, contrary to what Berzelius and Liebig had stated, that the substance of muscles when at rest is neutral, or slightly alkaline, becoming acid only after death, when *rigor mortis* sets in, but that also in the act of contraction acid is evolved.

In 1858 John Müller died, and Du Bois-Reymond was appointed in his place Professor of Physiology in ordinary, and Director of the Physiological Laboratory at the University of Berlin. In this position he has exercised a considerable influence on the progress of physiological study in Germany. Many of the professors of physiology at the other German universities have been his pupils; and this influence has been increased by the friendship which has always connected him closely with his fellow-students Brücke, Helmholtz, and Ludwig—all of them physiologists as averse as he to the doctrine of vital forces, and as eager to reduce physiology to applied chemistry, natural philosophy, and mathematics. He was also one of the founders of the Physical Society of Berlin, whose reports on the progress of natural philosophy are well known to every lover of science.

In 1867 Du Bois-Reymond was elected one of the secretaries of the Academy of Sciences of Berlin, and this office afforded him the opportunity of displaying, in the public addresses which it imposes on him to deliver, a new side of his genius. He generally chooses some subject in the history of science on which he knows how to throw a new and brilliant light, as in his essays on Voltaire and on Lamettrie, which have not yet appeared in English.

Du Bois-Reymond is considered one of the most successful teachers of the university, and the public lectures, in which he yearly alternates between "Anthropology" and "Some Recent Advances in Physical Science," are often dangerously crowded. Having been a good deal in England, and married a lady of English education, he commands the English language sufficiently to lecture in it. The late Dr. Bence Jones, of London, who had formed an intimate friendship with Du Bois-Reymond, and had published an abstract of his discoveries ("On Animal Electricity," etc., London, Churchill, 1852), engaged him repeatedly to lecture in the Royal Institution, where Dr. Faraday, and other eminent Englishmen of science, were much interested in his experiments. In 1855, in the theatre of the Royal Institution, he showed, and described in the *Philosophical Magazine*, the beautiful method of rendering the deflection of a galvanometer visible by a beam of light reflected from a mirror attached to the needle; of which method Sir William Thomson subsequently availed himself for the readings of the Atlantic Telegraph so successfully that it has ever since been attributed to that able physicist.

Du Bois-Reymond is a member of the Academies of Vienna, Munich, and Rome, and an associate of the Royal Societies of London, Göttingen, Upsala, etc. He has been employed these last three or four years in erecting in Berlin, at the expense of the German Government, the largest and finest physiological laboratory in existence. His new lecture-room is said to be the most beautiful and best appointed in the world.

EDITOR'S TABLE.

PROFESSOR JOSEPH HENRY.

IN the death of Prof. Henry, Secretary of the Smithsonian Institution, which occurred May 13th, American science has met with an irreparable loss. Little needs to be said in eulogy of a character so widely and familiarly known, and so profoundly respected and admired, as this venerable *savant*. In Volume II. of The Popular Science Monthly will be found an excellent portrait of Prof. Henry, with a sketch of his life, and an enumeration of his most important scientific labors; but there are two or three features of his career that are entitled to special recognition, now that he has passed away.

It is very well understood in the scientific world that, more than any other man, Prof. Joseph Henry is the scientific founder of the system of modern telegraphy, and this honor ought to be equally conceded to him by the general public. His earliest discoveries and his most important scientific work were in the field of electro-magnetic research, entered upon within a very few years after Oersted had announced the discovery of the relations of electricity and magnetism. Prof. Henry worked out experimentally, and by the most elaborate investigations, those laws and principles of electro-magnetic action which made the telegraph possible; and not only this, but he actually constructed and operated an electric telegraph years before Prof. Morse turned his attention to the subject. The great contrivance was of course bound to come, but no consideration of this kind should be permitted to detract in the slightest degree from the honor of those by whom it came. The scientific discoverer is entitled at any rate to have his work recognized, especially as he rarely gets anything else. It is the man who runs in upon his discoveries and applies them and brings them into notice that is usually credited in the popular estimation with all the honor. In this case, Morse has appropriated the glory that fairly belongs to Henry. Morse originated nothing by the current telegraphic alphabet—that is, the combinations of taps and clicks of the instrument, by which letters are denoted. Electricity had long been looked to as an agent for the transmission of intelligence. Many experiments had been made from the time of Franklin to secure this object, but none of them had succeeded. Various contrivances had met more recently with partial success, but Prof. Henry's sounder of 1830 has gradually displaced, and has now almost entirely superseded, all other methods of electric signaling. Mr. E. N. Dickerson, in tracing out the history of telegraphic invention, after stating the merits of various previous contrivances, thus refers to Henry's work:

"Then came Prof. Henry, who, in 1830, deduced from the hypothesis of Ampère—that magnetism was the circulation of electricity at right angles to the line connecting the poles of the magnet—the invention now known as the compound electro-magnet. In that year he constructed an electro-magnet that would sustain 1,000 pounds weight; and he answered the demonstration of Barlow, and proved that the electro-magnetic telegraph was possible. In the same year he set up an electro-magnetic telegraph at Albany, over a line of a mile and a half in length, using what is now known as the 'polarized relay,' between the poles of which a magnetic armature vibrated upon a hinge, as the current of electricity was reversed—the end of the armature striking a sounder, and transmitting the intelligence by sound. This was the first electro-magnetic telegraph (I use the popular phrase) ever made; and it was the first one possible to be made, because, until Prof. Henry's electro-magnet was invented, it was an impossibility. This electro-magnetic telephone, made by Prof. Henry in 1830, is the thing in universal use to-day. It goes by the erroneous name of the 'Morse telegraph;' and it will be in use till the end of time. The thing was perfect as it came from the hand of its author, and has never been improved from that day to this as a sounding telegraph."

Having immortalized himself by these brilliant researches of the laboratory, Prof. Henry was called into a more conspicuous sphere of action as the organizer and administrator of a great public enterprise of national scope in connection with the progress of science. John Smithson, an English chemist and physicist, and member of the Royal Society, had left upward of half a million dollars as a trust to the American Government, to be used for "the increase and diffusion of knowledge among men." How this language was to be construed and how the money was to be expended were open questions. The Washington politicians were in favor of spending it on buildings, libraries, and museums to be established at the national capital, and the whole fund would probably have been buried and lost in this way, but for the influence of Prof. Henry. He was appointed, in 1846, as secretary and principal executive officer of the Institution, and at once applied all his energies to rescue the fund from the misdirection that had been given to it, and to devise more efficient means of obtaining the comprehensive object to which it was devoted. As Smithson was a man of science, and an original investigator of that "natural knowledge" which the Royal Society of Great Britain, of which he was a fellow, was founded to promote, Prof. Henry fairly and justly assumed that the intention of the donor was the increase and diffusion of scientific knowledge—increase and augmentation by research and organized systems of observation, and diffusion by means of extended publication. Henry's policy, therefore, was to diminish expenditures upon buildings, libraries, museums, and art-galleries, that the money might be devoted to wider and more legitimate purposes. He took the ground that the Institution ought to do nothing which can be equally well done by any organization or instrumentality already in action. He accordingly drew up a scheme of operations which provided for extensive researches especially in the fields of ethnology and of meteorology. He had for many years five hundred meteorological observers scattered over the continent, accumulating data designed to elucidate the laws which govern the phenomena of the weather. This branch of work, begun on so thorough a scale by the Smithsonian Institution, has developed into the Signal Service and Weather Bureau in Washington, now so important to the agriculture and commerce of the country. In the department of publications the public has been furnished with the "Smithsonian Contributions to Knowledge," now consisting of many large quarto volumes, all valuable as positive additions to the sum of existing knowledge. Besides these, the Institution has put forth the "Smithsonian Miscellaneous Collections," and "Annual Reports," all of which are intrinsically valuable for the information they contain, and are very widely circulated through the country. Prof. Henry's plan also comprehended an extensive system of exchanges of works, proceedings, and reports, between the literary and scientific associations of the Old and New World. All these features of Prof. Henry's broad and liberal scheme of administering the Smithsonian trust have been carried out vigorously, and with a degree of success that has commanded universal approval. An administration of thirty years has settled the policy of the Institution, and will undoubtedly shape its future, and it is very doubtful if there was another man in the United States that could have done this work with such conspicuous success as the distinguished man to whom it was so fortunately intrusted.

It may be added that, in a business point of view, the establishment has been managed with great skill and efficiency. The amount of money received from Smithson, in 1838, was $515,000, to which was added in 1865 a residuary legacy of Smithson amounting to $26,000; and, notwithstanding that a large portion of the fund has been absorbed in building, all the plans of Prof. Henry have been carried out, and the fund now available exceeds $700,000.

MAGNIFYING SOUND.

How scientific discoveries run in groups, one thing suggesting another so quickly as to make an epoch, is just now illustrated anew in the field of acoustics, and with the usual result of rival claims and disputed priority. Following the telephone and growing out of it comes another remarkable revelation, that minute sounds may be magnified to the ear as minute objects are magnified by lenses to the eye.

The telephone, in transmitting sound, greatly reduces or minifies it, and it therefore became a problem for experimenters to find out how sounds can be transmitted with the least loss of volume and intensity. Mr. Thomas A. Edison early attacked this problem with his usual assiduity and fertile inventiveness. Operating upon many hundred substances of diverse qualities and in varying conditions to test their sonorous capacities under electrical influence, he found that carbon possesses this singular property in a very remarkable degree. He found, moreover, that the effect varies with the pressure upon the carbon, and, what is more astonishing still, that it varies so greatly with the small differences of pressure produced by the passage of sound-waves as to alter the flow of the electrical current. More than a year ago he embodied this principle in the "carbon telephone," by which the capacity of the instrument was greatly augmented.

But now Prof. D. E. Hughes, already well known as the inventor of the type-printing apparatus that bears his name, comes forward with an arrangement involving the same property of the same substance, but developing almost incredible effects. He claims to have reached these results in his own way, as follows: Following a hint of Sir William Thomson in regard to the molecular change and conductivity of wires under mechanical strain, he inserted a stretched and strained wire in his telephonic circuit. But no effect was produced until it broke, when a sound was given out so curious and marked that Prof. Hughes followed it up, by pressing the broken ends together, when the new effect was faintly reproduced. Following this suggestion, he introduced other pieces so as to have broken or imperfect connections, when the faint sounds were improved. Iron nails or a steel watch-chain also answered the purpose.

Prof. Hughes says he found the same property in porous charcoal, and that it was heightened by infiltrating the carbon with metallic mercury. The part introduced into the circuit Prof. Hughes calls the "transmitter," and the arrangement which he recently exhibited to the Royal Society consists of a glass tube two inches long, and one-fourth inch in diameter, filled with a series of plugs of mercurialized carbon, the end-plugs being attached to the wires of the circuit. He uses a small three-celled galvanic battery to furnish the current, and, with the transmitter introduced, sounds otherwise perfectly inaudible by the ear are not only heard, but are conveyed to great distances by the telephone. The surprising thing is that when these pieces of carbon barely touch each other the electric current will not pass; but when the molecules of those adjacent pieces are agitated by sound-waves they transmit electricity freely. The same effect is produced by light when the metal selenium is exposed to light, and its electrical conductivity is unequally affected by the different rays of the spectrum. Prof. Hughes calls his invention the *microphone*, and it has this peculiarity, that the sounds are taken up directly by the "transmitter."

The London *Telegraph* thus refers to the results of Prof. Hughes's experiments before the Royal Society: "Inserting a 'transmitter' in his circuit, an absolutely amazing sensitiveness to sound, as well as power of conveying it with the utmost fidelity, was displayed by the apparatus. A touch of the finger on the vibrating plate of the telephone was conducted to the speaking end in volume of vibration like the rustle of a forest; the stroking of a camel's-hair brush on a card was magnified into the sound of a loud whisper; the beating of a pulse or the tick of a watch was found to pass with perfect clearness through a resistance representing a hundred miles of space; and, when a fly happened to walk over the plate, the tramp of its feet was most distinctly caught, like that of some six-legged horse trotting, and it was, moreover, heard to trumpet from its raised proboscis like an elephant in an Indian jungle. Sounds, in fact, totally inaudible before to human ears, were arrested and reported by this simple and accidental expedient of interrupting the electrical circuit with a finely-divided conducting material."

CATHOLICISM AND ETERNAL PUNISHMENT.

UNDER the title of "Hell and Science," a writer in the *Catholic World* for June makes an elaborate reply to our recent comments on the doctrine of future punishment. He is especially indignant, as might be expected, at our remark that there has been a "rapid liberalization of theological opinion" on this subject. He says that "the doctrine of hell is not a theological opinion but an inspired dogma," which, of course, can be neither liberalized nor got rid of in any other way. In speaking of the altered theological tone upon this subject, we of course referred to what currently passes under the name of theology, but our reviewer avers that we were utterly wrong in the application of the word. This is his case:

> "Theology is essentially based on authority; hence theology has no existence in the Protestant sects, whose very reason of being is a contemptuous disregard of authority, and the assumed right of private interpretation. Now, all those who ventured to argue against the existence of eternal punishment belonged to Protestant sects; and, therefore, their 'liberal view' of the subject does not constitute 'theological opinion.' Protestants may, indeed, assume the title of 'divines;' but the title is not the thing. There is no real theology outside of the Catholic Church. When Catholic divines shall discuss the existence of hell as a free theological opinion—which, of course, will never happen—then only Prof. Youmans will be welcome to say that there has been a liberalizing of theological opinion."

We freely admit that there is great shrewdness in this policy of the Catholics, by which so effective an instrument of domination as the fear of hell is placed beyond examination on the part of the followers of that faith. By shutting off the right of private judgment on dogmas sanctioned by authority, they no doubt get rid of the ferment of discussion and diversity of opinion which, among Protestants, follows the exercise of the right of private interpretation. The writer in the *Catholic World* identifies liberalism with Protestantism, and recognizes that among Protestant sects the notion of hell is dying out. He thus concedes that liberalism leads to this result, which is all that we claimed, but he denies that modern liberalism exerts its baneful and pestilent influence within the precincts of his church, or that there is any change going on within it respecting the dogma of hell. Yet of this we are not so certain. The liberalizing influences of the age are subtile, diffusive, encroaching, and all-pervading. Such influences have been growing for centuries, and the Catholic Church has by no means escaped them in times past. They have convulsed it and rent it, and are now agitating it profoundly. What warrant have we that these patent disturbing agencies are to be inoperative in the future? Our reviewer, indeed, informs us that there is no change in his church in regard to eternal damnation. To our remark that the doctrine of hell is being refined away, he replies that "the literal lake of fire and brimstone is preached even now all over the earth;" and, to our assertion that the notion is growing obsolete, he rejoins that "two hundred millions of Catholics believe the doctrine as a cardinal tenet of the Church."

But it is important not to be misled here. In what sense are these two hundred million Catholics said to "believe" in the doctrine of hell? Belief implies evidence, and is founded upon it; how, then, can men believe that of which they are never permitted to think in connection with evidence? They may *assent* to the doctrine, or *accept* it under the influence of early teaching, or terror, or the coercion of spiritual authority; but the rational act of belief implies the liberty of doubt, the freedom of inquiry, and a judgment resting upon proof. How can this be possible with a dogma upon which men are forbidden to exercise their minds, and are not even permitted to class as a "theological opinion?" We know what the Catholics profess; it is quite another thing to know what they really believe. Of course, the term belief in the theological world is used in a very loose way, and is made to cover whatever is contained in an accepted creed. But in aiming to get at the real state of mind, which is the object here, it is necessary to discriminate between views that are rationally entertained on some claim of reasonable grounds and dogmas that are blindly held under theological dictation. Our reviewer admits that there is a growing liberalization, that it is the very essence of Protestantism, and that it is inroading upon the old doctrine of future everlasting punishment; and it is perfectly well known that the Catholic Church is deeply troubled about the encroachments of the so-called "spirit of the age," which it denounces in the most solemn manner. Can there be any doubt that the invading spirit of liberalism will affect Catholic minds in the same way that it has Protestant minds. If not, where is the danger, and what the excuse, for the anxiety of the Church? Under the external exertion of a rigorous ecclesiastical system, uniformity of profession can be secured; but of what avail is the force of authority in the case, or where does it take effect if not in resisting private reason, and substituting profession for real belief? There may be two hundred million Catholics who still accept the belief in hell, but it is not possible that all of them, in this age, can be in such a complete state of mental paralysis as not to reflect upon the grounds of their belief, and to hold the opinion with more or less of the same reservations that are exercised by other classes of Christian believers.

Prof. Du Bois-Reymond, of Berlin, several months ago gave an address before a scientific association at Cologne, which was recently published in an amplified form by the author. We procured an early copy for translation, and sent the English proof to the author for revision. Meantime the discourse had quickly passed through several German editions, revised by the author, so that the address, the first part of which is now presented to the readers of The Popular Science Monthly, embodies his latest corrections and emendations.

We were especially desirous of having a complete and authorized edition of this elaborate address, both from the profound interest of the topic, and because of certain special views developed by the author which are likely to attract much attention. It is an historical disquisition on the course of civilization in relation to science, and sketches the various stages and phases of man's progress in culture with masterly compression and a vivid eloquence, which will enchain all thoughtful readers. How the Greeks and Romans failed to seize upon the scientific aspects of Nature, and the calamities to the world that followed from that deficiency in their mental cultivation, are problems that Prof. Du Bois-Reymond handles in a fresh and original way. Equally interesting is his view, that for science the world is indebted to Christianity, which, by its monotheism and the intolerance entailed by sincere monotheistic belief, gave a new earnestness and intensity to the human mind, that impelled it to a deeper research into causes, and to a more thorough exploration of the order and method of Nature.

But Prof. Du Bois-Reymond's thesis does not stop with speculative inquiries; it extends to important practical results. The history of the rise of science, as discussed in the first part of his essay herewith printed, has a weighty interest on its own account, but its claim upon our consideration is redoubled from the import of the conclusions arrived at in the sequel. The history of science and civilization derives its highest significance from the bearing it has on the policy of modern culture. The organization or reorganization of education, the formation of national systems of instruction, and the modification and extension of the old colleges and universities, are undoubtedly the gravest questions that the present age has before it, and it is with these that the eminent German professor has grappled in this discussion. They, moreover, have become in a literal sense world-questions; and so intimate are now the intellectual reactions among distant and different countries that the higher policy of education is nothing less than international. Prof. Du Bois-Reymond is keenly alive to these broader aspects of the subject, and the views he presents will have a peculiar interest for readers in this country, because he recognizes not only that America is exerting an influence upon the higher education of Europe, but because he considers that influence as by no means of an elevating or ennobling character—as something rather that the intellect of Europe must put forth its utmost power to withstand.

We continue the important series of papers, by Prof. Alexander Bain, on "Education as a Science." He is now dealing with its psychological basis, and with those laws of mind—in the present paper, of sensibility and emotion—which govern the processes of culture and the arts of the teacher. In his great work on the "Emotions and the Will," Prof. Bain has carefully worked out the principles which are here briefly reëxpounded in their bearing upon educational practice. How to get command of the motors of intellectual cultivation—the emotions—is one of the teacher's most urgent problems. What emotions will hinder the work of culture, and what will promote it, how they are to be quickened and how restrained, under what circumstances they shall be appealed to, and how they come in play in different stages of development and in relation to different objects of study—all these practical questions turn upon a knowledge of psychology, which, if we are ever to have a science of education, must be so sufficient that it can be applied to individual cases. Prof. Bain is clearing the ground for a thorough-going discussion of that element of culture which has been more misunderstood and perverted than any other—the subject of discipline.

LITERARY NOTICES.

Synoptical Flora of North America. By Asa Gray, LL. D. Vol. II., Part I., Gamopetalæ after Compositæ. New York: Ivison, Blakeman, Taylor & Co. 8vo. Pp. 402. Price, $6.00.

We can in no way do such excellent justice to this comprehensive and elaborate work, as by quoting, in full, the able review of it that appeared in the *New York Tribune*:

"The 'Flora of North America,' by Drs. John Torrey and Asa Gray, was commenced in 1838, and appeared in numbers, at convenient intervals, until 1840, when, having reached, in the accepted arrangement of orders, to the end of Compositæ, its publication ceased. So valuable was this 'Flora' to the working botanists, that its discontinuance was a source of great disappointment; and those who were not aware of the reasons which made its intermissions almost imperative were not a little impatient. To those best advised, the discontinuance of the work was known to be really in the interest of American botany. The acquisition of Texas and of new territory at the close of the war with Mexico essentially changed our botanical as it did our geographical area. Up to that time, our knowledge of the far Northwest, the far West, and the Pacific coast, was mainly due to the labors of European explorers, to which were added the results of the journeys of Nuttall, Wyeth, Long, and a few others, but nothing like a general exploration had been made of those vast fields which have since yielded such rich botanical harvests. The two journeys of Fremont, the forced march to the Pacific on the line of the Gila, by Emory, with the volunteer expeditions of Lindheimer, Wislicenus, Fendler, Wright, and some others, resulted in such a wealth of new material, opening, in some cases, an entirely new flora, that it at once became evident to its authors that the 'Flora of North America' could not yet be written with any approach to completeness. These explorations indicated that the number of genera in the families, and the number of species in the genera, already published in the 'Flora,' were in many cases doubled, and it became evident that the authors must either continue a work which would be unsatisfactory when finished, or suspend it for a time, and devote themselves to the elaboration of the rapidly-accumulating new material, which would otherwise pass into other hands. They wisely adopted the latter course, a decision which proved all the more judicious when the survey of the Mexican boundary and the surveys of numerous routes for a Pacific railroad added most essentially to the already rich collections, and opened to botanical exploration such a breadth of territory that but few important localities were left unvisited. Besides these Government expeditions, and nearly contemporaneous with the later of them, came the private explorations of Parry, Hall, and Harbour, and others, while the rapid settlement of mining and other localities brought out a number of local collectors, who made important additions to the rapidly accumulating treasures. The State Geological Survey of California, and the survey under Mr. Clarence King under the fortieth parallel—thanks to Sereno Watson's energy and perseverance—also yielded important botanical results. The time has now arrived when the 'Flora of North America' may be written with the hope of presenting a fairly complete record. Of course new species and new genera are yet to be discovered, but no such bonanza of botanical riches as the past thirty years have developed can be looked for in the future, and our present knowledge may properly be embodied in a work which will serve as a standard, around which the clustering of future accessions will be an easy matter.

"One of the illustrious botanists, whose name appeared as joint author of the earlier 'Flora,' and which will ever be identified with North American botany, has passed away; but the results of Dr. Torrey's many years of labor since the first 'Flora' was discontinued will appear in the new work, the pages of which will show how industriously he labored during that long interval.

"We have said that the present is a most fitting time for making a 'Flora of North America;" it is so, not only in the fullness of materials, but especially so that its author is in the fullness of his industrious and useful life. Prepared, as no other can be, by years of study of our plants from every part of the country, and also by the experiences of extended field-observations on two journeys to the Pacific coast, our first botanist presents this, which we may regard as his crowning work. It is fortunate that, just at this time, those eminent botanists Bentham and Hooker have presented in their 'Genera Plantarum' a complete revision of the genera, made, so far as American genera are concerned, in full sympathy and correspondence with Dr. Gray. While, in the 'Flora,' Dr. Gray may not adopt all the views of these gentlemen, it is not the less gratifying to American botanists to know that the genera, so recently elaborated by three such botanists as Gray, Bentham, and Hooker, are likely to be accepted as established for a long while to come.

"With this brief statement of the 'conditions precedent' to the 'Flora of North America,' which have more interest for the botanist than the general reader, we glance at the work itself.

"The present (first in order of appearance, but not in botanical sequence) is the first part of the second volume, taking up the orders where the former flora left off. It begins with the *Goodeniaceæ*, and ends with the *Plantaginaceæ*. Two more parts will be required to complete the second volume; the one to immediately follow this will be devoted to the Apetalous and Gymnospermous Exogens, and the final part will contain the Monocotyledonous plants and the Vascular Cryptogamia. The first volume will include the Polypetalous orders, and the Gamopetalæ to the end of Compositæ. It is expected that each volume will contain about twelve hundred pages.

"The first thing which will strike the working botanist on opening its pages is the excellent mechanical arrangement of the flora, and especially its compactness as compared with the former 'Flora of North America.' This is attained in part by conciseness of description, but mainly by the omission of extended synonymy. This lack of synonyms is happily supplied by the contemporaneous publication, by the Smithsonian Institution, of the 'Bibliographical Index to North American Botany,' by that most industrious of botanical workers, Mr. Sereno Watson, of the Herbarium of Harvard College. This work gives full references for each species, and, while it is of the greatest importance that its matter should be recorded, it is not of a kind needed by the majority of those who will use the 'Flora,' and its preservation in a separate work is most fortunate, especially as it allows the 'Flora' to be much more compact.

"It is hardly necessary at this day to say anything in praise of Dr. Gray as a systematic botanist. Those familiar with his other works will be prepared for the admirable method which characterizes this; the same conciseness of description, the keen perception which seizes upon and points out the distinctive characters, and the same broad views of the range of genera and species which mark his other works, will be found here. Yet we venture to say that this work will add to his reputation with those who can understand the difficulties of his task, and can appreciate the completeness with which it is executed. Almost any one, familiar with botanical terms, can so describe a species that it may be identified by another. It is the treatment of large genera that puts the systematic botanist to the test. The generic description should give characters which cover every species, while the specific description should not repeat any of the generic characters—a matter simple enough, but its non-observance is very tiresome, even in the works of botanists of distinction. For convenience, large families have in many works an artificial key to the genera, and large genera a similar key to the species. This is well enough in elementary works. In the present 'Flora' the large genera are grouped in subgenera, which, if sufficiently important, have distinctive names; these subgenera are subdivided into sections and subsections, each briefly defined by prominent characters common to all the species it includes. For example, in 'The Flora' (which will soon become its accepted and familiar title), in the now large genus *Mimulus*, we have the primary divisions or subgenera: 1. *Eunanus;* 2. *Diplacus;* 3. *Eumimulus;* 4. *Mimuloides;* all except No. 3 having been ranked by one botanist or another as genera. Some of these subgenera include a dozen or more species, which are grouped in subdivisions of two to five, by characters common to all. It is in such grouping that the systematic botanist shows his tact, and we feel sure that those who make use of 'The Flora' will find that the eye of the author has lost none of its early keenness, and that his perception of the essential characters is as acute as ever.

"While we welcome this installment of the 'Flora of North America' as an important event in the history of American botany, and announce its appearance with no little national pride, we utter the wish of every American botanist when we express the hope that its author may be spared to complete the work so admirably begun."

American Journal of Mathematics, Pure and Applied. Editor-in-Chief, J. J. Sylvester, LL. D., F. R. S.; Associate Editor-in-Charge, William E. Story, Ph. D., with the coöperation of Benjamin Peirce, LL. D., F. R. S., Simon Newcomb, LL. D., F. R. S., and H. A. Rowland, C. E. Published under the Auspices of the Johns Hopkins University. Vol. I., No. 1. Pp. 104. Baltimore: printed by John Murphy & Co. Price, $5 per year; $1.50 single number.

This periodical is to appear quarterly, or as nearly so as may be found practicable, each volume of four numbers containing about 384 quarto pages. It is designed chiefly as a medium of communication between American mathematicians, and has for its primary object the publication of original mathematical investigations. "In addition to this, from time to time concise abstracts will be inserted of subjects to which special interest may attach or which have been developed in memoirs, difficult of access to American students. Critical and bibliographical notices and reviews of the most important recent mathematical publications, American and foreign, will also form part of the plan."

"The editors believe it will materially aid in fostering the study of mathematical science throughout this continent, and they feel it their duty to state that any good which may arise from it will be in a great measure due to the enlightened liberality of the trustees of the Johns Hopkins University, who have prompted the undertaking, and guaranteed a considerable portion of the pecuniary risk attendant upon it."

It is needless to say that this periodical is in no sense popular, and is wholly unintelligible to non-mathematical readers. But it deserves to be sustained in the interest of higher American scholarship, and public-spirited men, who can make it of no use to themselves, may nevertheless promote a good work by subscribing for it, and presenting it to libraries, educational institutions, and mathematical students, who are unable to pay for it themselves.

Tropical Nature, and other Essays. By Alfred R. Wallace. New York: Macmillan & Co. Pp. 356. Price, $3.50.

Mr. Wallace's new volume consists of some eight essays, of which the first four only can be strictly considered as coming within the scope of his principal title. Two of the chapters have already appeared in *Macmillan's Magazine*; one has been published in the *Fortnightly Review*, and one was originally delivered as a presidential address to the Biological Section of the British Association in 1876. Hence the whole work comprises a slightly heterogeneous mixture, and the first three essays have rather the appearance of an afterthought, inserted for the purpose of giving a consistent *raison d'être* to the publication, than that of a complete and consecutive treatise. But, of course, Mr. Wallace can never be otherwise than ingenious and interesting, nor does the present volume form any exception to the general excellence of his compositions.

The author sets out by stating that, while the luxuriance and beauty of tropical Nature are a well-worn theme, which has often suffered from the undue exaggeration of its exponents, no attempt has yet been made to give a broad sketch of those phenomena which are *essentially* tropical, and which mark the chief differences between equatorial and temperate climates. This desideratum he seeks to supply, from the exceptional experience of a long residence in the hottest regions of the Eastern and the Western Hemisphere alike. In pursuance of the design thus laid down, the first essay treats of "The Climate and Physical Aspects of the Equatorial Zone," both as regards their actual phenomena and the causes which lead to their production. Though possessing, of course, little absolute novelty, the facts are well arranged, and so displayed or illustrated as to bring the salient points of tropical meteorology in a very vivid manner before the untraveled student. The second essay, on "Equatorial Vegetation," contains an admirable sketch of the tropical flora, viewed in its *ensemble*, besides a vigorous exposition of the common but fallacious belief that large and brilliant flowers are exceptionally frequent in hot climates. Mr. Wallace succeeds in giving a clear and sufficient notion of the richness and profusion of vegetable growth without rousing any suspicion of that false theatrical glamour which ordinary writers have cast around the subject. The third essay deals with "Animal Life in the Tropical Forests," dwelling especially upon the *Lepidoptera* and *Hymenoptera* among insects; the parrots, pigeons, and picariæ among birds; and the monkeys and bats among mammalia—all of which form the peculiarly equatorial types of their several classes.

But it is with the fourth essay, on "Humming-Birds," reprinted from the *Fortnightly Review*, that the real interest of the work begins. Mr. Wallace gives a short sketch of the structure and habits of these birds, and then takes the species which inhabit the island of Juan Fernandez as illustrations of the action of variation and natural selection. In a bold and successful *a priori* reconstruction of their history, amply justified by the incidental verifications which crop out during the course of the argument, he traces their origin, with great probability, to two separate accidental migrations, under stress of weather, from the opposite coast of Chili. At the same time he shows the probable causes of the resulting variations, and starts a theory of organic coloration, which is more fully treated in the two succeeding essays. He then points out the strong structural resemblances between swifts and humming-birds, while demolishing the supposed connection between the latter and their Eastern representatives, the sun-birds—a connection based entirely upon adaptive and functional peculiarities, necessarily common to two families whose modes of life are so exactly analogous. No better practical specimen of the new biological methods than that afforded by this essay could possibly come into the hands of readers with good common-sense and little special scientific knowledge.

The fifth and sixth essays, on "The Colors of Animals and Sexual Selection," and on "The Colors of Plants and the Origin of the Color-Sense," lead us at once into the region of controversy. They appeared originally in *Macmillan's Magazine*, but they have since been enriched by numerous additions and alterations, in accordance with suggestions from Mr. Darwin or other correspondents. In the first of these two papers, Mr. Wallace brings a powerful battery to bear against the accepted doctrine of sexual selection, and it must be confessed not without effect in shaking, if not in demolishing, that stronghold of Darwinism. He contends that color is a natural product of organic forms, which may be checked or intensified by natural selection, but whose occurrence is quite normal, and so stands in need of no separate explanation. All colors in animals may be classified under four heads—protective colors, warning colors, sexual colors, and typical colors. The two former do not now require further definition; but sexual differences of hue he attributes not to conscious selection of mates, the occurrence of which is emphatically doubted, but to a special necessity for concealment in one or other sex; as, for example, in the incubating females of birds, or in the males among those species in which that sex undertakes the duty of hatching. This explanation would refer the variety in coloring to natural selection alone, acting unequally upon the several sexes, and so causing a partial suppression of bright tints. The vast majority of animal markings Mr. Wallace attributes to typical coloring; that is to say, a conventional or meaningless distribution of pigment, serving mainly for purposes of recognition between the members of the same species. Though it would be rash too readily to accept or reject these careful and well-reasoned conclusions, it seems probable that an intermediate belief will ultimately prevail. Certainly, Mr. Wallace has shown beyond a doubt that natural selection will adequately and simply account for many curious phenomena which Mr. Darwin believed to be due to conscious preference. The partial elimination of this markedly Lamarckian element in the theory of descent cannot but be regarded as a distinct gain, though few readers will be inclined entirely to agree with the author in his total rejection of sexual selection.

The sixth essay applies the same general principles to the colors of plants, and contains some interesting speculations on the beauty of Alpine flowers, and on the difference between succulent fruits and nuts. It also touches briefly on the question of the development in insects and vertebrates of a faculty for the perception of colors, with remarks upon the theories lately advanced by Geiger, Magnus, and Gladstone. This and the succeeding paper are chiefly noticeable for their exposition of the author's opinions upon certain ultimate teleological questions. In his book upon the Malay Archipelago, Mr. Wallace advocated the belief that all the beauty of the external world was due to natural causes, without any divine afterthought as to its effects upon the human mind. But, since that time, the implications contained in the doctrine of evolution seem to have clashed with earlier prejudices, and driven this otherwise acute and vigorous thinker into a coquetry with so-called spiritualism, which has vitiated much of his later work. In the present volume he suggests that the colors of the organic world, though developed by ordinary laws, may have been specially directed by some superior agency with reference to the final enjoyment of their beauty by man. In short, he inclines to the purely gratuitous supposition that butterflies, birds, and flowers, acquired brilliant tints in the Secondary and Tertiary periods, partly in order that men might look upon them in the Quaternary. And the essay which we are now considering concludes with the ominous sentence, "The emotions excited by color and by music, alike, seem to rise above the level of a world developed on purely utilitarian principles." It is greatly to be regretted that the joint discoverer of the theory of natural selection should allow himself to make use of such painfully dyslogistic and unscientific language.

The seventh essay, the presidential address, bears the title of "By-paths in the Domain of Biology," and consists of two totally distinct portions. The first comprises an excellent monograph, in the author's happiest manner, on the influence of locality upon coloration, and brings together a number of valuable facts upon which future theory may be founded when the time becomes ripe. But the second part is a criticism upon the views generally entertained by the scientific world on the origin and antiquity of man: and the conclusion toward which (though nowhere clearly stated) it implicitly points is the author's favorite dogma that the human intellect has *not* been evolved by the same natural causes which have developed the human organism. As elsewhere, Mr. Wallace seems disposed to believe in a special and solitary miracle, whereby a new form of consciousness was suddenly and supernaturally foisted upon the human brain. Readers of Mr. Herbert Spencer's "Psychology" will scarcely incline to accept this incongruous and ill-digested hypothesis.

The eighth essay treats of the "Distribution of Animals as indicating Geographical Changes." The author here treads again on firmer and more familiar ground, and his conclusions carry considerable weight.

As a whole, the work, in spite of many crudities and a marked increase of the teleological bias, is fully worthy of Mr. Wallace's deservedly high reputation. Every page is laden with fruitful and suggestive ideas; while the same charming and natural style as ever carries on the reader with unflagging interest from the first page to the last. The book is one which will arouse much controversy upon special questions; but it cannot fail to extort praise for its width of view, its subtilty, its firm grasp of principles, and its perfect mastery of facts. It should find a place at once in the library of every thinking naturalist and every general reader who feels an interest in the great and absorbing problem of organic evolution.

The Sugar-Beet in North Carolina. By A. R. Ledoux. Raleigh: *Farmer and Mechanic* print. Pp. 50.

We have in this pamphlet an account of certain experiments in the cultivation of sugar-beets in North Carolina, together with a statement of the present condition of the sugar-beet industry in the United States. Further, there is a synopsis of the results obtained in beet-culture in Europe. The information here contained would doubtless be of interest to farmers everywhere, though it is addressed primarily to those of North Carolina, the author being chemist to the Department of Agriculture of that State.

A Critical History of the Doctrine of a Future Life. By William Rounseville Alger. Tenth edition, with Six New Chapters, and a Complete Bibliography of the Subject comprising 4,977 Books relating to the Nature, Origin, and Destiny of the Soul. The Titles classified and arranged chronologically, with Notes and Indexes of Authors and Subjects. By Ezra Abbott, Librarian of Harvard College. New York: W. J. Widdleton. 1878. Pp. 913. Price $3.50.

The new and enlarged edition of this erudite and exhaustive work is now especially timely and opportune, as the doctrine of punishment in a future life is undergoing so thorough and searching a scrutiny. Dr. Alger's book is a perfect treasury of history, analysis, and criticism, in relation to the course of human speculation and of religious belief respecting man's future state. We published some strictures not long since, on the doctrine of eternal punishment, and aimed to show that the belief in hell is confined to no religion and no period, but in a great variety of forms is an ancient and universal belief. Our assertion has been feebly contradicted by an eminent Catholic authority, to whom we refer the encyclopedic work now before us. The added chapters in the tenth edition, it may be stated, greatly amplify and strengthen the proofs of the position we assumed—proofs that were already as overwhelming and demonstrative as anything to be found in the history of human opinion. Dr. Alger has contributed a standard and most valuable work to the literature of this interesting subject, which will be made doubly useful to all scholars and inquiring readers by the comprehensive and careful bibliography which has been appended to it, and we are glad to notice that the liberal publisher has issued the book in a handsome form and at a price so extremely low that it may take its place in every private library.

Insanity in Ancient and Modern Life. With Chapters on its Prevention. By Daniel Hack Tuke, M. D. New York: Macmillan & Co. Pp. 226. Price, $1.75.

This is a popular volume by an authority upon the subject which it treats, and which is becoming constantly of greater general interest. Formerly belonging to the medical profession, questions of insanity are now engaging the attention of legislators, educators, and sociologists. The historical chapters are curious and interesting, and those on the management necessary for preventing attacks of mental disorder are instructive and important.

The Boy Engineers. What they did and how they did it. By Rev. J. Lukin. New York: G. P. Putnam's Sons. Pp. 344. Price, $1.75.

The design of the author of this book is to inspire boys with an interest in engineering and mechanical work, and to develop any latent capacity they may possess in that direction. The work is written in the form of a simple autobiography, wherein a boy is supposed to chronicle his own and his brother's labors as amateur mechanicians and engineers. Still the volume contains something more than a record of boy engineering, though at the same time, as the author remarks, there is no work described in it which a persevering and industrious lad might not accomplish. The "Boy Engineers" cannot fail to exert a healthy influence on its youthful readers.

Intercultural Tillage. By Dr. E. Lewis Sturtevant. Reprinted from the "Report of the Secretary of the Connecticut State Board of Agriculture." Pp. 42.

By "Intercultural tillage," Dr. Sturtevant means tilling, stirring the soil while the plant is growing. The value of intercultural tillage has long been understood, but not so its *rationale*. Hoeing and ploughing serve to remove weeds, also to loosen the soil, and both of these things favor the growth of the plant. But Dr. Sturtevant finds that the main advantage derived from intercultural tillage is the *pruning of the roots*, causing them to branch out abundantly in every direction, in search of food. He cites sundry experiments made by himself, which go to show that this is the true theory of "intercultural tillage." The pamphlet is well worthy of the attention of farmers.

Journal of the Academy of Natural Sciences of Philadelphia. New Series. Vol. VIII., Part III. Pp. 127, with 14 Plates.

Two paleontological memoirs are contained in this number of the *Journal*, viz., a "Description of Vertebrate Remains, chiefly from the Phosphate Beds of South Carolina," by Prof. Joseph Leidy, and a "Description of a Collection of Fossils made by Dr. Antonio Raimondi in Peru," by William M. Gabb. The vertebrate remains determined by Prof. Leidy embrace species of *Equus*, *Hipparion*, *Elephas*, *Mastodon*, *Manatus*, *Cetacea*, Fishes, and other land and marine animals. Dr. Raimondi's collection represents the labors of eighteen years, and was described in part by Prof. Leidy, some years ago, in the *American Journal of Conchology*. The work is now complete, and there is appended a pretty full "Bibliography of South American Paleontology," together with a "Synopsis of South American Paleontology."

Chemical Experimentation: Being a Hand-book of Lecture Experiments in Inorganic Chemistry. Systematically arranged for the Use of Lecturers and Teachers in Chemistry, as well as for Students in Normal Schools and Colleges, and for Private Study. By Samual P. Sadtler, Ph. D., Assistant Professor of Chemistry in the University of Pennsylvania. Louisville: J. P. Morton & Co. Pp. 225. Price, $2.50.

This is a hand-book of chemical experiments, and makes no claim to be a chemical text-book. Following the order of Barker's "College Chemistry," the work is designed to give full instructions for the illustration of chemical lectures. A large variety of experiments are fully described, from which teachers may draw for such as are thought best for class-room illustration. It is an excellent compilation for an important purpose, and cannot fail to be useful in institutions which have ample command of chemical apparatus. The illustrations are large, numerous, and admirably executed.

At the Court of King Edwin: A Drama. By William Leighton, Jr. Philadelphia: J. B. Lippincott & Co. Pp. 157. Price, $1.25.

This is said to be considerable of a poem, and we know nothing to the contrary.

The author wrote "The Sons of Godwin," which was published a fortnight before Tennyson's "Harold," and the *Louisville Courier-Journal* said: "It appears at the same time with Tennyson's poem, upon the same theme, and does not suffer by comparison with it; it has more dramatic fire, and moves with brisker step, and has as sweet songs in it, and as much poetry." If all this be true, then there must undoubtedly be excellence in Mr. Leighton's present work.

A New and Important Cook-Book.—D. Appleton & Co. will shortly publish the "Hand-Book of the National Training-School of Cookery" at South Kensington, London. These practical "lessons in cookery" are the result of years of careful experience in training pupils of all grades and capacities in the art of preparing food in the best manner. The English press are unanimous in declaring that, in point of simplicity, clearness, and fullness of directions, in presupposing complete ignorance on the part of the learner, and adopting a method that is easy to follow, this book is greatly superior to any work upon the subject hitherto produced.

PUBLICATIONS RECEIVED.

Manual of the Vertebrates of the Northern United States. By D. S. Jordan, Ph. D., M. D. Second edition, revised and enlarged. Chicago: Jansen, McClurg & Co. Pp. 406. $2.50.

Machine Construction. By E. Tomkins. Vol. I., Text, pp. 368, $1.50; Vol. II., Plates (XLVIII.), $4.50. New York: Putnams.

Report of the United States Fish Commissioner (1875, 1876). Washington: Government Printing-Office. Pp. 1024.

Science Lectures at South Kensington. Vol. I. London and New York: Macmillan. Pp. 290. $1.75.

Current Discussion. Vol. II., Questions of Belief. New York: Putnams. Pp. 370.

Art Hand-books—Sketching from Nature. Pp. 74.—Landscape Painting. Pp. 74. New York: Putnams. 50 cents each.

Encyclopædia of Chemistry. (Parts 26 to 30 inclusive.) Philadelphia: Lippincott.

Iron-Works of the United States. Pp. 136. Report of the Iron and Steel Association. Pp. 89. Philadelphia: The Association.

Flowering Plants and Higher Cryptogams growing without Cultivation near Yale College. New Haven: The Berzelius Society. Pp. 71.

Pacific Coast Minerals, Ores, etc., in the Paris Exposition. San Francisco: E. Borqui & Co. print. Pp. 99.

Abstract of Statement of the Board appointed to test Iron, Steel, and other Metals. Salem: Printed at the Salem *Press*. Pp. 20.

Metric System of Weights and Measures. Philadelphia: The Engineers' Club. Pp. 5.

Mental and Moral Science. By H. Howard, M. D. From *Canada Medical Journal*. Pp. 15.

The Kirografer and Stenografer. Quarterly. Amherst, Mass.: J. B. & E. G. Smith. Pp. 32. $1 per annum.

Report on the State Asylum for Insane Criminals. Auburn, N. Y.: Moses print. Pp. 23.

Remarkable Case of Morphine Tolerance. By J. L. Little, M. D. From *American Journal of Obstetrics*. Pp. 6.

Vital Magnetism in the Treatment of Disease. By F. T. Parson. Brooklyn: The Author. Pp. 32.

Report of the Commissioner of Agriculture. Raleigh, N. C.: *Farmer and Mechanic* print. Pp. 18.

Perception of Color. By G. S. Hall. From "Proceedings of the American Academy of Arts and Sciences." Pp. 12.

Color-Blindness in Railroad Employés and Pilots. By B. J. Jeffries, M. D. Boston: Rand, Avery & Co. print. Pp. 40.

Medical Jurisprudence. By S. E. Chaillé, M. D. Philadelphia: Reported for "Transactions of the International Medical Congress." Pp. 40.

Filtration of Potable Water. By W. R. Nichols. From the "Massachusetts Health Report." Pp. 90.

Our Revenue System. By A. L. Earle. Pp. 47: France and the United States. Pp. 44; Suffrage in Cities. By S. Sterne. Pp. 41; Protection and Revenue. By W. G. Sumner. Pp. 38. New York: Free-Trade Club, 25 cts. each.

Report on the Retreat for the Insane. Hartford, Conn.: Case, Lockwood & Brainard Co. print. Pp. 27.

Report of the Zoölogical Society of Philadelphia. Philadelphia: The Society. Pp. 28.

The Medical Expert. By W. J. Conklin. M. D. From the *Ohio Medical and Surgical Journal*. Pp. 20.

New Method of planning Researches, etc. By R. H. Thurston. Salem: Printed at the Salem *Press*. Pp. 7.

The Psycho-Physiological Sciences and their Assailants. Boston: Colby & Rich. Pp. 216.

Contributions to Paleontology. By S. A. Miller and C. B. Dyer. With 2 Plates. From the *Journal of the Cincinnati Society of Natural History*. Pp. 16.

Petrography of Quincy and Rockport. By M. E. Wadsworth. From the Proceedings of the Boston Society of Natural History. Pp. 8.

POPULAR MISCELLANY.

Fossil Mammal from the Jurassic of the Rocky Mountains.—One of the most interesting discoveries made in the Rocky Mountain region is the right lower jaw of a small mammal recently received at the Yale College Museum, and described by Prof. Marsh under the name *Dryolestes priscus*. The specimen was found in the Atlantosaurus beds of the upper Jurassic, and the associated fossils are mainly Dinosaurs. The specimen is in fair preservation, although most of the teeth have been broken off in removing it from the rock. The penultimate molar, however, remains in place. The shape of the jaw and the position and character of the teeth show that the animal was a small marsupial, allied to the existing opossums (*Didelphidæ*). The tooth preserved has the same general form as the corresponding molar of *Chironectes variegatus* (Illiger). The angle of the jaw is imperfect, but there are indications that it was inflected. The present specimen indicates an animal about as large as a weasel. It is of special interest, as hitherto no Jurassic mammals have been found in this country.

Threatened Outbreak of Vesuvius.—Mount Vesuvius is giving signs of an approaching season of great volcanic activity. A bulletin issued by Prof. Palmieri states that the new mouth, which opened at the bottom of the crater in 1872, and which has been more or less active since December 18, 1875, began on May 2d last to give indications of being still more active. The fire cannot be seen from Naples, as it is at the bottom of the crater, and only its reflection is visible on the smoke which rises from it. This reflection is of course greater when the bellows of Vulcan blow up a stronger flame. The smoke, which abounds in acids, mingled with rain-water, is extremely injurious to vegetation, particularly in the direction of Ottaiano, where the vintage has been destroyed for nearly two years. So long as the eruption continues to be central, a long time must elapse before the lava will roll down the sides of the cone, as the cavity of the crater is far from being full. But, should the cone be opened laterally by some extraordinary eruptive force, then the lava will pour out in a deluge.

The Organ-Piano.—Many are the devices that have from time to time been contrived for the purpose of giving to the notes of the piano the "sustained" character possessed by those of the organ. For whatever reason, none of these contrivances have hitherto met with general acceptance, and "organ-pianos" are as yet merely curiosities. But an instrument of this kind is now on exhibition in Paris, which appears to be of practical value, and for which there is already a good demand. There is a brief description of this "organ-piano" in *Nature*, from which we take the following particulars: In this instrument the "organ" or prolonged sounds are produced by a succession of extremely rapid hammer-blows. Besides the usual piano-hammers, the piano-organ has a series of additional hammers (one to each string), mounted on watch-spring levers, all of which are carried by a bar of brass lying across, but above and clear of, the strings. To this bar is attached a rocking lever which is set in very rapid motion by means of an apparatus worked easily by a pedal. The pianist works the pedal, and thus sets the transverse bar with its series of hammers into excessively rapid vibration. By holding down any key of the instrument, the string belonging to it is brought within range of its corresponding hammer, and is struck with corresponding rapidity, giving out what sounds at a short distance like one prolonged note, lasting as long as the pedal is worked and the key is kept down. In this way the performer can produce either piano or organ notes at will.

Sun-Worship among the Moquis.—Traces of sun-worship still exist among the inhabitants of the Moqui villages in Arizona. They have lost the substance of the antique religion, but they retain a portion of the ceremonial—the watching for the emergence of the day-god in the eastern horizon. But it is not the sun they now watch for, but Moteculzuma (Montezuma), their Messiah, so to speak. Mr. Edwin A. Barber, in the *American Naturalist*, describes as follows the impressive scene witnessed every morning at dawn in the Moqui villages: "As the faint streak of red lights up the low horizon, tall, dark figures appear on the parapets of the seven Moqui towns" (a description of which was given in Vol. VI. of the Monthly), "and remain facing the dawn until the sun has appeared entirely to view. Then the muffled forms drop away slowly and sadly, one by one, for another morn has brought disappointment to the souls of many that have watched so eagerly and persistently for the coming of the great Montezuma. The routine of another Moqui day has commenced; all is bustle and life, and the subdued hum of household occupation floats out drowsily on the sullen, sultry air, and the sound of the hundred flour-mills (*metates*), grinding steadily on every side, seems, as it issues from the doors and windows of the stone houses, to pause in mid-air like a droning bee. Then scores of busy figures repair with their water-vessels to the verge of the steep bluffs, and disappear in the crevices of the rocks below."

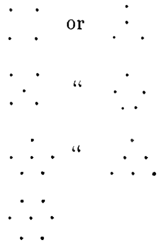
How Monkeys dislike Snakes. — That monkeys, like man, have a peculiar instinctive abhorrence of snakes, is shown by an experiment made in the Philadelphia Zoölogical Garden by Mr. Arthur E. Brown, and recorded in the *American Naturalist.* Mr. Brown having wrapped a dead snake in paper, set the package on the floor of a cage containing forty or fifty monkeys. It was instantly spied by a female cynocephalus, who quickly seized the paper and dragged it away with her. Soon the paper unfolded and the snake slipped partly out. On seeing what the package contained, the cynocephalus instantly dropped it and sheered off. The other monkeys now cautiously approached the dead snake, but all were careful not to come too near, with the exception of one, a large macaque, who would make an occasional snatch at the paper, as though to see whether the dreaded animal were really dead. A pull on a string attached to the tail of the snake, causing it to stir, sent the inquisitive monkeys scampering away, but they would again return, ever keeping at a respectful distance. The dead snake was then successively introduced into cages occupied by animals of other orders — carnivores, rodents, ungulates, etc.—but none of them paid it any special attention except one peccary, which, finding that it was dead, seemed disposed to eat it. The author observed in a deaf and dumb lady the expression of the same emotions and feelings, on beholding serpents, which had been exhibited by the monkeys. There were the same fear, the same attraction and repulsion; and after watching for a long time, with an expression of intense disgust, a cage of boas, she was led away by her friends, protesting that she wanted to stay.

Discoloration of Brick Walls. — Brick buildings, in the neighborhood of New York, are often seen disfigured by streaks and patches of white; but it is in Philadelphia that the evil is most noticeable. There these white incrustations are very general on brick house-fronts, and the study of their causes and their remedy has for some time engaged the attention of builders. Mr. William Trautwine is, so far as we know, the first who has attempted a thorough, scientific investigation of the subject; and his observations, published in the *Journal of the Franklin Institute*, are eminently worthy of the attention of architects in localities where this disfiguration makes its appearance. The evil, he says, is most noticeable in dry weather on parts of walls subjected to dampness, and on entire walls after rain-storms have soaked them. The white coating is derived primarily from both the bricks and the mortar. In some instances it undoubtedly comes from the bricks; here the white substance is dissolved by moisture from the bricks even before they are built into the houses. The author has found it in bricks just from the kiln. It has a peculiar taste—that of sulphate of magnesia; but besides this salt the bricks also contain sulphate of lime. The author's theory is that the silicates of magnesia and lime in the bricks are converted into the sulphates by the sulphuric acid evolved from the sulphide of iron and iron pyrites contained in the coal which is employed in the kilns. Now, sulphate of magnesia effloresces in dry air, and sulphate of lime is dissolved by moisture and appears on the surface of the bricks. Hence, plainly, one mode of preventing the incrustation is the employment only of wood or of coke free from sulphur in the kilns—at least this might be done in the manufacture of pressed brick for house-fronts. As for the incrustations having their origin in the mortar, the author remarks that sulphate of magnesia is largely produced by the decomposition of mortar. His observations on this head have special application to Philadelphia and its vicinity, where most of the lime used in building is from magnesian limestone. The resulting mixture of limestone and magnesia, when slaked and made into mortar, is very susceptible to the influence of sulphurous fumes in the atmosphere, which produce in the mortar sulphates of lime and magnesia. The great solubility of sulphate of magnesia facilitates its diffusion; sulphate of lime is comparatively insoluble, and does not cause so much disfigurement. Of course, mortar made with lime from magnesian limestone quickly decomposes, and the bricks it was intended to cement become loose. The remedy for this evil is the employment of lime from non-magnesian limestone.

This explanation of the phenomenon of incrustation is pronounced to be the correct one by the editor of the *Polytechnic Review*, who also approves Mr. Trautwine's proposed remedy for the evil. At the same time he offers, on theoretical grounds, a simpler remedy, which he proposes to have subjected to the test of practical experiment. This remedy is the addition of a small quantity of baryta to the water used for tempering the brick-clay. The *rationale* of this process we will state as briefly as possible, mainly in the author's own words: The incrustation being due to the process of soluble sulphates, caused by the decomposing action of sulphuric acid on the magnesia and lime silicate in the clay, the presence of a small amount of free baryta would either altogether prevent or at least greatly reduce the amount of this decomposition. The baryta, having a strong affinity for the free acid, would seize upon it, and with it form insoluble sulphate of baryta. Even though the free baryta did not altogether prevent the formation of the soluble sulphates, it is safe to assume that there will be present in the finished brick sufficient uncombined baryta to decompose and cement into insoluble barium sulphate such soluble magnesia and lime sulphates as may have been formed during the process of burning, so soon as these sulphates are dissolved by moisture. A like addition of baryta to mortar after it is prepared for use may reasonably be expected to check the tendency to efflorescence, except of course where the mortar, as in chimneys, is continuously exposed to the action of sulphurous vapors.

An Interesting Experiment.—A simple experiment, devised by Prof. A. M. Mayer, illustrates in a very effective way the action of the forces of attraction and repulsion on bodies freely moving in a plane, and serves to give clearness to our conceptions of molecular action. He takes a number of needles, of the size known as "number 6," and magnetizes them, giving to all the points the same polarity, say north. Then each needle is driven into a small cork float, so that it will keep the upright position in water, the eye just coming through the top of the float. If, now, three of the needles be dropped into a bowl of water, and the north-pole of a rather large cylindrical magnet be brought slowly down over them, the mutually repellant needles are made to approach one another, and then arrange themselves thus . ˙ . Raise the magnet, and the needles go farther apart; lower it, and they come together again, the three needles always holding their places at the vertices of an equilateral triangle. Add needles successively, and the following arrangements will be seen, viz.:

With 4 needles … or
" 5 " … "
" 6 " … "
" 7 "



The needles *can be made* to assume the arrangements shown in the second column, but these figures are not stable. So long as the magnet is held directly over them, the needles will remain in the positions indicated; but raise it, so as to let the needles go apart, and then bring it down again quickly, and in all probability the figure given in the first column will be the result. Prof. Mayer has obtained the figures up to the combination of twenty needles. He adds, in a note to the *American Journal of Science*: "These experiments can be varied without end. It is certainly interesting to see the mutual effect of two or more vibrating systems, each ruled more or less by the motions of its own superposed magnet; to witness the deformations and decompositions of one molecular arrangement by the vibrations of a neighboring group; to note the changes in form which take place when a larger magnet enters the combination, and to see the deformation of groups produced by the side action of a magnet placed near the bowl."

Experiments with the Electric Light.—A public exhibition was recently made in Cleveland, Ohio, of an electric-light machine invented by Mr. Charles E. Brush, of that city. The results were in the highest degree satisfactory, as will be seen from the following account of the experiment which we condense from the *Cleveland Herald*:

The machine is capable of giving a light of 12,000 candle-power, the electric fluid being distributed to four electric lamps, each having the power of three thousand candles. The exhibition was given in the establishment of the Union Steel Screw Company, where two of the lamps were placed on the third and two on the fourth floor of the immense building. The illumination was perfect. The rooms were flooded with a pure white light like the light of the sun, and it streamed out at all the windows, illuminating houses and streets for a long distance in every direction. The light was very uniform and steady, free from the flickering that used to be an accompaniment of electric light, and, considering the enormous illuminating power, the light was unexpectedly soft and endurable to the eyes. An opportunity was afforded to test the character and whiteness of the light. Worsteds, scarfs, afghans, etc., of brilliant shades were hanging against the wall at one side of the room, and it was noticed that the colors were brought out as clearly as by the full light of the sun. Estimates were made as to the amount that the light furnished by this apparatus would cost, if used by the Screw Company as it was used on the evening of the exhibition, and it was ascertained that the total cost of the whole light from the four lamps, including the items of consumption of carbon in the lamps, interest on the investment, and wear and tear, would not exceed thirty cents per hour. The light produced was photometrically equal to eight hundred gas-burners, burning five feet of gas per hour each. This amount of gas would cost eight dollars per hour in Cleveland.

Ascent of Mount Ararat.—In September, 1876, Mr. J. Bryce made the ascent of the greater peak of Mount Ararat, and at a recent meeting of the London Geographical Society gave an account of the feat. Mount Ararat is situated nearly in the centre of the region known as Armenia—a territory divided between three empires, and lying round the sources and upper courses of the Araxes, Euphrates, and Tigris. The mass of Ararat is about twenty-five miles long from northwest to southeast, and from twelve to fourteen miles wide. It consists of two peaks joined together by a sort of neck. The greater peak, Great Ararat, rises 17,000 feet above sea-level, and the lesser peak, Little Ararat, 12,800 feet; both are of volcanic origin. Mr. Bryce began the ascent from a small Tartar village on the northeastern face of Great Ararat, being accompanied by a friend and two guides, a Cossack and a Kurd. At the height of about 11,500 feet Mr. Bryce's friend abandoned the attempt to reach the summit. The remainder of the climb had to be made over beds of snow, and over bare, loose, broken stones; the latter course Mr. Bryce chose. At the height of 15,000 feet the Cossack and the Kurd refused to go any farther, so he was compelled to journey alone. The last part of the ascent was upon a slope of rotten rocks, rather soft and sulphurous, which crumbled under his feet, adding greatly to his fatigue. Near the top of this slope Mr. Bryce could just discern the edges of the plateau of snow, and hanging on this a curtain of clouds. After ascending into these clouds two strong blasts of wind swept them away, and then a wonderfully grand and extensive view lay before him. The Caucasus could be seen to the north, distant about 250 miles; the highest ranges of mountains round Erzeroum to the west; the mountains of Assyria, and South Kurdistan, the mountains in the direction of Nineveh, and the valley in the direction of the Zab, to the south; to the east, the enormous mountain-masses in Persia, and north as far as the Caspian. But in his fondest anticipation Mr. Bryce was doomed to a sad disappointment: he could find no fragment of Noah's ark!

Prevention of Contagious Diseases.—Two modes of fortifying the system against the attacks of zymotic disease are pointed out by Dr. E. M. Hunt, in the *Medical Record*, viz.: topical application of substances inimical to the development of contagia; and, secondly, the introduction into the blood of substances which shall prevent fermentive, defibrinizing or destructive processes. On the hypothesis that *contagium vivum* is introduced into the human system from without, and mostly through the inbreathed air, the author advocates the charging the mouth and nostrils with antiseptic substances so as to render the breath and the tissues more immediately exposed unfriendly to the development of the contagium. When the floating infective particle presents itself either for local manifestation or for absorption, it may require "but slight unfriendliness of reception to prevent morbid result." In diseases like diphtheria and scarlet fever, which at the outset have such marked local manifestation as to lead us to believe that they are local before they are constitutional, topical application of remedies seems to be clearly indicated. But the author thinks that the introduction of certain substances into the blood is a still more effectual mode of combating contagia. In this way not only are the portals of entrance protected, but the fluids, glands, etc., of the system are so permeated with the antiseptic or antifermentative agent as to be able to withstand the action of the disease-germ. How much may be due to the local hinderance to fertilization, and how much to the constitutional resistance established, may not in each case be easy to determine. But when we consider how readily chlorate of potassium, after being administered, is found in the secretions, how soon a few grains of pure protochloride of iron increase the number of the red globules of the blood, how defibrination of the blood is retarded by certain agents, we are justified in the hope that our power to suspend the action of disease-poisons will yet be greatly augmented.

Creosote as a Timber-Preserver.—Railway-ties, dried, and saturated with creosote, will last, according to Mr. E. R. Andrews, for twenty years or more in good condition. In ties so treated the spikes intended to hold the rail do not corrode nor work loose. Then, too, the surface of the tie under the rail does not decay nor wear, because it is not affected by alternate dryness and moisture. In the construction of wharves and in ship-building, creosoted timber is also of great advantage. It is proof against the ravages of the *Teredo navalis* and other mollusks which cause such destruction of timbers submerged in sea-water. The woods best adapted for the creosoting process are those which are light and porous, as these most readily absorb the creosote; so treated they become more solid and enduring than the most costly species of timber. "The cottonwood of the Southwest," writes Mr. Andrews, in the *American Gaslight Journal*, "can be made as useful as oak for ties. White pine absorbs creosote like a sponge, and the yellow pine of the South takes it readily also. In England fir from the Baltic is used altogether for ties, and I do not see why the despised fir from our forests may not be used for the same purpose here. Hemlock is good also; spruce is a firm, compact wood, and absorbs oil with more difficulty; neither does it require so much to preserve it. Oak has a coarse fibre, and is easily treated."

The Eyes of Deep-Sea Animals.—In giving to the National Academy of Sciences an account of recent dredging and sounding in the Gulf of Mexico, Prof. Alexander Agassiz referred to the question of sight in marine animals living at great depths. He said that the crustaceans and fishes taken from depths of from 1,500 to 1,900 fathoms or more present conditions diametrically opposite to one another with respect to vision, some of these creatures being eyeless or nearly so, others having eyes enormously developed, as if to enable them to see with the faintest glimmer of light. In the former class many very curious modifications of structure are to be seen taking the place of the eyes. The existence of these very wide differences of structure under identical conditions he regarded as strange, but, in the discussion which followed the reading of the paper, Profs. Cope and Gill held that this difference was precisely what we might expect, according to the evolution hypothesis. There is nothing surprising in the fact that in one set of animals "survival of the fittest" should work obliteration, and in another class abnormal development of the visual organs.

Studies of Embryo Life.—On opening the shell of a hen's-egg in the third day of incubation, Harvey noticed the heart-beats of the embryo, which, however, soon ceased. He then placed the egg in warm water, and the heart commenced to beat again. The same experiment, but with important modification, has been repeated by M. Dareste, who for some years past has devoted himself with great assiduity to the study of embryo life. He took from under a hen an egg on which she had sat for three days, and let it remain in the ordinary temperature for two or three days. He then again placed it under conditions favorable to incubation, and in due time a chick was hatched out, just as if there had occurred nothing unusual in the mean time. The result of this ingenious experiment, as M. Stanislas Meunier observes in *La Nature*, is to show that life may be suspended for a considerable length of time in warm-blooded animals without fatal effects, precisely as in animals of a very low grade, such as *Rotifera*.

Mars's Fast Moon.—The periodic time of the inner satellite of Mars is only very little over seven hours, while the axial rotation of Mars itself requires about twenty-four hours. Now, this discrepancy is in apparent conflict with the nebular hypothesis, which assumes all the secondary bodies of a system to have been evolved from their primary at successive stages, with the velocity of the primary's surface at the time of their being dropped as rings of nebulous matter. But here is a planet's satellite possessed of a velocity of revolution more than thrice as high as the velocity of axial rotation possessed by its primary. The problem, how to account for this accelerated movement of the inner Martial moon, has occupied the attention of astronomers since the discovery of Mars's satellites by Prof. Asaph Hall, a few months ago. The theory proposed by Prof. M. H. Doolittle, of the Coast Survey, appears to solve all the difficulties of the case. In three ways, according to Prof. Doolittle, the relative velocities of Mars and his moon might be modified by the impact of interstellar matter, or meteorites: 1. These bodies, by striking the satellite and forcing it to travel in a narrower orbit, its original absolute velocity continuing the same, would increase its relative velocity; 2. By striking the primary, they would increase its mass and its attraction on the satellite; 3. By increasing the mass of the primary and so reducing its absolute velocity they would make the relative velocity of the satellite higher.

NOTES.

The American Association for the Advancement of Science will assemble in St. Louis, on August 21st. The officers are: President, Prof. O. C. Marsh; Vice-President of the Physical Section, Prof. R. H. Thurston; Vice-President of the Natural History Section, Prof. Augustus R. Grote; General Secretary, Prof. H. Carrington Bolton; Secretary of Section A, Prof. Francis E. Nipher; Secretary of Section B, George Little; Treasurer, William S. Vaux; Chairman of Chemical Sub-section, Prof. F. W. Clarke.

The British Association meets this year in Dublin, on August 14th, under the presidency of Mr. William Spottiswoode, F. R. S.

During the summer vacation, teachers of mathematics or astronomy will be admitted to the Cincinnati Observatory, there to pursue the different branches of study connected with their special departments of instruction. Applications should be made to the director of the observatory, Mr. Ormond Stone.

The French Association for the Advancement of Science will this year hold its meeting at Paris, commencing August 22d. The officers of the Association are: President, Prof. Frémy, of the Academy of Sciences; Vice-President, M. Bardoux, Minister of Public Instruction; Secretary, M. Perrier, commandant d'etat-major.

The death of Dr. Charles Pickering, of Boston, is announced. He was a grandson of Timothy Pickering, and was born in Susquehanna County, Pennsylvania, on November 10, 1805; graduated at Harvard College in 1823, and three years later received his medical diploma. He was a member of the scientific staff on board of the United States ship Vincennes during Commodore Wilkes's Exploring Expedition around the world from 1838 to 1842. In 1843 he went to India and Eastern Africa, to complete his ethnological researches, and on his return home two years later began the preparation of his great work, "The Races of Man and their Geographical Distribution" (1848). He later published "Geographical Distribution of Animals and Man" (1854), and "Geographical Distribution of Plants" (1861).

In the Azores, a Portuguese subscribes himself at the foot of a letter as "your watchful venerator"—an expression doubtless as sincere as "your obedient servant." He dates all letters written from his own house "S. C.," meaning *sua casa* (*your* house), and he addresses them "S. I. C.," i. e. *Sua ilustre casa* (to your illustrious house). By a fiction of politeness, he assumes that the house he lives in is one of the inferior mansions of the person he happens to be writing to, who, possessing a more illustrious habitation, allows the writer to occupy it by indulgence or sufferance.

During the discussion of hell-fire which lately swept over this country, we did not notice in any of the brethren such gracious evidence of a meek and loving spirit as in "Brother" Swigart, of Huntington, Pennsylvania; Brother Swigart is what is known as a "Pilgrim Baptist." Says the *Primitive Christian:* "At our last prayer-meeting Brother Swigart took the position that we have nothing to do with hell. It was not prepared for the Christian, and *therefore need not concern us.* Heaven is the place about which we are concerned, and not hell."

The educational authorities of Berlin maintain a vast garden for the purpose of supplying fresh botanical specimens for the public schools of the city. Over 4,000,000 plants are required for botanical instruction during the year.

The biological department of the Johns Hopkins University will this summer organize at Fort Wool, Virginia, a laboratory for the study of marine zoölogy, the sessions commencing June 15th, and continuing till August 15th. The laboratory is designed to meet the wants of advanced scientific investigators, but at the same time there will be accommodations for a few less advanced students. A fee of ten dollars will be charged for the use of laboratory and apparatus, and board will be furnished at cost. Address Dr. W. K. Brooks, Johns Hopkins University, Baltimore.

A short time ago we published a few specimens of the absurd anomalies of our common "systems" of weight and measure. Many others are cited in a late number of the *Polytechnic Review.* Among these we notice two as being specially absurd. Thus a law of the colony of Pennsylvania, about the year 1705, enjoined that all brewers "shall sell beer and ale by wine-measure to all persons as *drink it in their houses*, and by beer-measure to all such persons as *carry* the same out of their houses." The other instance is quoted from Mr. Charles Reade, who says that in Shropshire they at one time actually had different weights for different market-days!

Exact experiments made by Grehant show that a man, or one of the lower animals, compelled to breathe for half an hour an atmosphere containing only $\frac{1}{770}$ of carbonic acid, absorbs that gas in such quantity that about one-half of the red blood-corpuscles combine with it and become incapable of absorbing oxygen; and that, in an atmosphere containing $\frac{1}{1440}$ of carbonic oxide, about one-fourth of the red corpuscles combine with the gas.

Dr. Percy, F. R. S., at a recent meeting of the British Iron and Steel Institute, gave some particulars as to the manufacture of Japanese copper. Bars of this metal present a beautiful rose-colored tint on their surface, which is due to an extremely thin and enduring film of red oxide of copper, and which is not in the least degree affected by free exposure to the atmosphere. Dr. Percy exhibited bars of Japanese copper which had been in his possession thirty years, and which had undergone no change, though freely exposed to the action of the air. The secret of this result is that the copper is cast under water, the metal being very highly heated, and the water, too, made hot. Dr. Percy had himself succeeded in casting copper in this way, with results the same as seen in the Japanese metal.

Whitebait, a favorite fish among British epicures, has made its appearance in the bay of New York. Mr. Eugene Blackford, of Fulton Market, is satisfied of the identity of the fish caught here with the English whitebait. Only a few specimens have been found as yet, but a full supply is anticipated when the proper nets are procured, and shoals of the fish are discovered.

The sum voted by the French Chambers for the maintenance of the national museums during the present year is 762,780 francs. With this pittance have to be defrayed all the expenses of the great museums of the Louvre, the Luxembourg, of Versailles, and St.-Germain-en-Laye, with their branches. Attention is called in *La Nature* to the significant fact that the single *Théâtre de l'Opéra* receives from the state a larger bounty than all these great museums taken together. In consequence of this parsimony on the part of the Government, many of the great French collections, once justly esteemed to be the completest of their kind in the world, are now far surpassed by similar collections in other countries.

The state of the "temperance question" in the United Kingdom of Great Britain and Ireland may be inferred from the following statistics, derived from official sources: In 1877 duty was paid in the United Kingdom on 29,888,176 gallons of home-made spirits, intended for home-use. This is 62,112 gallons less than in 1876, but the decrease is due exclusively to Ireland. England shows an increase of 414,947 gallons, and Scotland an increase of 16,051, but Ireland shows a decrease of 493,110 gallons. The number of gallons destined for consumption in England was 16,853,082, in Scotland 6,987,189, and in Ireland 6,047,905. The 10,618,564 proof gallons of imported foreign spirits entered for consumption in the United Kingdom in 1877 were less by 883,176 gallons than the quantity in the preceding year.

THOMAS A. EDISON.

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CIVILIZATION AND SCIENCE.[1]

By Professor EMIL DU BOIS-REYMOND,
OF THE UNIVERSITY OF BERLIN.

PART II.

VI.—The Technico-Inductive Period.

BUT there was still a long road to travel, before even the threshold of the temple of truth was reached. Nothing is better fitted to humble the spirit of speculation, which is ever and again lifting its head in Germany, than a contemplation of the first faltering steps of natural science, after it had at last been aroused from its slumber. If speculation were of any avail, one might suppose that it would succeed, above all, in throwing light upon a subject so comparatively accessible to our understanding as the laws of motion. But as Kant in later times failed to discover *a priori* the conservation of energy, so did the foremost minds of the Renaissance fail to find *a priori* the simplest truths of mechanics—truths since so transformed, if the expression be allowed, into flesh and blood of civilized man, that nativists[2] might be tempted to regard them as innate. To us it appears inconceivable that once it required the profoundest meditation to discover the first law of motion, the inertia, as it is called, of matter, in virtue of which the motion of a body does not change without an external cause; that, down to the period of which we are speaking, no one had acquired a clear notion as to why a rolling ball at last stands still. Galilei even at first believed that a body, water, for instance, may move in a circle, without being

[1] An address delivered before the Scientific Lectures Association of Cologne. Translated from the German by J. Fitzgerald, A. M., and carefully revised by the author.

[2] Upholders of the doctrine of *innate ideas*.

held in that course by an external cause.[1] Kepler least of all had any clear conception of the laws of motion, but held views closely resembling those of Pythagoras. But when we consider that, not reckoning Archimedes, whose teaching was not understood or quickly forgotten, the human mind had for two thousand years not made a step of progress in this matter, we cannot but wonder at the rapidity with which such ideas are now developing; and herein we recognize the influence of that new sense which has been awakened among civilized nations by monotheism. Scarcely had the human mind abandoned the waving sea of speculation, escaped from the *mare tenebrosum* of scholastic theology, and set its foot on the firm land of inductive investigation, when it triumphantly sped along a track which brought it at one bound, as we might say, up to the highest accessible point; for only fifty years separate Galilei's "Discorsi" from Newton's "Principia," and the formulation by Leibnitz, in the same year 1686, of the doctrine of the conservation of energy.

And so at last with a rapid succession of geographical, astronomical, physical, and chemical discoveries, came the period whose benefits we enjoy, and to which we give the name of the *technico-inductive period*, because its results are due to the fact that in natural science speculation has given way to induction, the *μεθόδος ἐπακτική*, of which it is so hard to give an idea to an outsider, because strictly it is nothing else but common-sense applied to a given problem.

The study of this new phase of human history is as full of comfort and encouragement as the study of the mind's enslavement, by the phantasms of its own imagination during the "middle ages," was painful and depressing. Nay, who will deny that, in reviewing the whole history of mankind, with the exception of the golden age of Grecian civilization, which passed away as rapidly as everything beautiful does, no nobler spectacle is to be seen than that which is beginning to unfold itself to our view, and which is even now becoming grander from day to day.

Here we have a universal history very different from the histories which commonly go by that name, and which tell of nothing save the rise and fall of dynasties and empires, treaties and disputed successions, wars and conquests, battles and sieges, rebellions and party strifes, devastation of cities and harassment of populations, murders and executions, court conspiracies and priestly intrigues; which exhibit to us, in the war of all against all, nothing but ambition, avarice, and sensuality, violence, treachery, and revenge, fraud, superstition, and hypocrisy. Only at rare intervals is this dark picture relieved by the cheering apparition of genuine princely magnanimity, or of peace and prosperity among the people, oftener by the soul-stirring deeds of a heroism which, alas! too often is spent in vain. For, whither ultimately leads this

[1] Concerning this stage of the mind's development, consult Whewell, "History of the Inductive Sciences," vol. ii., p. 23, *et seq.*

road, whose track lies across rivulets of tears and through a sea of blood? Can we discern in political history any steady progress effected by the play of the forces which constitute its subject-matter? Do kings grow wiser, or peoples more sober-minded? On the contrary, does not the lesson taught by history seem to be this, that history teaches no lesson? Till modern times, did humanity steadily and consecutively advance from step to step in liberty, morality, power, art, well-being, and science? Does not the history of which we speak present to our view rather a labor of Sisyphus, and does not the very conception of different periods of civilization imply the downfall of those civilizations?

Alas! we know only too well that this kind of history was for a long time the only one known to man; and for the mass of people it will continue to be the only one. The mighty game of chance, played for stakes the value of which is known of all men, and the strife of passions it calls forth—this drama, whereof man himself is at once the poet and the performer, irresistibly attracts the ingenuous mind, and is full of the profoundest lessons, however little they may be regarded.

But contemplate for a moment infinite space strewed with nebulæ in the chaotic state, with star-clusters and solar systems. Imagine, as an invisible point in this infinity, our own sun as it speeds on into unknown regions of the heavens, surrounded by its planets, each one revolving in its own proper orbit—Jupiter, the giant-planet, with his moons, and Saturn with his rings. Again, imagine our earth, a point in this system, shooting through universal space at the rate of a falling star, and rotating on its axis from morning to night, from night to morning—"mountain and sea borne along in the ever-rapid course of the spheres." Descend, in imagination, into its fiery interior, and learn the great outlines of its history. After ages innumerable, the flood of molten lava at its surface became sufficiently cooled to admit of the existence of life; organisms succeeded one another till, at length, the history of our own race begins in the twilight of fable, now, however, illumined by the discoveries of prehistoric research.

We will call this mode of looking at terrestrial phenomena, opposed as it is to the anthropocentric point of view, the *Archimedean perspective*, because thereby we in thought take a standpoint beyond the earth, just as Archimedes desired to have a *locus standi* outside the earth, in order to move it.

How lowly and insignificant do earthly things appear when thus contemplated! How petty now seem all those occurrences which we are wont to regard as so weighty, that we comprehend them under the high-sounding name of "universal history," whereas, in truth, one half of them belong to the history of the wars, and the other half to the history of the hallucinations of only a few civilized nations! How vain and foolish are wars for a patch of land or for blood-stained laurels! In presence of the sublime spectacle of the universe, may we not exhort to reconciliation and harmony the race of man, ever wrangling about pitiable trifles? How odd, from the Archimedean perspective, appear the fevered imaginings of mankind about higher beings inhabiting somewhere above our heads the icy, ether-filled cosmical space, vibrating with force-radiations, and pervaded by meteor-streams! How utterly absurd is the idea of an assembly of the gravest, most learned, and most profound men of their times sitting to decide whether Father and Son are of the same or of like substance! How ridiculous, were it not so tragical, was the scene of Galilei's abjuration, when we think of him and his judges being carried along together "in the ever-rapid course of the spheres!" But oh, how doubly hideous appear the massacre of St. Bartholomew and those *autos da fé*, whose atrocities reach their culmination in the burnings of Giordano and Servetus! For the objects of veneration to whom these hetacombs were immolated there is no place in infinite space from the Archimedean standpoint, and they will have to be collocated in the fourth dimension.

In truth, in this so-called "universal history," there is but one light to guide us, which, however, has not often been employed hitherto: that is the doctrine of epidemic mental disease. As in mental diseases occurring in individuals, so here, it is hard to draw the lines of distinction between insanity and depravity. But the few who contemplate, as it were, from the lofty summit of an intellectual crag, in an Archimedean way, the doings of mankind here below, cannot be very far wrong in holding *that* to be the true history of the human race which, through all its ups and downs of fortune, its crimes and its errors, traces for us its gradual rise out of a state of semi-brutishness, its progress in arts and sciences, its growing dominion over Nature, its daily increasing well-being, its liberation from the bonds of superstition, and its steady approximation to those ends which make man what he is. In polity and war, whose unprofitable and monotonous oscillations are the subject-matter of political history, man had predecessors among invertebrate animals even; but the human race alone offers a history of civilization. Hegel calls the horse and iron the "absolute organs for establishing civilized power." With greater justice we say that natural science is the absolute organ of civilization, and hence that *the history of natural science is the proper history of the human race.*

The punier man seems to be, as viewed from the Archimedean standpoint, the grander appear his achievements in the face of Nature, the nobler his efforts to subdue her, the more attractive the history of his intellectual conquests. As this history has memorable days and places different from those of political history, so, too, of course its kings and heroes differ from the kings and heroes to whom the thoughtless world is wont to pay homage. Who is it that in this history rivets our attention at the beginning of the eighteenth century? Not that king, surrounded by his confessors, his mistresses, and his incendiary marshals, against whom, as Ranke said to Thiers, we still bore arms after Sedan; but that greatest of men, Sir Isaac Newton, deeply pondering on a problem beneath the elms of Cambridge. Who at the beginning of this century? Not, amid the ruins of Moscow, the indomitable man who invented chauvinism as the instrument of his ungovernable selfishness, but Alessandro Volta, contriving, at his villa on Lake Como, the artificial electrical organ which gave to man the power of omnipresence, as it were; or that other conqueror of space, George Stephenson, setting in motion, in his coal-blackened cottage at Killingworth, the model of his railway-locomotive.

It were a noble task to describe the revolution that natural science has quietly produced in the condition of the human race during the last two or three centuries. Just as it has lifted from over our heads the confining roof of a solid firmament, so, too, has it liberated us intellectually. For every one who hearkens to her teaching she has fulfilled the aspirations of the poet, who, amid the throng of courtiers in the antechamber of Octavian and all the splendor of historical greatness, wistfully bethought him of the disciple of Epicurus as he reposes in powerful calm:

> "Felix qui potuit rerum cognoscere causas,
> Atque metus omnes et inexorabile fatum
> Subjecit pedibus, strepitumque Acherontis avari."[1]

> "How blest the sage whose soul can pierce each cause
> Of changeful Nature and her wondrous laws;
> Who tramples fear beneath his foot, and braves
> Fate and stern Death, and hell's resounding waves!"
> *Sotheby's translation.*

In the place of miracle, natural science has substituted law. Ghosts and spectres have disappeared before it as before the first rays of light in the east. It has broken the power of ancient lies; it has put out the fires in which witches and heretics used to be burned; it has placed a keen-edged weapon in the hands of historical criticism. But it has also curbed the pride of speculation. It has discovered the limits of knowledge, and taught its disciples to look down without dizziness from the airy heights of sovereign skepticism. How easy and free one breathes on those heights! How nearly inaudible to the mind's ear the hum of the vulgar multitude in the torrid lowland, the complainings of disappointed ambition, the battle-cries of nations! As of the anthropocentric, so, too, of the Europocentric idea natural science has made an end. As it opened the Ghetto, so it burst the fetters of the negro. How different its conquest of the world from that of Alexander or the Romans! If literature is the true intranational bond of nations, their international bond is natural science. Voltaire could abhor Shakespeare, but Newton he revered. The triumph of the scientific view of Nature will to future ages appear as a step in human development comparable to the triumph of monotheism 1,800 years ago. It matters not that the

[1] Virgil, "Georgics" ii., v., 490, *et seq.*

people will never be ripe for this form of religion, for where have they ever realized the ideal of Christianity?

If we ask ourselves where in literature did this conception of the universe first make its appearance, the answer will be, "In Voltaire." That mental characteristic of Voltaire, to which David Friedrich Strauss has not done full justice, namely, the scientific habit of thought which he contracted in England and developed at Cirey, enabled him clearly to perceive the difference between political history—the only form of history known down to his time—and the history of civilization; and in the latter with a boldness and perspicacity all his own to show retrospectively and prospectively the part played by natural science. In a hundred of his essays, letters, and philosophical novels, this fundamental idea rises to the surface; but, with the amazing versatility of his genius, he to-day, as in the "History of Charles XII.," looks upon events from the anthropocentric standpoint; to-morrow, as in the "Micromegas," from the Archimedean perspective.

Following in Voltaire's footsteps, the encyclopedists further developed this conception. They still more positively than he called attention to the methodical utilization of the forces of Nature as perceived in their regular working. Hence Diderot's partiality for the mechanic and useful arts, a trait well noticed by Rosenkranz, in which Diderot agreed with a man who also in a moral sense had come to meet him from the other shore of an ocean—with Benjamin Franklin, the father of utilitarianism.

What they dreamed is now more than accomplished. Man, whom we first met as a tool-making animal, is now become a rational animal who travels by steam, writes with lightning, and paints with the sunbeam. The reconversion into work of the sunlight stored up in "black diamonds" multiplies his energy a million-fold. The Seven Wonders of antiquity, the engineering works of the Romans, bear no comparison with the enterprises every day undertaken by our own generation. The periphery of our planet threatens to become too narrow for man's genius. Hardly any secrets do its heights and its depths still conceal from him. Whithersoever man is powerless to go bodily, his mind penetrates with the aid of the magic key of calculation. In the blackest night, on the stormiest sea, his bark steers the shortest course; she dexterously shuns the track of the destroying typhoon. Geology does all that the divining-rod was once supposed to do, giving us plentiful supply of water, salt, coal, and petroleum. The list of the metals is ever growing, and yet chemistry has not discovered the philosopher's stone; some day that too will be found, perhaps. In the mean time, it vies with organic Nature in producing things both useful and agreeable. From the black, noisome waste-products of coal-gas, which has transformed every city into another Baku, chemistry derives coloring-matters before which the splendor of tropic plumage pales. It prepares perfumes without sun and without flower-beds. And though it might not have solved Samson's riddle, who could have solved its own riddle of how to get sweetness out of what is disgusting? Gay-Lussac's art of preserving articles of food has done away with the distinction of seasons for the poor as well as for the rich. The poisoner, with impotent rage, sees all his crafty schemes unveiled. The destroying angels of small-pox, plague, and scurvy, are chained. Lister's bandage excludes from the wounds received on the battle-field the insidious and poisonous germs revealed by the sunbeam. Chloral spreads the wings of the god of sleep over the most tortured soul; and Chloroform sets at naught, at our pleasure, the Biblical curse of woman.

Thus is fulfilled the saying of that prophet of science, Francis Bacon, that knowledge is power. All European nations, the Old World and the New, are running a race on this course. A distinguished critic of art not long ago laid down the proposition that in the development of the plastic arts is to be found the measure of the height attained by humanity at any given time. If that is so, then the time from Phidias down to Lysippus, and the *cinque-cento*, would have seen the highest development of humanity ever reached hitherto, and perhaps never to be attained again; the present century would at best give out but a feeble flicker of culture, as having produced the cartoons of Cornelius! This measuring the height of man's development by one single aspect of human activity is in itself a false idea, and hence the judgment expressed above is as erroneous as is, for instance, the one-sided ethical conception of man held by Semitism. But if there exists any criterion which, *per se*, gives a measure of man's progress, it would appear rather to be the degree of mastery over Nature that has been attained in any age. The history of art is influenced by accidental circumstances, as talent, taste, patronage, prosperity. In the investigation and subjugation of Nature alone there is no standing still; the store is ever increasing, and the creative force is ever producing more and more. Here alone does each successive generation stand securely on the shoulders of their predecessors. Here alone is the disciple disheartened by no *nec plus ultra*, oppressed by no weight of authority, and even mediocrity finds an honorable place, if it does but seek the truth diligently and conscientiously. Finally, it is not art that saves civilization from another downfall. Art, with all its glory, would to-day, as often before, under the same circumstances, fall a helpless prey to barbarism, were it not that natural science gives to our present life a security, which we are so accustomed to consider as the natural condition of the existence of modern civilization that we do not even think of asking whence that security is derived.

We are all familiar with Macaulay's prophecy of the tourist from New Zealand who, while the Roman Church still exists in undiminished vigor, shall, in the midst of a vast solitude, take his stand on a broken arch of London Bridge to sketch the ruins of St. Paul's. In this gloomy picture Macaulay indulges pessimistic views such as are very likely to be entertained by the historical investigator who has constantly before his eyes the vicissitudes of political affairs. But in his ἔσσεται ἦμαρ the great rhetorician falls into the same error as he falls into immediately afterward in holding that the foundation of natural theology is to-day just what it was in earlier times; that, in philosophizing about the origin of things, a thinker at the present day is not more favorably situated than Thales and Simonides; and that, as concerns the question, what becomes of man after death, a highly-educated European, left to his unassisted reason—in other words, unaided by revelation—is as little likely to be in the right as is a Blackfoot Indian. In both cases Macaulay overlooks a fact alien to him as a writer of political history, and, as it would appear, particularly so to his special genius—namely, the changes wrought, and daily being brought about with ever-increasing rapidity, in the condition of the human race by natural science. Modern humanity is different from mediæval and ancient humanity; the condition, the views, and the ideas of our race, in ancient and in modern times are no longer comparable *inter se*, thanks to the new elements introduced by natural science. Our science and civilization securely rest on the basis of induction and the useful arts; ancient science and civilization were built upon the shaky foundation of speculation and æsthetics.

VII.—The Dangers which threaten Modern Civilization.

What now can check modern civilization? What lightnings can ever shatter this tower of Babel? It makes one dizzy to think of what mankind is destined to be a hundred, a thousand, ten thousand, a hundred thousand or more years hence. What is there to which it may not attain? As it nowadays, mole-like, works its way through mountain-chains and under the ocean, why may it not at some future time imitate the flight of the bird? And, as it has solved the enigmas of mechanics, why should it not solve also the enigmas of mind?

Alas! it is decreed that trees shall not reach the sky. It is more than doubtful that man will ever fly; but the time never will come when he can tell how matter thinks. It is easier for us to reconcile ourselves to these limitations than to that everlasting age of ice which science remorselessly points out to us as the last scene in the drama of human affairs. Thus curiously enough it happens that, whereas natural science had seemed to promise to civilization a perpetual duration by insuring it against the inroads of barbarism, it again makes the assurance void and robs us of our hopes of a stable habitation on the earth. The day will come when man no longer can say, "Lo! Homer's sun sends down his beams even on us;"[1] a day when the earth, over and over ice-clad, will travel sluggishly around the sun, whose fires will then burn only with a ruddy glow; a day when, just as in the begin-

[1] "Und die Sonne Homer's, siehe, sie lächelt auch uns"—concluding pentameter of Schiller's "Spaziergang."

ning, "Light was," because then the first eye opened, so "Darkness will be," because then the last eye closes.

But from this fate millions of years still separate our race. A young man does not allow himself to be thwarted either in his pleasures or in his ambitions by thoughts of the infirmities of age which await also him, or of the inevitableness of death. So, too, we are but little concerned about the fate that threatens our unimaginably remote posterity. Should we feel greater alarm for the immeasurably nearer danger which threatens our present civilization in the exhaustion of our coal-fields within a calculable period of time? No one, who knows how difficult it is to substitute another source of power, can contemplate without solicitude our scandalous waste of coal. The present demands of manufacturing industry are not very easily checked, it is true; besides, "the living are always in the right,"[1] and later generations must find out for themselves a means of navigating the ocean without coal; nevertheless, the British Parliament would be better employed in devising measures to prevent the waste of coal (which is greater in England than elsewhere), than in busying itself with questions of experimental physiology, as it has lately been doing to the injury of science and the impairment of its own dignity.[2]

Civilization is also threatened in another quarter. In the face of a new barbaric invasion, it need have no fear; but in the heart of every great city, in the busy hives of industry, civilization has itself brought forth a race which, misguided by insane or reprobate leaders, may be to it a source of greater danger, by their ignorance and brutality, than were the Huns and Vandals to the civilization of the ancient world. So wrote Macaulay, and Macaulay did not live to see the year 1871. Again, he takes too dark a view. In point of fact, these dangers are confined to certain points in time and space. Culture in general has nothing to fear even from the Red Internationale. The Servile War, the War of the Peasants, and the Revolt of the Anabaptists, were class-psychoses of the same character as the present disturbances. As we regard the former, so will future generations regard the insurrection of June and the Commune; and they will themselves have to deal with the same disease under other forms.

The peril of which I would here speak is not one which directly threatens the stability of civilization. We are concerned rather about the questionable form which civilization tends to assume, judging from the direction in which it is at present developing. It is not easy to define this peril, inasmuch as it is the product of a multitude of trivial circumstances, amid which we ourselves live, and whose influence steals

[1] "Der Lebende hat Recht."—SCHILLER.

[2] *See* Ludimar Hermann, "Die Vivisectionsfrage," Leipzig, 1877. Translated into English by Archibald Dickson, under the title of "The Vivisection Question popularly discussed," London, 1877. E. Du Bois-Reymond, "Der physiologische Unterricht sonst und jetzt," Berlin, 1878, § 21–23.

over us so insensibly that some degree of abstraction and keen observation is needed in order to detect it. This danger has already often been pointed out with apprehension; in fact, it is a very common thing to speak of the state of affairs from which it results as being one of the evils of our time; but yet it is not always clearly perceived that we have here to do with a necessary consequence of the progress of civilization as set forth in the preceding considerations.

When cultivated one-sidedly, natural science, like every other form of activity under the same conditions, narrows the mental horizon. Under such circumstances natural science confines our vision to what lies nearest to us, what is palpable, what can be directly apprehended with apparent certitude by the senses. It turns the mind away from more general and less positive considerations, and disaccustoms it to act in the region of the quantitatively indeterminable. In a certain sense we hold this to be a priceless advantage for natural science; but, where this tendency dominates exclusively, it is not to be denied that the mind becomes poorer in ideas, the fancy in images, the heart in sentiment, and the result is a narrowness, a dryness, and a hardness of mental constitution, abandoned by the Muses and Graces. Again, it is a peculiarity of natural science that on the one hand it has a part in the highest aspirations of the human soul, while on the other by insensible gradations it passes into handicraft, into activities whose sole end is lucre. Under the ever-rising demands of every-day life, a steady deviation in the latter direction is inevitable. That side of scientific activity which has to do with the useful arts is ever, unnoticed, coming more and more into the foreground; generation after generation find themselves more and more bent on caring for material interests. Even the universal participation in the over-estimated benefits of political life diminishes the respect for ideas. Amid the unrest which has taken possession of the civilized world, men's minds live as it were from hand to mouth. Who now has the time or the inclination to go down into the deep well of truth, to plunge into the sea of the Ever Fair? Education nowadays, too often an unorganized patchwork, consists of individual facts plucked up by the roots, so to speak, useful it is true, but dry and crude. Few now are concerned about the mode in which the truth has been discovered, or about the relations between things perceivable only in reascending to their origin—to say nothing of the charm of perfect form. Art and literature prostitute themselves to the gross and variable taste of the multitude, swayed hither and thither by the daily newspaper. Where fame lasts only for a day, one of the noblest incitements of human nature—the thought of being famous after death—ceases to have any effect. Hence the decay of intellectual production, which brings forth imperishable masterpieces only when the mind gives itself to its work with whole-hearted devotion and with patient fidelity. And if, as Fontenelle has said, industry is indebted for its quickening impulse mostly to pure science, even industry is compromised by what is in part its own work. In short, Idealism is succumbing in the struggle with Realism, and the kingdom of material interests is coming.

It is no surprise that this aspect of modern civilization should be most noticeable in a country where the creation of material resources and the removal of natural obstacles were for a long time of prime necessity; where an immigrant population had, in a measure, to begin a new life, and most of them had as it were burned their ships behind them; where no historic memories and literary traditions were available for stopping the tendency of the popular life, too exclusively directed toward the useful arts and the acquisition of wealth. It is no wonder that America has become the principal home of utilitarianism. While at times the very first conditions of human society are there in dispute, it is in America especially that those existences come into being whose wealth, luxury, and external polish, contrasting as they do with their ignorance, narrowness, and innate coarseness, give one the idea of a neo-barbarism. In view of this aspect of American life, which has been again and again portrayed by writers, from Sealsfield down to Bret Harte, it has come to be the custom to characterize as an *Americanization* the dreaded overgrowth and permeation by realism of European civilization, and the rapidly-growing preponderance of manufacturing industry. Later the starry flag has waved in a war for an idea, a glory which the tricolor has been wont to claim for its own—and then has, like your true mercenary, demanded its pay for service done. Still another starry flag may the land of the future confidently oppose to such reproaches as are implied in the term "Americanization"—the flag of its young literary honors, each star being some name illustrious in science, in song, or in story. However, the term "Americanization" is now naturalized, nor will non-Americanized Americans object to the employment of it, as most of them are quite ready to admit the weak point in the young giant's education which this term is used to designate.

But, in thus animadverting on American civilization, is it not a fact that we see the mote in our brother's eye, but perceive not the beam that is in our own eye? What of the resistance that ought to be made to these redoubtable tendencies by our German civilization, ancient and firmly rooted as it is, when compared with the American? Unless we give way to one of our latest-cherished self-delusions, we must confess that we have already made such progress in "Americanization" as should give us pause. Germany is become united and powerful, and the longing of our youth to see the German name again respected by land and sea has been fulfilled. Who would find fault with such an achievement? But go back in thought to the divided, powerless, provincial Germany of our youthful days—passing as it were from the cold splendor of the imperial city into the narrow streets of some old town in Middle Germany, with their overhanging gables, and the house-fronts hung with grape-vine and ivy—is there not something lacking in the noisy Present, with all its glittering and dazing magnificence? Must we not, in the words of the "Schwalbenlied," exclaim, "Oh, how remote from me is that which once was mine!" In the revolution which Germany has undergone within a generation, has not the good been sacrificed as well as the evil? Besides its vague longings, its futile struggling, its uneasy doubts as to its own powers, has not the German nation furthermore dropped somewhat of its enthusiasm for ideals—its unselfish striving after truth, its deep and quiet inner life? Like a dream the short-lived bloom of our literature has vanished. As politics and natural science, with their harsh realities, have silenced the delightful *causerie* of the Parisian *salons*, so here, too, have they given poor entertainment to the descendants of the heroes of classic story and of romance. Goethe himself, were he now a young man, would, in all probability, leave "Götz," and "Werther," and "Faust," unwritten, and would rather practise in the Imperial Diet his power of public oratory, diagnosed in him by Gall, but which, during his life, he tested only with the "birds of Malcesine."[1] With all the splendor of German science to-day, we painfully miss, in the rising generation, the noble passion which alone guarantees the continuity of intellectual effort. The recently reawakened liking of the Germans for philosophic speculation simply proves the truth of the old saying—

"Naturam expellas furca, tamen usque recurret;"

but it is not calculated to quiet our apprehensions, with regard to the universally-diffused and rapidly-increasing indifference of our youth toward everything that they cannot see through and through, or that does not bring money or advancement.

[*To be continued.*]

PROFESSOR HUXLEY'S ADDRESS AT THE HARVEY TRICENTENARY.

MR. PRESIDENT: In attempting to fulfill the task you have imposed upon me, I am mindful that I address myself to an audience which is already familiar with William Harvey's claims to the honor which we are assembled to show him. For, within these walls, the memory of your illustrious Fellow and chief benefactor is kept perennially green by the customary piety of the speaker of the annual oration which Harvey founded; and his merits have been placed before you, with exhaustive completeness, by a long succession of able and eloquent orators. Even if the time and place were fitted for a disquisition on these topics, I could not hope to be able to add to the facts

[1] Birds in Aristophanes's sense. The allusion is not easy to explain in a few words. —(*See* Goethe's "Italian Journey.")

already known, or to place them before you in a new light. And, happily, this is not my function; I have to act simply as your remembrancer, to play the part of the herald who announces the familiar titles of a monarch on a state occasion.

Harvey's titles are three: he was the discoverer of the circulation of the blood; he wrote the "Exercitatio de Motu Cordis et Sanguinis;" he formulated anew the theory of epigenesis, and thereby founded the modern doctrine of development.

His first and, in general estimation, his greatest title to our honor has been challenged; but only to the confusion of the challengers. A century ago, your Fellow, Dr. Lawrence, in the excellent memoir prefaced to the college edition of Harvey's works, met the arguments of those who had, up to that time, attempted to dim his fame, with a solid refutation, which has never been answered, and to my mind remains unanswerable. In our own day, Dr. Willis has stated the facts of the case, and deduced the inevitable conclusion, with no less force and cogency. And, having taken some pains to get at the truth of the matter myself, I may state my clear conviction that Harvey stands almost alone among great scientific discoverers; not so much that, as Hobbes said, he lived to see the doctrine he propounded received into the body of universally-accepted truth, but because that doctrine was both absolutely original and absolutely new. I have yet to meet with a single particle of evidence to show that, before Harvey declared the fact that the blood is in constant circular motion, there was so much as a suspicion on the part of any of his predecessors or contemporaries that such is the case. Neither in Galen, nor in Servetus, nor in Realdus Columbus, nor in Cæsalpinus, is there a hint that a given portion of blood sent out from the left ventricle passes through the body and the lungs and returns to the place whence it started; yet this is the essence of Harvey's discovery.

Hence, when we hear of pompous inscriptions being put up in Spain to Michael Servetus, "the discoverer of the circulation," or in Italy to Cæsalpinus, "the discoverer of the circulation," it is well to recollect that churchyards have no monopoly of unhistorical inscriptions. Indeed, have we not ourselves, within easy walking-distance, that famous monument, the subject of Pope's scathing but just lines:

"And London's column, soaring to the skies
Like a tall bully, lifts its head and lies?"

Sir, I have no sympathy with *chauvinism* of any kind, but, surely, of all kinds that is the worst which obtrudes pitiful national jealousies and rivalries into the realm of science. We will not shame ourselves by permitting the fact of Harvey's English birth to enter into the consideration of his claims as a discoverer; but those claims once established beyond dispute, it is, I hope, something nobler and better than mere national vanity which brings us together to celebrate his birth;

to take an honest pride that such a man came of our English race; and as, I hope, to feel the deep responsibility which is laid upon us to have a care that the stock which in the same hundred years bourgeoned out in a Harvey and a Newton, shall not have its capacity for producing like growths, in the present and in the future, starved by devotion to mere material interests, or stunted by ignorant outcries against scientific investigation.

The second title which I have claimed for Harvey is that of author of the "Exercitatio de Motu Cordis et Sanguinis." And that title is, happily, quite indisputable. But some may suppose that I have so far thrown myself into the spirit of my assumed office as to insert a superfluous appellation—a sort of "Defender of the Faith." However, this would be an error. Harvey might have discovered the circular course of the blood; he might have given sufficient evidence of his discovery; and yet he might have been quite incapable of writing that little essay of fifty pages which no physiologist of the present day can read without wonder and delight. For, not only is it a typical example of sound scientific method and of concise and clear statement; but, in addition to the evidence of the course of the blood through the body, it contains the first accurate analysis of the motions of the heart; the first clear conception of the mechanism of that organ as a pumping apparatus; the first application of quantitative considerations to a physiological problem; and the first deductive explanation of the phenomena of the pulse and of the uses of the valves of the veins. "Libellus aureus," Haller called it—and never was epithet more aptly bestowed.

Harvey's third title to honor is the authorship of the "Exercitationes de Generatione." In this treatise Harvey grapples with two of the most difficult problems of biology—the physiological problem of generation and the morphological problem of development. It was simply impossible that he should solve these problems, for they can be approached only through the microscope; and Harvey was dead before Hooke, Malpighi, Swammerdam, or Leeuwenhoek, the fathers of microscopy, began their work. He saw the circulation in shrimps "ope perspicillo" indeed—but the perspicillum was a mere hand-glass. Hence it is not wonderful that Harvey's theory of fecundation is altogether erroneous; and that he is no less mistaken respecting the nature of the parts of the embryo which first make their appearance and the mode of their formation.

Nevertheless, just as it is the fate of dullness to be blind to the significance of justly-observed facts, so is it the rare privilege of men of the highest genius to discern the true light among the *ignes fatui* of error. They know the truth, as Falstaff discerned the true prince among his pot companions, by instinct. Explain the matter how we will, it is an indubitable fact that, though Harvey's fundamental observations were either inadequate or erroneous, some of his most important general conclusions express the outcome of modern research.

For a whole century Harvey's successors, even though the illustrious Haller was among them, went wrong when Harvey was right; and though Caspar Wolff returned to Harvey's views and thereby laid the foundation of modern embryology, the definitive triumph of the doctrine of epigenesis is the result of labors which have been effected within the memory of living men.

Such appear to me to be the chief claims of Harvey to be held in everlasting honor among men of science. We know that they represent a mere fraction of what he did. But the violence of an unhappy time has robbed us of the rest. I should trespass unwarrantably on your time if I insisted on the applications of Harvey's discoveries to medicine and surgery in the presence of those whose daily avocations bear witness to them.

I have hitherto dwelt upon the claims to our honor of Harvey the philosopher; one word, in conclusion, concerning Harvey the man. There have been great men whose personality one would gladly forget: brilliant capacities besmirched with the stains of inordinate ambition, or vanity, or avarice; or soiled by worse vices; or men of one idea, unable to look beyond the circle of their own pursuits. But no such flaw as any of these defaces the fair fame of William Harvey. The most that tradition has to say against him is, that he was quick of temper and could say a sharp thing on occasion. I do not feel disposed to cast a stone against him on that ground; but rather, such being the case, to marvel at the astonishing, not only self-control, but sweetness, displayed in his two short controversial writings—the letters to Riolan; a man who really was nothing better than a tympanitic Philistine, and who would have been all the better for a few sharp incisions.

Moreover, in such a temperament, while the love of appreciation is keen, the sense of wrong at unjust and willful opposition is no less strong. But I do not recollect, in all Harvey's writings, an allusion to the magnitude of his own achievements, or an angry word against his assailants.

Ready to welcome honor if it came, but quite able to be content without it; caring little for anything but liberty to follow in peace his search into the ways of the unfathomable cause of things—"sive Deus, sive Natura Naturans, sive Anima Mundi appelletur"[1]—one fancies this man of the true Stoic stamp would have summed up his eighty years of good and evil in the line of the poet, which was the favorite aphorism of his great contemporary, Descartes:

"Bene qui latuit bene vixit."

But he lived too well that the memory of his life should be allowed to fall into oblivion; and we may hope that recurring centennial anniversaries will find our successors still mindful of the root whence their ever-widening knowledge has sprung.—*Nature.*

[1] "Exercitationes de Generatione," Ex. 50.

THE TEREDO AND ITS DEPREDATIONS.[1]

By Dr. E. H. VON BAUMHAUER,
COMMISSIONER TO THE CENTENNIAL EXHIBITION FROM HOLLAND.

I.

DURING a period of about twenty-five years previous to 1858, the injuries caused to the timber of marine constructions by the *Teredo navalis* were rarely noticed in Holland, when, during the summer of that year, public anxiety was awakened afresh on that subject. Some repairs, undertaken at that time, of the marine works of the port of Nieuwendam, a village situated on the Y, brought to light the fact that all the piles broke off at the slightest blow, and were found to be entirely eaten off by the teredo.

The late secretary of the Royal Academy of Sciences of Amsterdam, Prof. W. Vrolik, called the attention of the Academy to this subject at a meeting held November 27, 1858, and the Academy appointed a commission from its own members, composed of Messrs. W. Vrolik, P. Harting, D. J. Storm Buysing, J. W. L. van Oordt, and E. H. von Baumhauer, charged with the duty of collecting and examining into all facts known concerning the natural history of the teredo, and, at the same time, to inquire into the best means for preserving wood from destruction by that mollusk.

Considering the great importance of this question to our country, bathed on all sides by the sea, the commission asked the assistance of the Government in its work, which was readily granted. This subject being of equal importance to other countries situated on the sea, and researches into the means of preventing the ravages of the teredo having been undertaken and the results published, especially in England, France, and Belgium, I have thought that a brief communication of the results we reached would be interesting and perhaps useful abroad, especially as our work was conducted on a large scale.

Before relating the experiments conducted by the commission, I propose to give a sketch of the examinations made by Mr. Harting, on the structure of the teredo and its mode of life, which have been very carefully studied by M. P. Kater, at Nieuwendam.

On the Mechanism of the Apparatus with which the Teredo perforates its Galleries.—The researches of several leading naturalists into the habits and structure of mollusks which perforate hard substances, such as wood and stone, have shown that some of them, which are found in calcareous rocks, make their excavations through some chemical means, i. e., by the dissolving action of an acid secretion, while the teredos and some others employ in their work purely mechani-

[1] Extract from the Archives of Holland, vol. i., translated by Edward R. Andrews.

cal means only. The manner in which the teredos proceed in their work has not, however, been clearly pointed out. In fact, while Hancock does not consider the shell, but the fleshy foot, as the boring instrument, and Quatrefages attributes that *rôle* to a part of the mantle of the animal, extending like a fold to the margin of the shell, Corilland has indicated the shell itself as the perforating instrument. By fastening the shell of a teredo on the end of a small stick of wood with gum, and turning it between the thumb and finger, he has succeeded, after four and a half hours' labor, in boring a hole in wood thirty millimetres deep. Mr. Harting arrived at the same conclusions by a careful microscopic examination of the shell and the muscular system of the teredo. We will point out the principal results of his studies, with illustrations to make them clear:

The shell is composed of two valves of equal size, which are not fastened together with a hinge; this is also the case with all other species of the genus *Teredo* and *Pholas*. The valves are maintained in place by a fold of the mantle in form of an arc (Fig. 1, *b*), which encircles them posteriorly. Moreover, the posterior part of the mantle has a

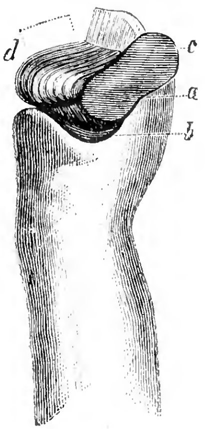


Fig. 1.

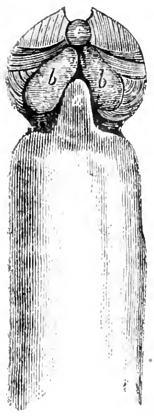


Fig. 2.

prolongation (Fig. 1, *a*, and Fig. 2, *a*) which covers, to a certain extent, the dorsal side of the valves, and extends on each side to their margin, forming two lobes (Fig. 1, *c*, and Fig. 2, *b*), which nevertheless do not adhere to the shell; by this mode of union the relative position of the valves is maintained. With other bivalve mollusks, which do not perforate, this relation is firmly fixed by a hinge; but, with the teredo, the valves have a certain play, which allows a slight displacement in their relative positions. The valves are, moreover, connected by two adductor muscles, which we will soon examine more closely.

The shell presents, even when the valves are brought closely together, three large openings.

The first, on the dorsal face (Fig. 3), is occupied in part by a pallial prolongation, a continuation of which is introduced by this opening into the interior of the shell, in part by the small adductor muscle.

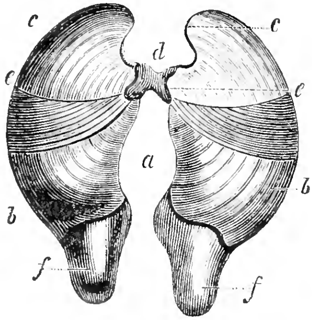


Fig. 3.

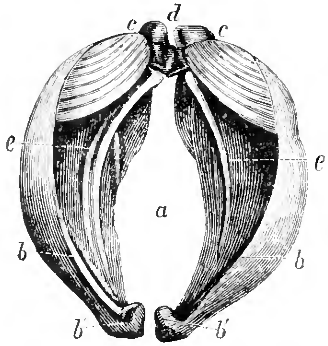


Fig. 4

The second opening is posterior (Fig. 4, *a*), and serves to open a passage to the internal organs contained in the cavity of the mantle.

Finally, the third, placed obliquely in front (Fig. 5, *a a;* Fig. 4, *a*), is the largest, and remains always gaping open to allow the foot to pass out (Fig. 5, *b*).

Each of these valves, which form the shell, is formed of three parts, viz.:

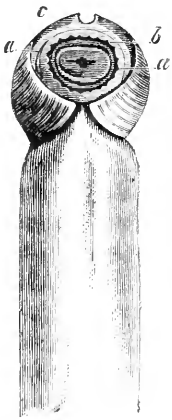


Fig. 5.

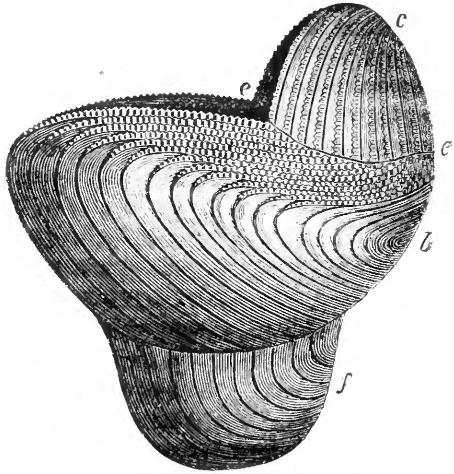


Fig. 6.

1. A posterior part (Fig. 3, *f;* Fig. 6, *f;* Fig. 7 *f*), which we can call the neck part; this posterior is the least arched, and thinner than the rest of the shell: its posterior edge is embraced by the folds of the mantle, which we have already mentioned, and thus the mantle is solidly attached to the shell.

2. The middle part (Fig. 3, *b*; Fig. 6, *b*; Fig. 7, *b*), which is the largest, is strongly arched, and presents, when seen from the side, the form of a half-moon ; its ventral portion is a little more pointed, curved inwardly, and terminated by a small swelling or tubercle (Fig. 4, *b'*; Fig. 7, *b'*), which, when the shell is closed, comes in contact with the similar tubercle on the opposite valve.

3. The anterior part, which is a continuation of the upper portion of the preceding part, and is more or less spiral in form (Fig. 6, *c*; Fig. 7, *c*; Fig. 3, *c c*; Fig. 4, *c c*), and its edge makes, when seen from the side (Fig. 6), an angle of a little more than 90° with the free edge of the middle part. The limit of these two parts is marked by a zigzag line, which resembles a sort of suture (Fig. 3, *e*; Fig. 6, *e e*). This part of the shell curves backward and inward, and there terminates in a small rounded tubercle (Fig. 4, *d*; Fig. 3, *d*; Fig. 7, *d*), situated opposite the corresponding tubercle of the other valve. This point is the axis of rotation of the two valves; that is to say, when the shell opens or closes, the tubercles retain their relative positions, while all the other portions of the valves describe about them an arc of circle more or less large.

On each of these tubercles is a short, pointed projection, on which are implanted at about a right angle two other large projections, which extend into the interior of the shell a third or half its length (Fig. 4, *e e*; Fig. 7, *e*). These projections are slightly curved and flattened; they penetrate among the soft parts, so that their inner face reposes upon the visceral mass; their outer face comes in contact with the thin lining or mantle, which covers the interior of the valves and extends to their extreme edge.

Examining the shell with a magnifying-glass, one sees (Fig. 6) a large number of curved lines of growth, parallel, as is usual, with the free margin of the shell ; a closer examination shows that those lines differ in each of the three parts of the valve, although in fact they form a continuous whole.

On the back part of the neck of the valve (Fig. 6, *f*), the lines seem to be simply curved lines without any especial peculiarities. This is equally true of those on the posterior and largest portion of the middle part of the shell (Fig. 6, *b*) ; they seem to be only linear thicknesses ; yet, between each pair of the strongest lines, which are the lines of growth, properly so called, one discovers a multitude of others, much finer, which follow the same direction. Here (Fig. 6, *e e*) the lines of growth form partitions between as many rows of small, sharp, wedge-shaped teeth. Each of these teeth has two rectangular faces on either side of two small triangular faces inclined toward each other (Fig. 8); its cutting edge is placed in the direction of the axis of the animal.

The size of those small teeth varies according to the position they occupy: those which are in the vicinity of the hinge-border are the smallest, those which are on the outer edge are the largest. And, as the part of the shell which is nearest the hinge is the earliest formed, in fact the only portion which exists at a very early period, it follows that the average dimension of the teeth increases with the size of the shell, that is to say, with the growth of the animal. On a shell, for instance, of $7\frac{1}{2}$ millim. in its largest dimension, where the total number

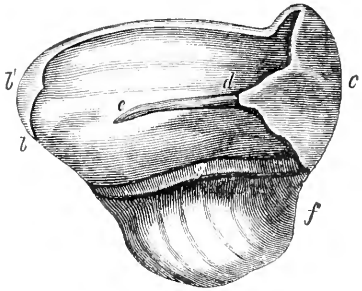


FIG. 7.

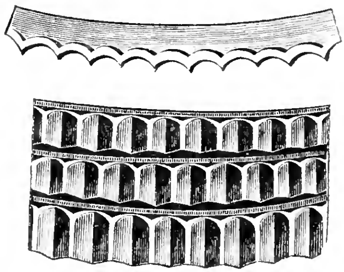


FIG. 8.

of rows of teeth reaches 41, the width of each row near the hinge-part is 52 mmm. ($\frac{1}{19}$ millim.), and the size of each compartment occupied by a tooth is 28 mmm. ($\frac{1}{36}$ millim.), while the same measures, taken on the outer edge of the valve, give 145 and 45 mmm. ($\frac{1}{7}$ and $\frac{1}{22}$ millim.). At this last point the small, wedge-shaped teeth rise to a height of 32 mmm. ($\frac{1}{33}$ millim.) above their common support. On an average, there are in each row about 100 teeth, and consequently more than 4,000 on each valve, and more than 8,000 on the two valves together.

The anterior part, in the form of a spoon, has a similar structure, but still more delicate. The lines of growth form an angle of a little more than 90° with those of the middle part, of which they are a continuation. They appear like small, projecting ribs, the outer edges of which are cut in the form of small teeth pressed one against the other (Fig. 6, *c*, and Fig. 9). These denticles are also in form of wedges; their cutting surfaces are perpendicular to the axis of the animal, and consequently form a right angle with the cutting surfaces of the teeth of the middle part of the shell. But they are much smaller than the latter; their width is only 10 to 15 mmm. ($\frac{1}{100}$ to $\frac{1}{66}$ millim.). Their number is also more considerable, even although that part of the shell is less fully developed than the rest.

On the same shell of $7\frac{1}{2}$ millim. diameter, the number of these denticles is, on an average, 250 on each rib, which makes 10,250 on the 41 ribs, and 20,500 on the two valves.

We should also point out the fact that this spiral part of the shell is evidently composed of more solid matter than the rest of the shell. It has more lustre, and the look of porcelain, and its surface between the ribs is smooth and glossy.

The consideration of the structure which we have related led Mr. Harting to the conclusion that it would be difficult to imagine an instrument better adapted than this shell for boring galleries in wood.

In fact, each valve presents in a certain way a combined auger-bit, gouge, and file. The ordinary steel file is made with two rows of notches, in order that the tool may cut simultaneously in two different directions; in this shell the same end is attained by the two rows of denticles, the action of which is equally in two directions perpendicular to each other; and our shell has another advantage, that it does not foul so readily with the filings as does an ordinary file.

Nevertheless, the winding direction of the galleries, in which it is not unusual to find right angles, or even somewhat acute angles; the defective cylindricity in the form of the galleries, which often appear as if composed of rings piled up one upon another, some larger and some smaller; the form of the end of each gallery, which is always perfectly smooth and hemispherical without any projection in the centre—all these facts show, according to Harting, that the action brought to bear upon wood by the teredo is not that of an auger boring a hole by rotary motion, but rather that of a file; this is rendered more apparent from the results of the careful anatomical study given by Harting to the muscular system of the teredo.

Although confined during its entire life to the dwelling which it has itself constructed, the teredo still has a strongly-developed muscular system. It is evident, moreover, that he uses all his muscles, excepting only those which serve to move the siphons, more or less directly, in the perforation of his galleries.

The first system of muscles is that which one finds in the mantle. That organ is provided through its whole length with longitudinal and

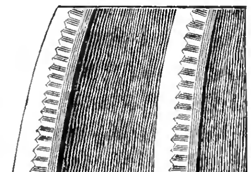


Fig. 9.

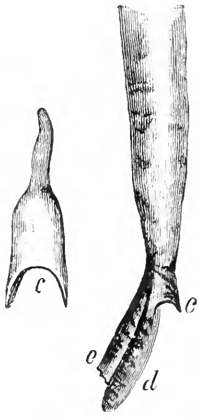


Fig. 10.

transverse muscular fibres. These fibres give the teredo the power of elongating or shortening its body; and also, by the partial action of some bundles of fibres, to make a slight movement of torsion.

At the base of the palettes, at the posterior portion of the mantle, is a powerful muscular ring (Fig. 10, e); by means of this ring, when the posterior extremities are expanded, the siphons (Fig. 10, *e* and *d*) can be carried outside into the water; at the same time the access of the two siphons, and consequently the entrance and exit of water, can be more or less hindered. As we have seen, the mantle is prolonged in the direction of the shell in an appendage which extends over the two sides of the dorsal surface of the valves (Fig. 1, *a*, and Fig. 2, *a*), the central portion of which forms a swelling of considerable thickness, composed of various anatomical elements; beneath the epidermis the tissues are partly of vesicular and partly of membranous character, which, through inherent powers of swelling and hardening under the action of the blood, serve a purpose in operating the movement of the valves.

To explain the physiological *rôle* of this organ (*a*, Figs. 1 and 2), it is necessary to recall the fact that it receives on either side, in the arched folds of the mantle, the neck-portions of the valves of the shells. By the contraction of the bundles of muscular fibres, the two valves would separate slightly one from the other, a movement which is still better understood if it is proved that that organ can become hard by the afflux of the blood and thus furnish a better fulcrum for the action of the muscles. Up to a certain point this part is similar to the hinge-ligament of other bivalve mollusks; but only in this respect, that it serves to open the shell. For the true ligament, wherever it exists, is always composed of elastic tissue, and its action is purely passive, while with the teredo the opening of the shell is a muscular action and consequently active. Moreover, the hinge is wanting in this case, which allows the supposition that the animal has the power of modifying at will, by the partial contraction of its muscles, the direction in which the valves separate, so that it may be at one time the middle parts and at another the anterior parts of the valves which separate most from each other. Besides, the effort which this action demands is extremely feeble, and the movement of the valves themselves is very limited.

There are two adductor muscles. The first and largest is already well known; it has been described by all writers who have made the teredo an object of study. It extends (Fig. 11, *m*) between the two valves in the form of a muscular mass, relatively quite large, and occupies about two-thirds of the length of the shell and one-third of its width. It rests on either side on a sort of pad situated at the limit between the middle and neck parts of the valve. The second or small adductor muscle, which appears to have escaped the attention of most observers, is found near the dorsal side of the shell in the cavity between the anterior portions of the valves. One can see its exterior surface, clothed with a thin epidermis and slightly projecting immediately in front of the pallial prolongation, which extends over the dorsal face of the shell; in appearance it is only a continuation of this muscle, but in reality it is entirely distinct.

The principal mass of this muscle is implanted upon the sides, bent backward within the anterior, spiral parts of the valves (Fig. 11, *p*) below the line which passes by the two tuberculous extremities, coupled together, i. e., by the centre of rotation of the valves. From this principal mass some slender muscular fibres extend over the two thorny protuberances (Fig. 11, *e e*), which may be compared to two arms of levers, whose common fulcrum is found in the centre of rotation of the valves. It is clear that, by this arrangement, the action of the muscle is considerably strengthened.

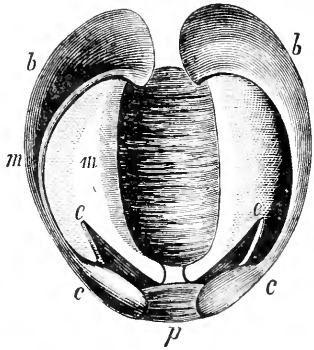


FIG. 11.

The two adductor muscles are composed of the same microscopic elements, that is, of fibres and fibro-cellular tissue, easily separated in form of a ribbon, six mmm. wide and one mmm. thick; their length is relatively considerable, and probably equal to that of the muscles themselves, inasmuch as one can nowhere discover any free extremities. These fibres are distinguished from the fibro-cellular tissue of the mantle not only by their greater length, but also by their darker outlines, which indicate thicker walls and, consequently, greater solidity and strength.

The effect produced by these muscles in contracting is very evident. The large adductor muscle, situated on a plane a little above the general centre of rotation of the valves, serves to draw together the rounded sides of the valves as well as all the other parts of the valves situated posteriorly on the same side of the centre of rotation. The small adductor muscle, placed in front of the centre of rotation, exercises a more limited action. When it contracts, the anterior extremities of the spiral part of the valves approach each other; simultaneously, all the parts of the shell situated behind experience a slight displacement forward, as if they tried to turn about an axis passing by the centre of rotation; but the one which they thus describe is necessarily very small, on account of the shortness of the muscle. It is evident that the direction of the movement made by one of these adductor muscles is nearly a right angle with that of the other; the anterior and middle parts of the valves, which are first acted upon by the action of the muscles, meet at an angle of 90°.

Finally, the teredo has also a muscular organ, without which it would be impossible for him to pierce his galleries. It is the part known as the foot, which has the power of projecting outside between the anterior opening of the valves (Fig. 5, *b*; Fig. 1, *d*—the dotted line indicating the outline of the foot in the state of extension). This foot has the power of extension and retraction, and terminates at the end with a suction-disk, by the aid of which the animal can attach itself to the wood.

From what precedes, it is evident that the teredo, far from being, as Deshayes has pretended, an animal having very few if any muscles, is, on the contrary, richly provided with those organs. There are the longitudinal and transverse muscles through the whole length of the mantle, a true sphincter (Fig. 10, *c*) at the base of the siphons, a muscular organ which receives and covers a part of the valves, two adductor muscles for the movement of bringing the valves together, and a foot provided with a suction-disk and susceptible of extension and retraction—truly a profusion of motive organs which one would not expect to find in an animal which passes its entire life in a narrow canal which it can never quit. Moreover, all these motive powers have only one essential end, namely, to endow the teredo with the power of boring his gallery—his home.

But all the muscles which we have enumerated do not coöperate to that end in an equally direct manner. When water has entered by the incurrent siphon, the animal can, by contracting the transverse muscles of the mantle, force the water through the whole length of its body up to the end of the gallery, and then drive it out by the excurrent siphon. The teredo undoubtedly makes use of this as a means of getting rid of the fine filings of wood which the valves of the shell have detached. He can then draw back a little the anterior part of his body by the action of the longitudinal muscular fibres, supporting himself by the two palettes pressed against the inner walls of the calcareous tube at a distance of two or three millimetres from the exterior opening, by which the siphons project outside the wood. It is probable that the teredo takes that position during his periods of repose, which come from time to time, and which he uses for repairing his tools.

The teredo possesses, on the other hand, the means of preventing or hindering the outflow of water at will, so that its body, distended by the liquid, occupies at that time the whole extent of the gallery, and his anterior portion touches with the valves of its shell the end of the gallery. In this position he can carry on his work of miner. He commences then by extending his foot (Fig. 1, *d*), which he fixes by suction against the side of the cavity. At the same time the valves separate a little; then, while the foot draws the shell to itself and thus presses its exterior surface against the wood, the valves close up again, and the denticles with which they are furnished cut into the wood.

In this labor there are still two peculiarities worthy of notice: First, the limited extent of movement with which the valves are endowed, their anterior extremities moving only a very short distance from each other. But this circumstance, in view of the narrow space in which the teredo works, gives him this advantage, that, by the rapid succession of movements of opening and closing the shell, he attains his end—namely, to reduce the wood to an impalpable powder—better than if each blow of the instrument had a wider range. In the second place, we should recall the fact that the directions of movement of the two adductor muscles are at right angles, as are also the directions of the cutting surfaces of the denticles on the two parts of the same valve. Hence it is clear, after the description which we have given above, that if the large adductor muscle contracts, the denticles of the anterior or spiral part of the valve cut the wood ; if, on the contrary, the small adductor muscle is shortened, it is the middle part of the valve which undergoes a movement of rotation, and the teeth which it bears are set at work. Thus, then, whether the two muscles contract simultaneously or one by one, the woody cells are cut by successive incisions, which would divide them into small quadrangular pieces, if there be no rending of the fibres. It is evident that the hardest task is demanded from the spiral part of the valve, for it is that part which is first brought to bear upon the wood. This part also has a more solid structure and the denticles are much finer; it is moved by a muscle of considerable size ; the power of this muscle is, moreover, sensibly increased by the fact of its being implanted upon the two middle parts of the valves, each of which can be considered as a long arm of a lever whose extremity passes over a space at least four times as large as the portion of the valve which, strictly speaking, does the work.

The foot remains fixed in the same spot a very short time only. The form of the end of the cavity, that of a regularly rounded basin, suffices to prove that the valves of the shell are placed every instant in contact with a different spot. The foot displaces itself, little by little, so as to give a rotating movement to the shell, and at the same time to all that part of the body beyond the shell, even as far as the palettes. When the torsion thus produced becomes excessive, the foot loosens its hold, and the body returns to its former position. Thus, then, the rotary movements remarked by some observers, far from being the cause, should be considered rather the effect ; they are only the shifting of position of the animal, and nothing more.

The teredo does not bore out his galleries, but he hollows them out with an action analogous to that of a file, by means of the thousands of cutting teeth with which its valves are armed. If the teeth do not break away rapidly, it is due to their wedge-like form and to the oblique direction of the planes which bound each of these wedges. Moreover, as the animal grows, new rows of teeth are formed, so that the rows which have served in youth are no longer of any use in more advanced age; they are principally the outer rows of teeth, the last formed, which do the work.

The sense of touch exists in the teredo in the suction-disk. This is not only a muscular organ, but one rich in nerves. Quatrefages has already pointed out the two small ganglia, situated on the intestines, which furnish the nerves for that part of the body. The foot, when extended, commences by feeling the place before attaching itself to it and drawing the shell after it. Naturally, it avoids the places which seem to offer too much resistance; but he avoids with equal care the parts where there only remains a wall of wood too thin for sufficient resistance. In this case, in fact, the gallery is approaching either the surface of the wood or a neighboring gallery ; a teredo is never known to destroy the work of another ; that, moreover, would not serve him, for, even should he perforate the woody division between them, he would drive against the calcareous tubes, which, being scarcely less hard than the valves themselves, cannot be attacked by them. Whenever the teredo encounters an obstacle, he simply turns aside; he acts like the mole, which, excavating her trenches by preference in a rich loam, makes a *détour* around the stones which she meets in her way, and changes her direction when she comes near the breast of a ditch, to avoid the open air.

I will state, moreover, that the conclusions regarding the manner in which the teredo perforates his galleries, deduced at first by Harting from the anatomical examination of his organs, have since been fully confirmed by direct observation ; Kater, having opened laterally one of the galleries, so as to partially expose the animal, has seen him at work, executing all the movements above mentioned.

[*To be continued.*]

ON THE DREAD AND DISLIKE OF SCIENCE.

By GEORGE HENRY LEWES.

IN the struggle of life with the facts of existence, science is a bringer of aid ; in the struggle of the soul with the mystery of existence, science is a bringer of light. As doctrine and discipline its beneficence is far-reaching. Yet this latest-born of the three great agents of civilization—Religion, Common-Sense, and Science—is so little appreciated by the world at large that even men of culture may still be found who boast of their indifference to it, while others regard it with a vague dread which expresses itself in a dislike, sometimes sharpened into hatred.

I shall be told, perhaps, that the growing demand for popular expositions of scientific results and the increasing diffusion of scientific inquiry point to a different conclusion. It is true that there never was a time when science was so popular. It is true that every year the attendance on lectures and the meetings of scientific associations is larger. The tide is rising. The march of Science is bit by bit conquering even the provinces which most stubbornly refuse allegiance to it. But, meanwhile, among the obstacles it has to overcome are certain prejudices and misconceptions which are the grounds of a deep-seated dread. No better illustration can be given of the general suspicion and dislike of science as science than the great stress which is laid on the "iniquity of vivisection," *because* experiments on animals are pursued for purely scientific purposes. The animating impulse of an effort to awaken a due sympathy with animal suffering and check an inconsiderate infliction of it is one which so entirely commands my esteem, that I would willingly overlook the flagrant contradiction of people tolerating without a murmur the fact that yearly *millions* of creatures are mutilated and tortured to give a few men pleasure, to make food more palatable, and domestic animals more tractable, yet are roused to fury by the fact that a few *score* creatures are mutilated (a smaller number tortured) to discover remedial agents and scientific truths. All the pain inflicted for sport or other pleasure is condoned; the pain inflicted for scientific ends is pronounced diabolical. Is it, therefore, not on account of the suffering inflicted, but on account of the scientific purpose, that vivisection is to be reprobated? Ten thousand times the amount of suffering is disregarded if only its purpose be *not* that of acquiring knowledge. And that this is so, is manifest in another case. For suffering may be also inflicted on human beings, and on a large scale, without exciting any outcry, if the motive be commercial advantage. Not to mention wars undertaken to push commerce, let us only consider some industrial experiment which will certainly drive hundreds of families from their employment with starvation as the consequence; yet the sufferings thus occasioned, if they excite pity, weigh so little against the prospect of the general good, that if the starving workmen revolt and destroy the machinery, the philanthropist is ready to enforce on them the utmost rigor of the law. Here the social benefit is allowed to override the individual injury. That is to say, an experiment which has the prospect of enlarging *wealth* may inflict suffering on men, women, and children; but an experiment which has only the prospect of enlarging *knowledge* must be forbidden if it inflict suffering on animals! Obviously such a contradiction could not be upheld if science were recognized as a social benefit. It is not so recognized. And one indication of this is the frequent accusation that physiologists are actuated by the "selfish motive of acquiring reputation," not by the unselfish motive of benefiting mankind. I will not pause to discuss the question of motives, nor how far the selfish motive may further a social advantage; I will only ask whether the motive of the industrial experimenter is less selfish? Unless science were a social benefit, no one would ardently desire a scientific reputation.[1]

Having indicated the existence of the dread and dislike of science, let us now glance at the causes.

The primary cause is a misconception of what science is. No rational being dreads and dislikes knowledge. No one proclaims the

[1] When one observes those who believe hospitals and colleges to be important institutions, socially beneficial, threatening to withdraw all support unless the teachers openly declare what they do not believe, namely, that vivisection for scientific ends is unjustifiable, one is reminded of the recent outbreak of fanaticism on the part of the Jains. This Hindoo sect has such a horror at the destruction of animal life that a group of the most fervent murdered all the Mussulman butchers in the neighborhood.

superiority of ignorance as a guide of conduct. Yet science is simply knowledge classified, systematized, made orderly, impersonal, and exact, instead of being left unclassified, fragmentary, personal, and inexact. Auguste Comte calls it "common-sense methodized and extended." There is plenty of knowledge which is not exact, and of exact knowledge which is not methodized. There is plenty of experience which is personal and incapable of being communicated to others. Wanting the illumination of many minds, this store cannot do the work of science, which is the experience of many enlarging the experience of each. If there is immense benefit in knowing what are the facts and the order of the physical world in which we live, and of the social world in which our higher life is lived, there is clearly a great advantage that this knowledge should be made orderly and communicable; and the dread of such an arrangement of knowledge is obviously irrational. Thus enlightened, we recognize in science the deliberate effort to reduce the chaos of sensible experiences within the orderliness of ideal constructions, condensing multitudes of facts into simple laws—an effort which the intellect acknowledges as a supreme duty, and which conduct acknowledges as a guide.

Another source of the dislike is the opposition of our native tendencies. Science is abstract, impersonal, whereas our experiences are concrete and personal. It is systematic, and systematization is troublesome: our native indolence renders us impatient of labor, and our impatience leads us to prefer the facile method of *guessing* to the difficult method of *observing:* we have to be trained into the preference of observing what the facts are, instead of arguing as to what the facts must be. Science, moreover, is greatly occupied with remote relations; now, to feel an interest in these we must first have had them "brought home" to us. Knowledge springs from desire. It begins when prolonged *observation*, stimulated by emotion, replaces the incurious animal *stare* at things; and for this prolongation there is needed a sustaining motive. The sustaining motive of research is the conviction of the vast increase of our power which science creates. Measuring by a foot-rule and measuring by trigonometry may be taken as types of common knowledge and science: the result reached may in some particular case be the same, whichever method be used; but the incomparable extent of the second method, which is applicable where the foot-rule cannot reach—which measures the heights of mountains and the distances of stars—furnishes the sustaining motive to the study of trigonometry.

Science demands exactness, and this demand irritates the vulgar mind. The impatience with which your cook listens to your advice that she should measure and not guess the quantities (advice you can never get her to follow) is but the same movement which rouses your resistance when any one desires to test your opinions by weighing the evidence, or endeavors to show that your traditional beliefs rest on no verifiable observations. Is not he who insists on evidence commonly styled "a bore" by all whose opinions have been adopted quite irrespective of evidence? Is it not pronounced "narrow" to hesitate in accepting wide conclusions without a keen appreciation of their data?

The distaste for accuracy, and the impatience at any restriction of the divine right of judging without evidence, will disappear with the advance of knowledge; and with this advance will also disappear certain mistaken pretensions of scientific men too ready to step beyond their own domain. It is this which causes the distaste of artists, men of letters, and moralists; and their opposition to the spread of scientific teaching. They do not oppose knowledge in the abstract, nor any particular knowledge; what they resist is the idea that the conclusions reached in one department of inquiry are to dictate conclusions in another. The artist is quite willing to accept the chemist's methodized experience of chemical facts, but refuses to listen to the chemist theorizing about art. The moralist will accept from the physicist equations of light, and from the anatomist relations of structure; but reserves to himself the right of deciding on a moral question.

One must admit that in the inarticulate resistance of sentiment and common-sense against certain applications of scientific doctrines there is often a justification. For example, there are mechanical laws and equations which admirably explain the facts of motion, yet sentiment is shocked at the attempt to explain Nature on mechanical principles only, and is sustained by common-sense, which sees other facts besides facts of motion, and sees that Nature is not mechanical only. Again, when the stored-up wealth of sentiments laboriously evolved in civilized life is set aside in favor of some analogy drawn from observed processes in the inorganic world, when the moral impulse to cherish the weak and sickly is condemned because Nature (which is *not* moral) cherishes the strong and pitilessly destroys the weak, common-sense protests, and the protest helps to intensify the popular distrust of science. Yet, in truth, the wiser heads among men of science are equally alive to the mistake of such applications.

What is to be understood by Science? It means, first, a general Method, or Logic of Search, applicable to all departments of knowledge; and, secondly, a doctrine, or body of truths and hypotheses, embracing the results of search. In this second acceptation there are the particular sciences—such as mathematics, physics, chemistry, biology, psychology, etc.—which are the special applications of the general method to special departments of knowledge; and although there is an interdependence of these sciences, each is restricted to its own class of facts, none can legislate for the others. But because the various branches of knowledge have been very unequally reduced to the exactness and orderliness of science, those which have been most successfully reduced have acquired the almost exclusive title; so that science is generally regarded as something apart—the peculiar study of a particular class.

Hence also the opinion that there is a profound separation between the principles applicable in the physical sciences and the principles applicable in the moral sciences. What has been the consequence? It has been that the method which is no longer regarded as a rational procedure in dealing with the phenomena of Nature is followed without misgiving in dealing with the phenomena of human nature; and the supernaturalism long banished from physical theories is still invoked in psychological and social theories.

Of late years this has ceased to be the universal error, though it still remains a wide-spread error. We are slowly beginning to recognize that there may be a science of History, a science of Language, a science of Religion, and, in fact, that all knowledge may be systematized on a common method. The facts of the External Order, which yield a cosmology, are supplemented by the facts of the Internal Order, which yield a psychology, and the facts of the Social Order, which yield a sociology. These are all comprised in science. However imperfect the second and third may be, in comparison with the first, the greater complication of the phenomena does not warrant the introduction of another Logic of Search. The principles which have guided us successfully in the first are to be followed in the others. The three classes of facts are all facts of experience, so far as they are known, and must all be tested, classified, and systematized, by the same rules.

This being so, we can separate the rational from the irrational antagonism against science. It is rational when protesting against the misplaced application of the results reached in one department to problems belonging to a different department—for this is an offense against scientific method. It is irrational when protesting against the rigorous application of one logic to all inquiries. Those, therefore, who sneer at science, and would obstruct its diffusion, are sneering against the effort to make all knowledge systematic, and are obstructing the advance of civilization.

The notion, implied or expressed, of two Logics, two Methods of Search, two systems of explaining phenomena, the natural and the supernatural, is the foundation of the great conflict between Science and Theology. And since, in the majority of minds, theology is identified with religion, and religion is of supreme importance to man, it is natural that science should be regarded with dread and dislike. Before proceeding to dissipate the confusions on this subject, it will be needful to glance at the attitude of sincere theologians in our day, and at the reasons which justify to their minds the acceptance of scientific doctrines side by side with the acceptance of theological doctrines. It would be equally ungenerous and short-sighted to suggest that a mind which is deeply impressed with the truth of certain theological opinions may not be also deeply impressed with the beneficence of science in general, and the truth of scientific doctrines which do not directly embrace moral and religious questions. We have too many conspicuous examples of men eminent in science and sincere in their theological professions, not to admit that the mind *can* follow two logics, and can accept both the natural and the supernatural explanations. Whether the mind *ought* to do so, is another question. Let no one, therefore, suspect me of a doubt as to the sincerity of theologians who proclaim that the sphere of science is limited to the processes of the physical world, and may be frankly accepted in all that it teaches respecting such processes, without in the least involving the moral world, or in any way affecting the truths respecting that moral world which theology derives from a source independent of experience. Science, they say, systematizes whatever experience reveals; its test is Reason. Theology systematizes what had been revealed from a higher source; its test is Faith. Between reason and faith there is an absolute demarkation; and between science, which relies on observation and induction, and theology, which relies on precept and intuition, there is no conflict. As the artist appeals to the chemist for a theory of salts, and to the mathematician for a theory of singular integrals, but declares both chemist and mathematician to have no voice in a theory of art, so the theologian accepts the teaching of mathematician, physicist, chemist, and biologist, in their respective departments, but peremptorily excludes each and all from the supreme department of moral and religious duties founded on a theory of the relations of the world to its Creator.

Thus stated, one must admit a sufficient logical consistency in the present condition of compromise, and need suppose no kind of insincerity, no conscious equivocation in the acceptance of both the natural and the supernatural modes of explaining phenomena. Nor, indeed, could the fundamental inconsistency of such a compromise have been even recognized, until the quite modern extension of scientific method to moral questions had come to complete the disintegrating effects of historical and philosophical criticism applied to the sacred books on which theology relied. In the earlier stages of development, although the natural explanation was adopted in reference to the most familiar experiences, and framed the rough theories of common-sense for the habitual guidance of conduct, both in relation to the physical world and to society, the supernatural was adopted in reference to whatever was unusual and unseen; and the wider range of this speculative method was due to the immensity of ignorance. The slow progress of positive knowledge has more and more enlarged the domain of natural explanation, more and more restricted the domain of the supernatural. Yet, even now, the majority of cultivated men regard the facts of human nature as only partly explicable without aid drawn from the supernatural; and resist, as impiety, the attempt to assign natural causes in explanation of moral relations. That is to say, there where the operation of natural causes escapes our penetration, supernatural causes are invoked. Just as to men, ignorant of natural conditions, thunder was the fury of the storm-demon, or an eclipse was God's anger, so nowadays men, ignorant of natural conditions, interpret epidemics as "visitations," and regard "intuitions" as of divine origin. The inconsistency, then, of the acceptance of theological side by side with scientific principles, is only a continuation of the primitive mental state, and must vanish when there is a general conviction that science is orderly knowledge, and is coextensive with experience. If we can have no knowledge transcending experience in the widest sense, and if faith is the vision of things unknown—dealing with what transcends knowledge—then the conflict between science and theology is the conflict between knowledge and ignorance.

Unless this be the character of faith, I dispute the claim of Theology to the exclusive possession of faith as a principle of guidance. Science also has its faith, and by it must all men to a great extent be guided. But the faith of Theology and the faith of Science are very different in their *credentials.* The former is the reliance on the truth of principles handed down by tradition, of which no verification is possible, no examination permissible; the latter is reliance on the truth of principles which have been sought and found by competent inquirers, tested incessantly by successive generations, are always open to verification in all their details, and always modifiable according to fresh experiences. We believe in the law of gravitation, though we never opened the "Principia," and could not, perhaps, understand it; but we rely on those who can understand it, and who have found its teachings in harmony with fact. We believe in the measurement of the velocity of light, though ignorant of the methods by which the velocity is measured. We trust those who have sought and found. If we distrust them the search is open to us as to them. The mariner trusts to the indications of the compass without pretending to know how these indications were discovered, but assured by constant experience that they guide the ship safely. That also is faith.

But if the mental attitude is one of the same obedience as the theological faith, its justification is different. Its credentials are conformity with experience. Those of theology are the statements of the sacred books: the Vedas, Zendavesta, Bible, Koran. The statements therein made concerning the divine nature, its relations with the human, and the providential government of the world, are not open to the verification of experience, for they were not sought and found in experience. If we ask for their credentials, we are told that they are of divine origin. If we ask for evidence of this divine origin, we are referred to history or to our moral consciousness. Tradition has handed down these statements through successive generations; yet if we ask, as we ought to ask, how the tradition itself originated, we are brought face to face with this twofold difficulty: we cannot recognize that those who first promulgated the statements *had any better means of knowing the truth than we have;* and we are struck with the fact that the statements thus handed down by tradition do not agree. That of the Hindoos is not that of the Jews; the Persians reject the traditions of both.

Modern historic criticism has made such havoc with the historical pretensions that theologians are now throwing all the emphasis on moral consciousness. The doctrine of our sacred books is said to be unequivocally ratified by our intuitions: we feel their truth, and we see in their moral influence on mankind the verification of their divine origin. But here again the scientific method, which applied to the historical evidence has shattered its claim, applied to the evidence of moral consciousness is equally destructive. Psychology not only enlightens us as to the genesis of the intuitions, but, in a comparison with other nations and the earlier stages of human development, shows how they vary. If the intuitions of the savage are not those of the civilized, if precepts which the Hindoo feels to be divine are opposed to precepts which the Chinese, the Jew, the Mohammedan, and the Christian, feel to be divine, we need a criterion beyond these varying standards.

There is a wide-spread superstition which regards whatever is innate, or otherwise unexplained, as of a higher authority and diviner sanction than what is acquired through individual experience or is explicable on known laws. Our religious instincts are appealed to, as if instinct were the infallible guide in conduct; although a moment's reflection will show that it is the great aim of civilization to correct and repress many instincts. If the developed music of our day is of a higher order and more adapted to our sensibilities than the music of the middle ages; if our theories of natural phenomena are of a higher order and approximate more nearly to the truth than the corresponding theories of Aquinas and Albertus Magnus, why should our theories of moral phenomena be deemed inferior to those of Judaism or the councils? Is the nursery a school of riper wisdom than the laboratory?

So much as to method; now as to results. The sacred books of all theologies claim to expound a theory of the universe and a theory of human life and destiny. Their theories of the universe, both as general conceptions and particular explanations, are in such flagrant contradiction with the teachings of Science, that nowadays no one who is worth a moment's consideration seeks astronomical, geological, or physiological explanations in the sacred books. There has arisen the assertion that the sacred books were never intended to teach man scientific truths, but only to teach him his duties. The answer is twofold: first, that man's duties are comprised among scientific truths; secondly, that the books *do* teach, not scientific truths, but doctrines which science shows to be erroneous. We ask, therefore, if their dicta are proved to be erroneous on points where the control of observation is possible, what authority can they claim on points beyond all such verification? If their astronomical, geological, and biological statements are false, why are we to believe their statements respecting the origin of the universe, the laws of its evolution, the nature of man, and the conduct of man?

The escape from this dilemma which is attempted by giving up the physical world to science, reserving the moral world for theology, is only a temporary escape. Let it be granted that the authority of the sacred books refers solely to to the phenomena of human nature in the double aspect of the relations of man to God and his relations to society. If they contain explicit statements which are at variance with our moral culture—such as that God is "jealous" and "vindictive," or that sinners will be consigned to everlasting torment—they must have some other guarantee of their truth than the ratification of moral consciousness, since that rejects them; and if they contain statements respecting man's nature which are at variance with experience when they can be verified, how shall we accept their authority when the statements are beyond verification?

When the statements are ratified by experience and moral culture, theology can give these no *extra* sanction; when they are not so ratified, theology cannot make them acceptable. By way of illustration of the conflict between Science and Theology, in their explanations of human phenomena, with the precepts which are founded upon each, let us take the case of disease.

Very little is accurately known of its causes; but whatever they are, science, recognizing disease as the result of some disturbance of the organic functions, seeks the unknown causes in the known properties of the substances composing the organism. Theology, which uniformly explains the unknown by the unknown, invokes a supernatural cause for this natural effect. It declares that God sends diseases as chastisements and lessons. Nor is this declaration withdrawn when common-sense objects that the chastisement is often an injustice and the lesson an enigma. The innocent are seen to suffer even more than the guilty, and no one knows why they suffer; no one can regard the punishment of the child for the sin of its father as in agreement with human justice. But you say, "All men are guilty?" Then why are not all punished? And why are animals and plants also afflicted with diseases? Have they, too, the burden of Adam's disobedience? There was a time when such explanations reconciled the doctrine with observation; but nowadays cultivated minds shrink from the conception of "imputed sin" as a rational explanation of human and animal suffering.

In applauding this progress we must also point out the logical inconsistency of those who maintain the absolute authority of the texts of which such conceptions are the necessary applications. Theology maintains its doctrine even when theologians set aside the practice which that doctrine ordains. To claim absolute submission to the physician's formulas, and yet refuse to follow his prescriptions, is surely irrational? Yet this is the case nowadays. When the supernatural theory of disease was undisturbed by positive knowledge, prayers and incantations were the remedies in vogue; but now even those who will not acknowledge the theory to be an antiquated error practically disavow it, for they replace prayers and incantations by drugs and diet. Only the small sect called "The Peculiar People" trust entirely to prayer; and Christian magistrates are so outraged at this trust that they punish it as a crime! In vain are epidemics declared to be visitations, in vain are books written with such titles as "God in Disease;" the practical sense of the nation decides that cholera or cattle-plague are not to punish landlords and farmers for the skepticism of a few speculative minds, and hence that we had better seek to avert them by a course of treatment and "an order in council," than by pulpit eloquence and a "day of humiliation."

I have taken the case of disease because it is less open to the ambiguities and difficulties which beset a moral problem, but a similar discrepancy might be pointed out between the theological precepts and the moral practices. Here, as everywhere, it is patent that as knowledge advances, theology loses its hold; and morality, instead of remaining stationary like theology, advances with an enlarging insight into the healthy conditions of human relations. Science is often taunted with its imperfections and its inability to explain the mysteries of life. Imperfect it is, and that is why we should all strive to make it less so. Mysteries will doubtless forever encompass us. But Science may answer the taunt by challenging Theology to show that its explanation of the mysteries has any claim to our acceptance. The question is not whether *an* explanation can be given, but whether the given explanation has any verifiable evidence. Kant has truly said that now criticism has taken its place among the disintegratory agencies, no system can pretend to escape its jurisdiction. The Church has its texts, and has decided once for all what meaning these texts must bear. But the criticism of scientific method asks for the evidence which can prove these texts to be of divine origin, and the evidence which can prove these interpretations to be in agreement with fact. In both respects the answer is unequivocal. There is no evidence to prove the texts. The interpretations are discordant with experience. Thus the Catholic who accepts Galileo and Newton must give up the texts, or take the first step toward Protestantism, which asserts the right of interpreting the texts according to private judgment. And the Protestant who asserts this right of interpretation, and forsakes the literal meaning of the texts, has taken a step toward rationalism, and implicitly disavowed the authority of the texts, since what he obeys is not their teaching, but the teaching of the culture of his day and sect. The rationalist, in turn, has taken a step toward the scientific position; he regards the texts as symbols of an earlier stage of culture, which need the interpretation of our present culture; and when he learns—as easily he may learn—that all the facts of the moral world are to be investigated and systematized on the same principles as the facts of the physical world, setting aside in the one as in the other all supernatural and metempirical conceptions, because these cannot enter into the framework of knowledge, he will learn that science, in the true meaning of the term, embraces Nature and human nature, and moreover that it expresses what is *known* of both, whereas theology is only "the false persuasion of knowledge."

Many readers may vehemently deny the assertion just made. They will maintain the validity of theological explanations, all the more because, persisting in the old confusion of theology with religion, they refuse to acknowledge that a science of Nature and human nature, if truly expressing the facts, must be a better foundation for religion than a theology which untruly expresses those facts. The whole contest lies between the two modes of explanation and the results reached by such modes. I accept the appeal to history. This shows how, in proportion as knowledge became exact and orderly in each department of inquiry, the supernatural and metempirical explanations were silently withdrawn in favor of natural and experimental explanations. Nowadays, among the cultivated minds of Europe, it is only in the less-explored regions of research, where argument is made to do duty for observation, that the supernatural and metempirical explanations hold their ground. When science has fairly mastered the principles of moral relations as it has mastered the principles of physical relations, all knowledge will be incorporated in an homogeneous doctrine rivaling that of the old theologies in its comprehensiveness, and surpassing it in the authority of its credentials. "Christian ethics" will then no longer mean ethics founded on the principles of Christian theology, but on the principles expressing the social relations and duties of man in Christianized society. Then, and not till then, will the conflict between Theology and Science finally cease; then, and not till then, will the dread and dislike of science disappear.—*Fortnightly Review.*

CURIOUS SYSTEMS OF NOTATION.

By T. F. BROWNELL.

THERE is no example of a people without a system of numeration. The rudest savages manage to count to some extent. The attempts of many of them, however, do not succeed with numbers greater than three or four. With increasing knowledge, they learn to count larger numbers, but the process is a slow and troublesome one. It is performed in all cases by the use of the device of grouping. All systems of numeration that are known consist of this device. In the first stages, the groups are all of the first and lowest order. The savage, counting from one to five upon his fingers, closes his hand to express five; then he again begins counting upon his fingers to form a second group; and he continues to form groups of five to as great a number of groups as he can express. But all his groups are of the first order, and consist of units. He must make great advance in intelligence before he can take the next logical step in counting, by grouping the groups of five and then indicating these groups of the second order by a symbolic act.

In nearly all instances the method of grouping connects itself with the number of fingers on one or both hands, or the number of fingers and toes. Classification by pairs is also common. This is the simplest method, and was probably the first that was used. It arose, without doubt, from the common use of the hands in separating and combining articles in pairs. But the bases found most commonly in use are five, ten, and twenty. So universal is the selection of these numbers, that systems founded upon them have been termed the natural systems. There can be no doubt that the use of them arose from the number of fingers and toes. But, as has been said, these systems are natural only in the sense that ignorance is natural. They originated among the most ignorant races, without alphabet or figures. They were selected in crude attempts by unlettered savages to count game, or the days as they passed. The fingers formed the most convenient counting-board, and were therefore used.

The number of the fingers upon one hand was probably used in counting before the device of using the number upon both hands was thought of. In many of the Oriental languages the name for five means also hand. Vestiges of a scale of five are found in the decimal systems of many countries.

But the quinary system usually passes into the decimal for numbers above twenty, and frequently at some higher point into a third system in which twenty is a basis. Some of the Celtic dialects present a strange mixture of the three. The French language shows the vicinary scale in parts of its notation, and the use of this scale is much more common than is usually supposed. The Greenlanders give to twenty a name which means "a man." Our word "score" is probably a vestige of this scale. Its use was at one time very common for numbers between sixty and one hundred, where a similar counting now obtains in French. There can be little doubt that our Teutonic ancestors formerly used the vicinary scale for a portion of their counting. There are other instances where the vicinary has preceded the decimal system; but there is no example where the twenty scale has been carried to groups of the second order. Usually, like the five scale, it has been superseded by the denary system, which is now universally used.

With devices for numeration, there have been developed different systems of notation. By these, the attempt has been made to express numbers by written signs or symbols. As a general rule, practical methods of numeration have preceded the use of written symbols. The different systems of notation which have been developed and used, exhibit different degrees of excellence. The Greek and the Roman systems need no description. The Hindoo notation now in use, which superseded the Roman, differs from those which preceded it in many respects, all of which are to its advantage. It requires only nine symbols, together with the dot or zero. Its chief excellence, however, arises from its principle of "local values." Each symbol has two values: one intrinsic, and the other local. The intrinsic value is that which the symbol has when it occupies the unit place. Thus, the nine significant digits express the numbers from one to nine. The local value is that which a digit derives from its position in the number to which it belongs. Thus thirty is expressed by 30, the 3 by being thrown into the second place obtaining a positional value which is ten times greater than its absolute value. Since this increase is tenfold, the system is called decimal. If the figures are removed one place farther to the left, their value is again increased tenfold, and a like increase obtains for each removal. If removed to the right, their value is decreased ten times for each place of removal. The number by which the positional value changes is termed the root or radix of the system. It is one of the advantages of this notation that it enables us to express numbers with great ease, but its principal advantage appears in the simplicity which it gives to computations of all kinds. Another peculiar merit appears when fractions are involved, in the facility with which "decimal" fractions may be used.

But the merit of the Hindoo notation does not arise from the fact that it is decimal, but from its system of "local values." Ten was used as its radix simply because that number happened to be the basis of numeration universally in use when the notation was invented. Any other radix might have been used, since the principle of local values may be applied to all numbers. It has not, however, been popularly applied except to the number ten. Discussion, however, has arisen from time to time as to the merits of the number ten in comparison with other numbers. It appears to be admitted by all who have considered the matter that ten is far from being the best number for the purpose. It would be remarkable if it were. It came into use not on account of any intrinsic excellence, but because the number of the fingers is ten. For no other reason, ten was the number of objects placed in each group when the device of grouping came into use; then, naturally, it became the basis of the early systems of notation, and when the Hindoo notation was invented, it was taken for the radix of that system. It evidently was not selected on account of its fitness for the position. Were we eight-fingered, we should without doubt perform all our calculations with a scale of eight, to our great advantage in all arithmetical work.

Ten is, theoretically, ill suited for the radix of a system of notation, because it permits of only one bisection. The half of it is five, an odd number. It also is incapable of any other division. On account of these defects the system is ill adapted to the operations of the shop and market. Although our calculations are universally made in the decimal system, none of our tables of weights and measures are decimal in any one of their subdivisions. In all departments of trade the current prices have been derived from a process of successive halvings. The shopman reckons by halves, quarters, eighths, sixteenths, and thirty-seconds, and not by fifths or tenths. The yardstick is divided in its practical use into halves, quarters, eighths, etc., by successive bisections. Even the sixteenth of a unit is more commonly used in trade than the tenth. In the stock-exchange, shares change in price by eighths of a dollar, and not by tenths. Even with our decimal system of money, we require coins for half and quarter of a dollar for practical use in trading. Almost the entire price-list of our stores advances and recedes by these fractions of a unit formed by successive bisections.

The attempt by the French to compel the use of the decimal system shows the difficulty of such an undertaking. Popular necessities compelled the introduction of binal divisions. The prices of their money and stock markets are still frequently quoted in quarters and eighths. The attempt to divide time decimally was a failure. After trying to give to their decimal metrology a universal application, they have been compelled to modify it in many of their weights and measures. From the inherent defects of a ten scale, all attempts to introduce an international decimal system of weights and measures have met with strong opposition.

The decimal system, then, appears to be ill adapted both to arithmetical calculation and to the practical needs of trade. Since the principle of the Hindoo notation is one of universal applicability, its merits do not arise from the number which happens to be used as its radix. One number, however, may be better for that purpose than another; and attempts have been made to supply the place of ten with numbers claimed to be more suitable. New systems have been elaborated and offered as substitutes for the one now in use. There is probably no one, except perhaps the authors of these new systems, who supposes that any of these, however theoretically perfect, will ever supersede our common decimal system. Yet these new systems of notation are not without a theoretical interest, for some of them are certainly better than the system which we are compelled to use. A brief statement of some of these curious systems will enable the reader to understand the advantages and disadvantages of our own.

The first and most noted is the binary system, first brought to the notice of Europeans by Leibnitz. He esteemed it so highly that he zealously urged its adoption. He claimed that its superiority to the decimal system was so great that time would be saved by reducing the decimal expressions of a problem to a binary form, performing the calculation, and then restoring the answer to the decimal notation. A short description of the system will show the peculiarities upon which this claim was founded: In the Hindoo notation the number of significant digits is always one less than the value of the radix. In the decimal scale there are nine digits; in the binary, there would be only one—the figure 1. The radix, whatever it be, has no separate symbol, but is represented by 10. In the binary scale, since two is the radix, two would be so written. The square of the radix is represented by the symbols 100. In the binary these would, therefore, stand for four, while eight, which is the cube of the radix, would be denoted by 1000. The first ten numbers, counting from one, would be: 1, 10, 11, 100, 101, 110, 111, 1000, 1001, 1010.

In this system, then, the only digit employed is 1. The 0 plays the same important part in it as in the decimal system. It multiplies the figure that immediately precedes it by the value of the radix. The symbol 40, in our denary scale, represents ten times four; in the octenary it would denote eight times four, and in the quinary five times four. These two symbols, 1 and 0, then, are the only ones that enter into calculations. It is evident that thought in arithmetical work is almost superseded, and that all numerical operations are reduced to the manual labor of writing. As the scale has only one digit, it would require more figures to represent a number than other scales require. The present year 1878, which is expressed in our scale by four figures, would require eleven in the binary scale. It would be written—10101010110. And, generally, the binary scale would call for about three and a half times as many figures as the denary. This fact would occasion increased expenditure of time and manual labor in calculations. It is, however, claimed by those who favor the system, that, since only two symbols are used, and since almost all mental labor is saved, it would, probably, in most calculations, afford a real economy of labor. But the great number of figures required would unquestionably make the use of this system a tedious process. It would no doubt be a favorite with children, since it has no tables of addition or multiplication; for all of its processes of addition are simple counting, since only the figure 1 is ever added, and there is no mental multiplication at all. Mathematical thought, therefore, is almost entirely dispensed with. This simplicity, it is claimed, gives the system a great merit on the score of accuracy.[1]

A system of notation with sixteen as a radix has also been proposed. It was invented by a well-known civil engineer, who gave to it the name

[1] The following illustration of a simple problem in multiplication will furnish to those who are curious in numerical matters an opportunity to compare the two systems:

```
Decimal.                 Binary.
   87         =          1010111
   29         =            11101
 ----                    -------
  783                    1010111
 174                    1010111
                       1010111
                      1010111
 ----                 ------------
 2523         =       100111011011
```

of the Tonal System. He published an account of it about twenty years ago. It was carefully elaborated in all its parts, and a new system of weights and measures proposed to conform with it. New methods of dividing time, the sphere, the barometer and thermometer, were also proposed. A description, however, of so much of the system as relates to the notation is all that is required for our present purpose. The tonal system requires fifteen digits in addition to zero. Six new symbols were accordingly invented to represent the numbers, from ten to fifteen inclusive. New names were given to all the digits, in order to avoid confusion in using the new system. The reader may find it difficult to shift the symbols from their ordinary values to tonal ones; but, if it be borne in mind that **11** represents not ten and one but sixteen and one, **22** twice sixteen and two, **100** the square of sixteen, and that a similar change of value obtains with all the figures, the difficulty will disappear. The tonal figures below are printed in heavier type than the corresponding decimal ones, but the six new symbols are omitted.

The names and figures in this curious notation are as follows:

1	2	3	4	5	6	7
an	de	ti	go	su	by	ra
8	9	(10)	(11)	(12)	(13)	(14)
me	ni	ko	hu	vy	la	po
(15)	**10**	**11**	**12**	**20**	**21**	**30**
fy	ton	tonan	tonde	deton	detonan	titon
40	**50**	**100**	**101**	**102**	**120**	**135**
goton	suton	san	sanan	sande	sandeton	santitonsu

200	**1000**	**10000**	**100000**	**1000000**
desan	mill	bong	tonbong	sanbong

The new name "ton" given to **10** furnishes the system with its name of tonal. 0 was called "noll." The names of the figures above **10** were formed by simple combinations of the names of the digits. The present year, 1878, would be represented by **756** in this system, and be called *rasan suton by*. A lady 35 years old would be only **23** were the tonal system in use, and the grave author of the scheme called attention to this fact in an ingenious endeavor to make the better half of mankind warm advocates of the tonal counting.

However strange and fanciful this system may seem, its theoretical advantages are many and valuable. Its radix is susceptible of indefinite bisections, and is also a square and a fourth power. The vulgar fractions in common use, which require from four to seven places of decimals, would occupy only one or two when written in the tonal scale, as the following table will show:

	Denary.	Tonal.
$\frac{1}{2}$	.5	.8
$\frac{1}{4}$	.25	.4
$\frac{1}{8}$	.125	.2
$\frac{1}{16}$	.0625	.1
$\frac{1}{32}$	.03125	.08
$\frac{1}{64}$	.015625	.04
$\frac{1}{128}$	.0078125	.02
$\frac{1}{256}$	.00390625	.01

The disadvantages also of this scale are many. It requires a multiplication-table for all numbers from one to sixteen. The mental labor of calculating would, therefore, be increased. The number of symbols required would not be quite so large, but the advantage from this source would be slight. It may be noted, in passing, that in the Hindoo notation, the smaller the radix the greater is the number of symbols required to express any number, but the easier the mental work of calculating. The binary scale, which has the smallest possible radix, is an extreme example under this rule. For instance, the lady who would be called 23 under the tonal system would have to confess to no less than 100011 summers were she living among people who counted with a binary scale! On the other hand, the larger the radix the less the number of symbols required, but the greater the difficulty of computation. Thus the tonal system expresses numbers more compendiously than the decimal, but the difficulty of its many tables would make the use of it a continual and severe strain upon the mind.

Its author proposed also a tonal unit of linear, superficial, and cubical measurement, a tonal watch, a tonal compass, tonal wet and dry measures, a tonal currency for the world, a tonal division of time, tonal thermometers and barometers, and tonal postage-stamps. There is not opportunity in this paper to describe these schemes.

But other numbers might be used as radices, though most of them will be found to be ill adapted to the purpose. The number three would furnish a system which would possess no merits whatever. Its scale would present only two digits, and the first ten numbers would be 1, 2, 10, 11, 12, 20, 21, 22, 100, 101. But three is an odd number, and the first bisection would result in an endless fraction. The same is true of all systems in which odd numbers form the radix.

The number four, however, would furnish a practicable scale. It is a square, and can be bisected indefinitely without producing an odd number except at unity. The notation would be simple, and the tables of combinations easy to learn. Theoretically, the scale would be an excellent one, but calculations in it would require much manual labor, and consequently be more tedious than similar computations in our system. There would be three digits and the first ten numbers would be 1, 2, 3, 10, 11, 12, 13, 20, 21, 22.

The five scale, which is in use to a very limited extent among savage tribes, does not furnish a good system of notation, because five is an odd number. The first ten numbers would be 1, 2, 3, 4, 10, 11, 12, 13, 14, 20.

The six scale is theoretically superior in some respects to the decimal, because its radix can be divided by three, but it is objectionable for the same reason as the decimal. Its radix admits of only one bisection. Its notation would be somewhat simpler than that now in use, but more places of figures would be required. Its first ten numbers would be 1, 2, 3, 4, 5, 10, 11, 12, 13, 14.

Of the seven, nine, and eleven scales, it needs only to be said that they present no merits, since the numbers upon which they are founded are odd numbers.

None of the scales to which we have briefly referred have been advocated as practicable systems, but the duodenary or twelve scale has many striking advantages, and is used to some extent for certain classes of calculation. Its radix is divisible by two, three, four, and six. It can be bisected twice. The system has not only been the favorite with many who have theorized upon the subject, but it has been used to a great extent by different nations in the practical affairs of life. The Scandinavian nations have a preference for this scale. Traces of its use appear in our words *dozen*, *gross*, and *great gross*. It also appears in quite a number of the primary divisions in our weights and measures. Its use is quite common among mathematicians in long arithmetical computations. The additional mental labor required to compute in this scale is not very great, while the manual labor is somewhat less than in using the decimal system. The scale has always been a favorite one with those who object to the decimal notation.

The sexagenary system, founded upon the number sixty, deserves a passing mention on account of its historical interest. It was used for a long time by the Greeks in astronomical and other calculations. Our subdivisions of time and the circle are made with reference to it; but for practical operations it is very laborious and complicated.

The octonary system, founded upon the number eight, most completely presents the qualities which are desired in a system of notation. Eight is without doubt theoretically the best number of all to be used. It is a cube, and admits of indefinite subdivisions by halving. The system appears to have all the merits of the sixteen scale, while it avoids the disadvantages of a large radix. It is much easier to use than the decimal scale. It requires only seven digits. The figures 8 and 9 do not appear, and its tables of addition and multiplication are much simpler than those now in use.[1] The danger of error in computations is

[1] The following multiplication-table, given by the author of an octonary scale, will show how simple must be the mental work of calculating in that system:

1	2	3	4	5	6	7
2	4	......	......	......	......	......
3	6	11	......	......	......	......
4	10	14	20	......	......	......
5	12	17	24	31	......	......
6	14	22	30	36	44	......
7	16	25	34	43	52	61

correspondingly lessened. The mental work in using it would not probably be more than half that called for by our notation, while the number of places of figures required would be only slightly greater. The year 1878 would also be expressed by four figures, 3536, in the eight scale. Its fractions would be much simpler than those of the decimal system. They would differ very little from those of the sixteen scale.

The merits of the octonary scale have long attracted the attention of those interested in the subject of numerical notation. Charles XII. of Sweden seriously proposed introducing it in his kingdom. He commissioned Swedenborg to prepare the necessary details of a plan for establishing it. It is said that a complete system was elaborated, but the attempt to introduce it was prevented by the death of the king. No record of the system has been preserved.

But a complete octonary system has been elaborated, and a description of it was read by its author before one of our scientific associations about twenty years ago. In many respects, the details of it resemble those of the tonal system, which, in point of time, it preceded. New names were supplied for the digits as follows:

1	2	3	4	5	6	7	10	11	12
un	du	the	fo	pa	se	ki	unty	unty un	unty du

20	30	31	50	100	200	1000
duty	thety	thety un	paty	under	duder	untyder

10000	100000
unsen	untysen

The names of the larger numbers were made by compounding those of the smaller. Thus the present year, 3536, would be called *thetyder pader thety se.*

The octonary, like the tonal and quaternary scales, is without doubt admirably adapted to a natural system of weights and measures, and it is not without interest from a theoretical point of view. The disadvantages of the decimal system are clearly great, but the projects of those who expect to subvert it, with its immense store of arithmetical tables and formulas, are of course chimerical in the last degree. The author of the octonary system, just described, declared that the change involved no real difficulty, and that the national Government had only to will it, in order to bring the octonary scale into general use in one or two generations. But although the introduction of this or any other numerical scale in the place of the decimal is a dream without any probability of fulfillment, there can be no question that, theoretically, the octonary system of notation would be a vast improvement upon the one now in use, the basis of which was ignorantly bequeathed to us by our savage and barbarous ancestors.

MAN AND HIS STRUCTURAL AFFINITIES.[1]

By A. R. GROTE, A. M.

AN average coroner's jury might sit on the skeleton of an anthropoid ape and return a verdict that the deceased came to his death at the hands of parties unknown, with the sublime consciousness of having performed their duty and earned their fees. The suspicions of the more intelligent jurymen might easily be allayed by the common conception of what the word "monstrosity" will cover, and the similarity is indeed so great that I see no reason why the verdict should not be unanimous.

The gorilla has no more tail than a professor, while the knowledge that monkeys have tails, and the idea that these external appendages are a badge of general monkeyhood, are deeply rooted in the popular mind. But the apes are as tailless as man is, and no more so. I might say even less so, for the gorilla seems to have one caudal vertebra less than man; but we must give more weight to the head than the tail in matters of classification. In this world heads win throughout the game of life. Certainly, the bones of a gorilla, for instance, may be readily distinguished from those of a man, but certain bones in woman differ also slightly from the corresponding ones in man, and it is a recorded fact that juries have in this way mistaken the sex of the human subject of their deliberations. In England, in 1839, a double jury sat on the skeleton of a woman accidentally found, and upon which a man had been arrested for the supposed murder of his brother, for whose remains the bones had been mistaken. Their real nature fortunately transpired before a verdict was rendered. It is evident, however, that the bones of extinct animals have been mistaken for human remains, and so have inspired accounts of prehistoric giants; while it is certain that the bones of fossil mammalia have been revered as relics in Europe during the middle ages, and even up to the time of Cuvier. The correct determination of bones is, indeed, a more difficult matter than may be supposed from the readiness with which naturalists sometimes deal with the subject. A great deal depends on the state of preservation of the bone; and, again, what particular bone it is. Certain single bones, as the tooth, or one of the bones of the feet or hands, are much more decisive in their character than the ribs or vertebræ. The structure of the teeth shows a relation to the character and consistency of the food, and there is no doubt that, so long as the lion has his present dentition, and while his appetite remains, he will always lie down with the lamb—inside of him. In land-animals the bones of the limbs have more play in their sockets than in air or water animals, because flexibility is necessary to

[1] From a lecture delivered before the Buffalo Society of Natural Sciences, March 9, 1878.

speed over the ground or trees, but it is an objection where the limbs are to be used as paddles against the air or water. In fact, the more we know of the skeleton and the environment of the animal, the more we see that its variations throughout the animal kingdom are the combined results of the movements of the organism itself and the opposition of the medium in which it moves. Where the actions of the animal are slow, it is found that the bones of the limbs are more rigid and often joined, as shown in the case of the sloth by Prof. Cope. The head and the ends of the limbs, being in constant use against the vital conditions of the environment, are the soonest modified. The bones are formed by the muscles, and the muscles are developed through the movement of the animal. We may all have noticed that, when the skin is stripped off, and the extremities of the backbone, the head and tail, are cut off, together with the feet, the carcass of a cat looks much like that of a rabbit in the same condition.

Those who have not investigated such an instance of similarity, yet know that in a butcher's shop there is a superficial sameness in the appearance of meat which it is the business of a good marketer to see through; while a good many of us, who are unaccustomed to provide, would no doubt be not a little puzzled to distinguish the body of a calf from that of a sheep as it hangs in the stalls. The same thing holds good with the bodies of birds and other animals: a duck is identified most quickly by the webbed feet and flattened bill. Thus it is a matter, perhaps, of general knowledge that an animal is difficult to recognize when the head and extremities of the limbs are missing, and we see now the reason that it is so. We may go even further than this and account for the mistakes of antiquity on the same principle. It is not credible that the head or feet of a mammoth could have been mistaken for those of a man, nor were they as a fact; but a thigh-bone, or rib, offered less difficulty by reason of the greater resemblance. Hence we find that these mistakes have been made with some excuse for their commission. The difference existing between these fossils and the corresponding bone in man was so small as to escape the notice of the anatomists of antiquity. The general resemblance between the skeletons of all vertebrate animals was not then fully appreciated. People distinguished the animals in old times from man by their heads, feet, and fur, to say nothing of their tails; and, when they found an isolated internal bone, they may readily be forgiven for having wrongly referred it.

Again, the bones being produced through the muscles, and these through the nutrition of the animal, there is always a proportion between the skeleton and the stomach and soft parts of the body. The skeleton is a very good index of the comparative bulk of the animal, and this fact assists us when we attempt restorations of extinct species.

From the herd of monkeys found in the Oriental and Ethiopian regions of the Old World, the apes are readily distinguished by certain structural characters. The body is that of a human being, except that the arms are proportionally longer, and the legs shorter, than in the average man. The face is very human from the structure and position of the eyes and ears. A tail, external to the rump, is entirely wanting. The body is covered with sparse and soft hair, except the face, toes, palms, and soles, which are bare. The species which has been written about the most, and about which, strange to say, we know the least, is the gorilla (*Gorilla Savagei*). Whether this ape was the species called by this name two thousand years ago by Hanno is doubtful and of no importance.

Wilson and Savage, two American missionaries, seem to have been the first, in 1846 and 1847, to bring us certain information of this comparatively near relative of ours. I do not think that we are grateful for the discovery. Generally speaking, we could have dispensed with this satire upon ourselves, although we have no responsibility in the case. At any rate, we can appreciate one value of missionary labor. American missionaries, by their intelligence and perseverance, have given us invaluable information from time to time concerning countries difficult of access, and their strange inhabitants.

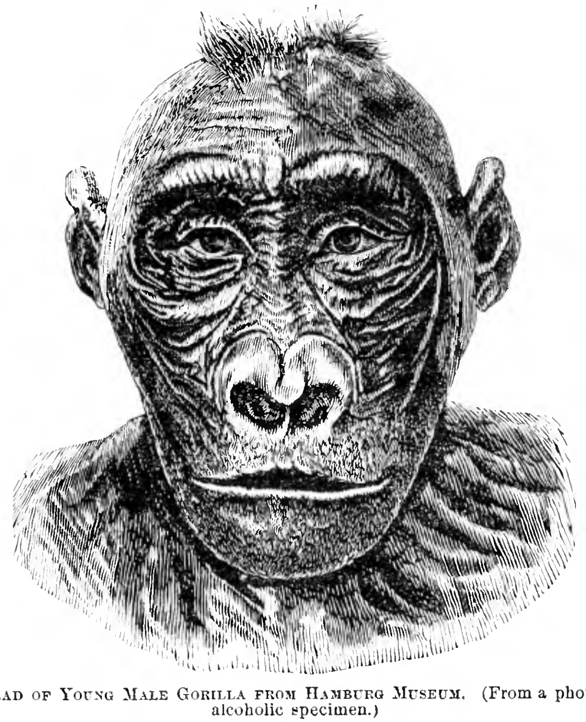


FIG. 1.—HEAD OF YOUNG MALE GORILLA FROM HAMBURG MUSEUM. (From a photograph of alcoholic specimen.)

Since this discovery of the gorilla, the animal has been written about by several travelers. The accounts of personal encounter furnishedby Du Chaillu are now known to be largely fanciful; and Win-wood Reade, a most reliable traveler, doubts if an adult has ever yet been seen alive in its native haunts by a white man. The specimens sent alive to Europe, and which have been claimed to be gorillas, have almost always turned out to be chimpanzees in various stages of growth. But the skulls and skins sent by Dr. Savage have been followed up by complete skeletons and preparations sent by other travelers, and naturalists have been able thus to study the appearance and structure of the most formidable of the man-apes, which is credibly stated to inhabit Central Africa from Sierra Leone in the north to Loango in the south. Living in the dense forests of that region and avoiding the presence of man, it is only with difficulty they are to be met with, and, from the inefficiency of negro courage and weapons they are rarely killed. We have thus no authentic portrait of the live adult gorilla, but we give here (Fig. 1) a picture of the head of a young male gorilla preserved in spirits in the collection of the Society of Natural Sciences of Hamburg.

In comparing the skeleton of the adult gorilla with that of man, we find that the vertebral column offers slight and unimportant differences. The number of ribs is thirteen; while in man it is usually twelve, but occasionally also thirteen are found. The curve of the back is slightly different because the erect position is not always maintained, and to this circumstance I would also attribute the difference in the shape of the pelvis. In man the viscera have to be supported during his usually erect position, and the bones of the pelvic girdle are larger, giving space for the attachment of the larger muscles of the spine and thighs, which render the attitude possible without inconvenient fatigue. But it is a fact that in a child, before it learns to walk, the pelvis is as contracted as in the apes. In its efforts to walk the girdle is opened out, the sutures being flexible during childhood. When we come to the skull of the gorilla, we find a great difference in the relative proportion of the different parts. The bones of the face are large and the jaws project. There is a variation in the different races of man in this respect, as an examination of the skulls of different races shows. The relative large size of the jaws and lower parts of the face we see in the negro races especially, as compared with our own, and to this type we give the name *prognathic*.

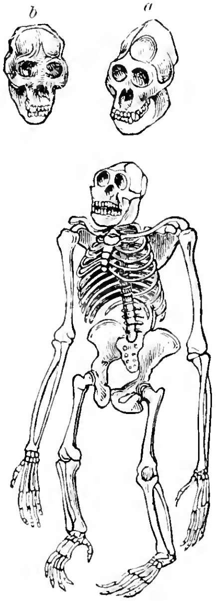


Fig. 2.—Skeleton of Gorilla, and Male (*a*) and Female (*b*) Skulls.

The man-apes show an excessive development of this type. At first sight this large development of the lower face and jaws might distinguish the apes from man with great clearness, but its importance seems diminished when we compare the man-apes with the baboons and lower, tailed monkeys in this respect. The cranium of the gorilla is also very small in proportion to that of man. The contents of the smallest skull of man is given at sixty-two cubic inches; that of an adult gorilla is given at thirty-four cubic inches. But this difference loses much of its value when we see the amount of variation in men of the skull measurements. Thus the largest human skull shows a capacity of 114 cubic inches, being about twice the size of the smallest adult human skull.

Now, the difference thus shown in man of fifty-two cubic inches between the capacity of the largest and smallest skulls is greater than that between the smallest human skull and that of the gorilla, which is only twenty-seven inches. These figures will probably be still further modified so soon as we get accurate measurements of the skulls of certain African and Indian hill tribes more recently discovered. Indeed, it is already stated that twelve cubic inches of cranial capacity will cover the difference between the smallest human and the largest simian skull yet known. Again here, as with the prognathic characters, the importance of the difference in cranial size is diminished by the fact of its variation among the apes and monkeys, which latter are found to fall as much below the apes in cranial capacity as the apes do as compared with man. The skull of the gorilla exhibits considerable variation in the specimens which have been yet examined. The males seem to have a prominent bony ridge on the crown of the skull, but this development of the bone stands in proportion to the muscles of the jaws which reach on each side up to the crest which they deposit. Where the jaws are weaker, as in the female, the crest is undeveloped, the muscles do not reach up so far and they deposit smaller ridges on the side of the skull. These crests are, however, wanting in the orang-outang, a lower kind of man-ape than the gorilla, where they are replaced by two bony ridges, a couple of inches apart, as we learn from Mr. Wallace's interesting writings. But the variation among the skulls of the gorilla yet examined is so great in the proportion of the different parts of the face, that it is evident there is a greater amount of individual peculiarity in this than in any other animal except man. This point is worthy of a much more extended examination than it is now possible to give to it. It is sufficient to state that these differences seem to have prompted Dr. Wyman and Du Chaillu to suspect species where in fact we find only one kind of gorilla as more specimens come to hand and supply the intermediary links. With regard to the permanent teeth of the gorilla they are thirty-two in number, just as in man. The principal difference is that the canine teeth, at least in the adult males, are longer than in man, and project. The jaws being more powerful and more constantly in use, the teeth are stronger and proportionally stouter than in man. And where we find any difference, such as is offered by the large canines, and the break in the lower series to admit of the play of these fangs, we find, just as we did before, that there is a greater difference here between the man-apes and the lower monkeys than between the man-apes and man. The canines are either much more developed or there is a change in the total number of teeth indicative of a greater departure from the human type of dentition.

You will remember that I called attention to the fact that throughout the animal kingdom we were to find the greatest changes in the structure of the extremities of the limbs, because these were brought

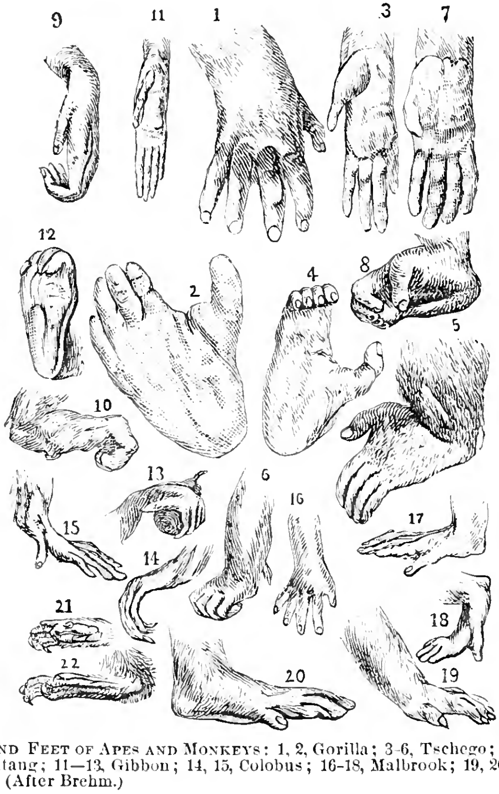


FIG. 3.—HANDS AND FEET OF APES AND MONKEYS: 1, 2, Gorilla; 3-6, Tschego; 7, 8, Chimpanzee; 9, 10, Orang-outang; 11—13, Gibbon; 14, 15, Colobus; 16-18, Malbrook; 19, 20, Baboon; 21, 22, Silk Monkey. (After Brehm.)

into constant use against the immediate surroundings of the animal. In truth, the greatest differences between the gorilla and man are found in the feet. The hands are not very unlike a man's; every bone and muscle is here again in its place; the thumb is a little shorter and the whole hand heavier. The muscles of the arm are more powerful and the hand is used for coarser work than man's, but after all not for work very different in kind. With them the gorilla builds a nest to sleep in, breaks off boughs, handles its food, and also attacks its enemy, holding him fast so that it can bite him. We do all these things with our hands; and there is a legal term, *mayhem*, to denote the crime of mutilation with the teeth, which is not uncommon among brutal men of some countries considered civilized. But the foot seems at first very different from a man's, although here again every bone and the determining muscle (*peroneus longus*) of the foot of man are present. The foot is set more obliquely on the leg and the big-toe is farther from the rest, proportionally shorter and weaker, and, above all, more flexible. Certainly these important differences are connected with its mode of life, which is more arboreal than that of man.

With its foot the gorilla can steady itself in climbing and hold fast to objects from which the rigid foot of man would slide away. Still our feet are not wholly unfit for grasping, and you may have noticed barefooted boys cutting up "monkey-shines" on trees with entire safety to themselves, though not to the complete satisfaction of their parents. The female gorilla seems to consider her young one safe when he is up the tree; but the anxious human mother does not feel easy until the child is on the ground again. Circumstances thus alter cases throughout the range of experience. Again, we are familiar with the fact that men who have lost their arms often learn to write and perform other actions with their feet. But, notwithstanding these important differences between the feet of the gorilla and our own, there is again the greater difference to be considered between the hands and feet of the lower monkeys and those of the gorilla. The thumb ceases to be opposable in the American monkeys, and is again reduced to a mere rudiment covered by the skin in the spider-monkey. Indeed, we may say that, looking through the succession of simian forms, from below up, there is a constant increase of the characters which prepare us for man. And the gorilla exhibits these in their fullest development. From the gorilla it is indeed easy to predicate man—much easier than to suppose the gorilla from the lowest monkeys.

Another interesting man-ape is the chimpanzee (*Chimpanza niger*). Many living specimens have been brought to Europe and lately to New York from Africa, where it inhabits the same territory as the gorilla. It is a smaller species than the gorilla, the head proportionately larger and less prognathic, the arm shorter. The foot is more hand-like, and there is a slight difference in the dentition. In running, the chimpanzee goes on all-fours, but in walking or carrying anything the position it assumes is nearly erect. In captivity the chimpanzee has developed most amiable qualities. It has been taught to sit at table, and even to conform to what we esteem good manners. It becomes passionately fond of its keeper, clinging to him, and refusing to be separated on any occasion. It is extremely kind to children, showing no trickish or malicious temper, even endeavoring to amuse them, and induce them to play. As long as there is light in the room the chimpanzee will sit up at night; as soon as the light is withdrawn it goes to sleep, lying stretched out with its hands under its head if the temperature is pleasant, but, if cold, cowering together like a human being under similar circumstances. It is evident that much might be done with the chimpanzee to make him an agreeable companion to man. Fortunately, this hard fate may be spared to the chimpanzee, because he cannot support existence in the colder regions to which our race has become acclimated.

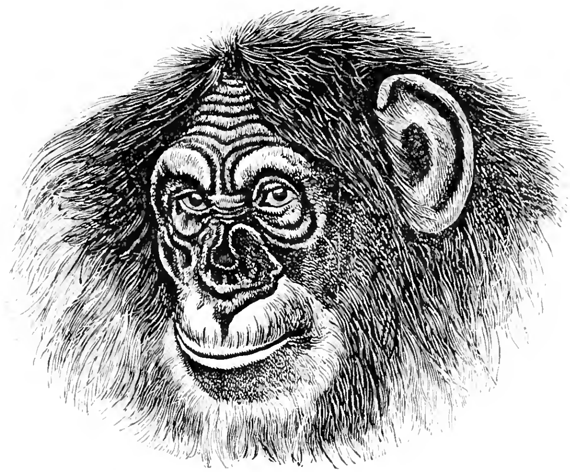


FIG 4.—HEAD OF CHIMPANZEE.

The negroes do not seem to court his companionship. One notable feature in the chimpanzee remains to be stated, and that is his peculiar behavior to other animals. He is perfectly contemptuous in his treatment of our small, domestic animals, such as rabbits. He is frightened at large and fierce dogs, and exhibits an extreme terror at snakes and ugly reptiles. In this latter fact we recognize a mental state which is still shared by man, suggesting the probable origin of the serpent as an embodiment of the devil in the ideas of primitive man, and which still survives among us at the present day. Another species of man-ape is the tschego (*Anthropopithicus tschego*), which is only known from a single living female brought to Dresden from Loango. This species seems to be but little smaller than the *gorilla*, intermediate in size between this and the *chimpanzee*. In the proportion of its parts the most notable peculiarity seems to be that the legs are longer than in the other man-apes. The behavior of the specimen in confinement did not differ greatly from that already related of the chimpanzee.

The Asiatic man-apes differ from those of Africa by the proportionally longer arms, which reach down to the ankles. The orang-outang (*Simia satyrus*) inhabits most commonly the island of Borneo, and has recently been collected in considerable numbers by Mr. Alfred Wallace. It has only twelve pairs of ribs, as is usual with man. The body is broad at the hips, and joined to a pyramidal-shaped head by a short neck, which is still further concealed by heavy folds of the skin, which can be puffed out by the animal when angry. The eyes and ears are small, but not unlike those of man. The nose is quite flat, the mouth is large and ugly, from the thick lips. The jaws are extremely powerful, and the canine teeth prominent. The breast is thinly haired, and the face, the fingers, palms, and soles, are naked. The back and top of the head are thickly haired, and on the side of the jaws the hair de-

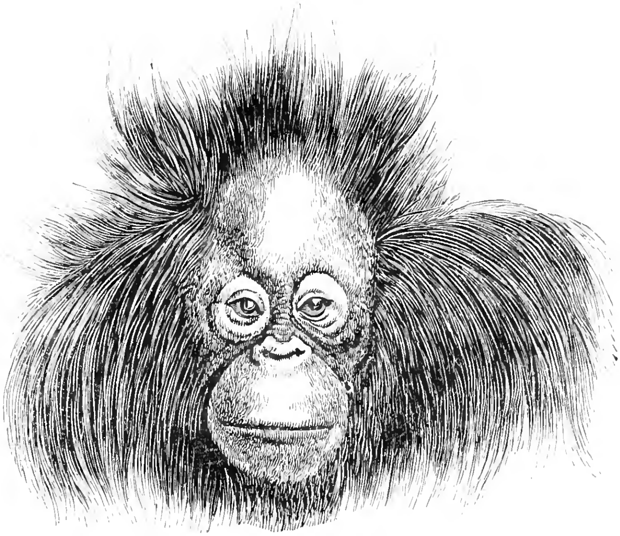


FIG. 5.—HEAD OF ORANG-OUTANG.

scends like a beard. In color the hair is a dark, rusty red, sometimes brownish on the back, the fringing hair of the face usually lighter than the rest. The color of the skin is bluish-gray. The old males may be distinguished by their longer beards, which are wanting in the young, and by a peculiar swelling of the cheek from the eyes to the ears, which makes their aspect more repulsive.

The orang-outang was certainly known to the ancients, and Pliny gives an account of this species which has been extensively copied. One peculiarity, only recently observed, is that the skull undergoes a greater change in shape than usual during growth. The heads of baby-orangs bear a close resemblance to those of infants ; but afterward the lower portion of the face increases rapidly in size, and the aspect of the adult is more repulsive and animal-like than the chimpanzee. Wallace says they frequent swampy localities in Sumatra and Borneo, and visit the orchards of the Dyaks for the purpose of devouring the fruit. They build nests in the trees, of boughs, in which they sleep. They climb with great ease, and traverse the forest from tree to tree in a semi-erect position, assisted by their long arms, and are capable of progressing at the rate of eight or nine miles an hour without any appearance of hurry or fatigue, going as fast as a man on the ground beneath them can run.

The food of the orang-outang is strictly a vegetable one. It has the habit of not rising very early in the morning, waiting until the sun has dried the dews, and Nature has dressed herself for its appearance. Although the orang does not court danger, it does not seem afraid to fight if necessity obliges. Wallace narrates the combat between a Dyak and an orang, in which the native was terribly bitten and might have been killed had not assistance arrived. The orang was then killed by numbers, and Wallace rescued the skin and head to be added to his large collections, and taken later to England. Mr. Wallace also succeeded in finding a baby orang-outang, and gives his experience with it as follows:

"When handled or moved it was very quiet and contented, but when laid down by itself it would invariably cry; and for the first few nights was very restless and noisy. I fitted up a little box for a cradle, with a soft mat for it to lie upon, which was changed and washed every day; and I soon found it was necessary to wash the little orang as well. After I had done so a few times it came to like the operation, and as soon as it was dirty would begin crying, and not leave off till I took it out and carried it to the spout, when it immediately became quiet, although it would wince a little at the first rush of the cold water, and make ridiculously wry faces while the stream was running over its head. It enjoyed the wiping and rubbing dry amazingly; and when I brushed its hair seemed to be perfectly happy, lying quite still with its arms and legs stretched out, while I thoroughly brushed the long hair of its arms and legs. For the first few days it clung desperately with all four hands to whatever it could lay hold of, and I had to be careful to keep my beard out of its way, as its fingers clutched hold of hair more tenaciously than anything else, and it was impossible to free myself without assistance. . . . Finding it so fond of hair, I endeavored to make an artificial mother by wrapping up a piece of buffalo-skin into a bundle and suspending it about a foot from the floor. At first this seemed to suit it admirably, as it could sprawl its legs about and always find some hair. I was now in hopes that I had made the little orphan quite happy; and so it seemed for some time, till it began to remember its lost parent and try to suck. It would pull itself up close to the skin and try about everywhere for a likely place; but, as it only succeeded in getting mouthfuls of hair and wool, it would be greatly disgusted and scream violently, and after two or three attempts let go altogether."

This account is interesting, because it shows that in its actions the young orang-outang recalls what we are familiar with in infants; and again it illustrates the activity of the limbs at an early age and before they can be used intelligently. There can be no doubt that in this way we come to use our limbs at first, by a sort of blind groping in the uncertain light of infancy. We feel a sympathy for Mr. Wallace that his baby orang-outang never would do anything to reflect credit on its bringing-up, and finally died in an obstinate and childish manner. It was thought that it never entirely got over its separation from its family, but this may have been a fancy.

Another long-armed ape is the gibbon (*Hylobates lar*), which is smaller than the orang-outang and exceedingly intelligent. This species readily assumes the erect position when not executing its incomparable gymnastic feats, swinging with its arms and leaping from one rope to another in the rooms fitted up for its dwelling in confinement. It walks with the knees bent and the long arms stretched out with the hands hanging down, reminding one of the position of a rope-walker. The gibbon is extremely neat and cleanly with its person, and is not distinguished by any peculiar odor, as are some of the other species of

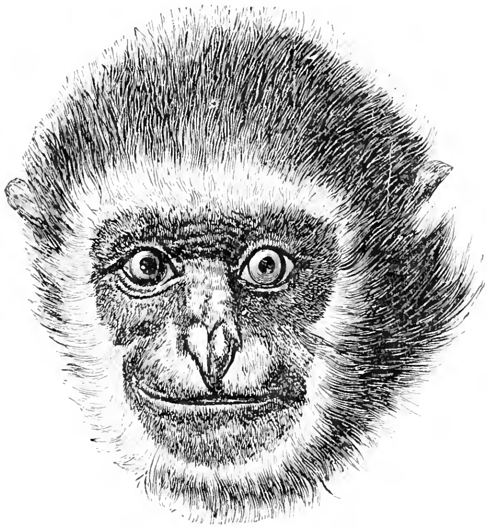


FIG. 6.—HEAD OF GIBBON.

apes. As a prisoner the gibbon eats bread, milk, and fruit. Before drinking, it has been remarked that it tastes the fluid doubtfully with the tip of the tongue, which in the apes, as in man, is the most sensitive portion of that organ. Dr. Hermes says that the gibbon is an aristocrat among the man-apes and always on the best behavior.

I conclude this outline description of the man-apes with the statement that the duration of life among them is not accurately known, and probably varies with the different species. The gorilla and chimpanzee probably attain the average age of man.

The position of science with regard to man and the anthropoid apes is, that in no case can these latter be considered our progenitors or descendants. The physical and mental characteristics are too diverse to admit of such conclusions. The apes have evidently come down another line of descent, although the time when both the apes and man may have emerged from a common branch of the tree of animal life may not be so very long past. But, whenever the line of man and that of the anthropoid apes coincided, it is clear that now the tendency must be to diverge more and more. The resemblances between the apes and man, however, cannot be overlooked by the thinking mind. They are so great that if we assumed the theory of degeneracy to be true, and so were willing to throw the whole animal kingdom backward on its tail instead of forward on its feet, we might consider them to be degenerate and "wild" men. And it is interesting to find that this is what they were formerly held to be. The early pictures of the orang and chimpanzee exemplify this notion by giving them perfectly human features and erect position, brutalized only by their hairy body. They were, in fact, assumed to be a very abandoned kind of man, and not a very elevated kind of monkey. It is thought by some tribes of men to this day that the apes could talk if they would, but they are afraid that if they do they will be made slaves of and obliged to work. From the naked white skin, through the yellow and red to the black and then to the black with hair, does, indeed, seem a gradual transition; and, if we concede the erect posture, the admission of the ape into the human family carries with it no little show of justice. It is not so long ago that we denied human rights, and both openly and impliedly consanguinity, to the negro, as to make it impossible that we should not come to regard the gorilla in a more affectionate light than we do at present. But, in point of fact, the different races of mankind represent a kinship remote in proportion to their structural differences; and most of us, perhaps, would be willing to admit at once the truth of this proposition. Science insists that it is true throughout the animal world, and expects that the time will come when it will be acknowledged, and our behavior improved by an increasing kindness on our part to our inferior and weaker fellow-inhabitants of the earth. The proof of the evolution of man we find first in the fact that for every bone and muscle or organ in man there is a corresponding one in the anthropoid apes. Having shown in this way that man is not separable from his physical characteristics, science enters into a comparison with regard to the difference in brain-power. The mass of the brain, as judged by the cubical contents of the cranium, we have seen, can be no certain criterion for the intelligence, but only of comparative value, because it was so variable in the apes and man. It is, however, a guide from a physiological point of view by which we can estimate an advance in thinking powers throughout the animal kingdom. It has been amply shown by Prof. Marsh that, as a whole, the proportion of the brain-case has increased through the succession of fossil vertebrate life from the time when coal was formed up to the present. And it can be shown that this proportion is greater in man to-day as compared with existing mammals. When we come to the structure of the mass of the brain, that of man offers no perceivable difference of importance from that of certain apes. The discussion on this point has been fully entered into by distinguished anatomists, and need not be detailed in this place. Alone, the weight offers a difference. The heaviest human brain known is given at 1,872 grammes, the lightest brain of a sane person 907 grammes, both these extremes being furnished by women. The difference between the mass of the brain of man and that of the gorilla is proportionally, perhaps, the greatest that exists to separate the two. It has been considered by Huxley to approximate to twelve ounces. But the difference between the extremes of brain-weight in man, as exemplified in the figures here given, shows that we cannot consider intelligence to depend on the weight of the brain. All that we can say is, that a man with a large brain has capacity for the display of intelligence. It depends on his use of the senses, which are the feeders of the intellect, whether he displays high wisdom or not. It is quite possible that an ape may be more intelligent than a human being who has not properly supplied his brain with information. Human beings born dumb and blind are not born *ipso facto* intelligent, but are taught with great trouble and patience through the channels of the remaining senses. The facts known in regard to afflicted persons are amply sufficient to warrant the statement that the intelligence depends on the senses, and if these are interfered with, either in the structure of the organs, or by giving them a limited opportunity for activity, you have, as a result, less intelligence in the individual, be it man or ape, or other animal. We can show that the difference between man and apes is a *quantitative* and not a *qualitative* one.

A NEW PHOTOGRAPHIC PROCESS.[1]

SO manifold are now the uses of photography that we need not dwell upon the importance of processes which allow of the employment of easily-handled apparatus, and which do away with cumbersome and fragile glass plates. Deyrolle's photographic process, described below, answers all the requirements of portability.

The idea of substituting sensitive paper for heavy, brittle plates of glass is not new, but all the processes hitherto offered labor under the serious disadvantage of necessitating a long exposure. Besides, the proofs are usually imperfect on account of the granulations which the paper leaves on the positive. M. Deyrolle's collodionized paper does not present these difficulties. It is covered with a special coating, insoluble in ether, alcohol, or water, and thus it undergoes all the operations of photography without change. This paper is collodionized and treated precisely as though it were glass. It is, in fact, quite equal to glass plate for the uses of photography, and in addition possesses the following advantages :

The layer of collodion is so firmly attached to the coating of the paper that it cannot be injured by contact with a hard object, nor even by slight friction. Besides, the picture can be developed by total im-

[1] Translated from *La Nature* by J. Fitzgerald, A. M.

mersion in the developing liquid, instead of pouring the latter on the collodion layer, as in the case of plates of glass, an operation that requires some dexterity and long practice.

This paper will retain all its sensibility for about two years, provided it be sheltered from light and moisture; it is not affected either by cold or heat. Hence it is destined to be of great use to travelers who explore remote regions.

After the light-impression has been made on the paper, it remains to develop the image. This operation presents no difficulty, success depending, so to say, only on the time of exposure. First, the paper is dipped in common water, care being taken to make the immersion complete. There it must remain for at least five minutes, or until the paper, which was beginning to curl, becomes perfectly flat. In the mean time the following solution is prepared in quantity only sufficient for the pictures to be developed at once, for oftentimes it decomposes in the course of a day or two:

Distilled water	1	litre.
Glacial acetic acid	20	grammes.
Citric acid	20	"
Pyrogallic acid	3	"

Into a basin with flat bottom, and of a size corresponding to that of the proof treated, is poured enough of the above solution to completely submerge the proof; a depth of three or four millimetres is amply sufficient. Into this is dipped the proof after taking it from the water and draining it, the collodionized side uppermost. After inclining the basin in every direction, so as to cause the liquid to pass several times over the proof, a portion of it is poured into a glass, and then we add to it a few drops of the following solution:

Distilled water	100	grammes.
Crystallized nitrate of silver	5	"

Stir well, so as to mix thoroughly. The whole is poured into the basin, which again is inclined as before. The image now appears; seven or eight minutes suffice to completely develop it, with the sky or the lighted parts of an intense black.

When the proof is sufficiently developed it is put in water, and then dipped in a solution of hyposulphate of soda, 40 per cent., to fix it; it is then freely washed in water in the usual way. It is now dried between leaves of silk-paper or blotting-paper.

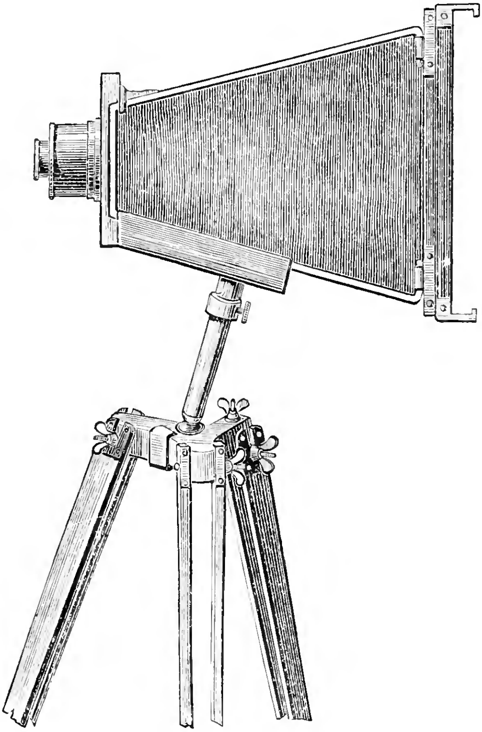
Treated in this way the proof is perfectly secure: it is not affected by changes of temperature, and may be exposed either to damp or to drought without the least injury. To preserve it, we have only to place it in a book or in a portfolio, so that it may not be creased or rubbed on the collodionized side.

When we would take positive proofs, we detach from the paper the layer of collodion, thus getting the image on a thin transparent pellicle.

This is a very simple operation, consisting merely in adding to the collodion layer firm and transparent substances, till the *cliché* attains the proper consistence. To this end, we prepare a normal collodion of the following composition :

Gun-cotton	25 grammes.
Sulphuric ether	½ litre.
Alcohol of 40°	½ "

Lay the proof on a plate of glass, having first turned up the edges all round, so that the liquids to be poured upon it shall not overflow. On the collodion layer containing the image pour the normal collodion, beginning at one of the corners of the proof most remote from the operator. Then incline it slightly, so as to cause the liquid to flow ; and, after the entire surface has been covered, the excess of liquid, if any there be, is poured back into the bottle. Then the *cliché* is laid flat in a roomy box, or in any other place where it will be sheltered from dust,



and left for a few hours to dry. When fully dried, or when it is no longer sticky to the touch, we again, in the same way as before, pour over the layer of normal collodion a layer of caoutchouc dissolved in benzine. When this has become dry, we apply a second layer of normal collodion, then caoutchouc again, and, lastly, a final layer of normal collodion.

The *cliché* is now left to dry for twenty-four hours, and it is trimmed all around. Then, at one corner, the paper is separated by a finger-nail from the coating formed upon it. Having in this way loosened the coating at one corner, it may easily be stripped off altogether, with a little care, leaving the paper clean and white, as though it had never undergone any treatment. In this way is got a negative at least as transparent as though it were on glass; but it possesses the advantages of not being brittle, of not being damaged by rubbing, of occupying but little space, and, finally, of giving better proofs than can be got from *clichés* on glass.

To utilize this process, M. Deyrolle has constructed a strong but portable apparatus, made almost entirely of copper and iron, weighing not over 400 grammes for one producing proofs 0.13 metre by 0.18 metre, or 700 grammes for one producing proofs 0.24 metre by 0.18 metre (*see* figure on page 443).

The camera, which, when folded, is only four centimetres high, is held distended by two steel rods, which connect the frame of the object-glass with that for the slide. The support for the apparatus consists of three double legs with joints; these are fastened by thumb-screws to a triangular table. The stem supporting the camera is articulated with the centre of this table by means of a ball-and-socket joint, which allows the instrument to be turned in any required direction. The ball may be made fast at will by means of a steel spring. This new form of foot has the great advantage of being extremely light, and of allowing the camera to rest in any plane whatever.

We would add that, when this system is employed, the complete outfit of an explorer who wishes to take 300 negatives will not weigh over six kilogrammes, including the instrument, the *clichés*, and all the chemicals needed for developing the negatives.

VOLUNTARY MOTION.

By Professor PAYTON SPENCE, M. D.

"The primitive elements of the will have been stated to be—1. The spontaneity of movement; and, 2. The link between action and feeling, grounded on self-conservation. In the *maturing* or *growth* of the will, there is an extensive series of *acquisitions*, under the law of retentiveness or contiguity" (Bain, "Mental Science," p. 318).

"The elements of voluntary power being assumed as—1. Spontaneity; and, 2. Self-conservation, we have to exemplify the connection of these *into the matured will*, by a process of *education*" (Bain, "Mental Science," p. 325).

TO what extent we differ from the above propositions, and especially from those parts of them which we have italicized, will more fully appear in the following article.

To the superficial observer, a human being, during the interval between birth and adult life, seems to learn a great deal; but, if he did really learn all that he seems to learn, it would be marvelous in a degree wholly beyond the power of the human mind to conceive of, and far beyond the power of human language to express. Omitting, at present, that immense domain of the mind which is embraced under the terms sensation, emotion, and intellection, we will endeavor to make a comparative estimate as to how much we seem to learn, but do not learn, and how much we do really learn, in that limited department of the will which is covered by the term voluntary motion.

We will begin by endeavoring to ascertain how much a child would have to acquire in simply learning to pronounce the letter A, at will, supposing that none of the movements, or combinations of movements, which are made in the utterance of that one sound, are organic and inherited, but that they all have to be acquired or learned by practice and experience.

Between the states of the greatest and the least contraction of any muscle of the body, there are, of course, an infinite number of degrees of contraction. In order, however, that we may not seem to exaggerate the difficulties of the child's task, we will suppose that a muscle is susceptible of only three degrees of contraction, and that, therefore, three experiments, at most, would ultimate in the production of the sound of A, supposing it to depend upon the proper contraction of only one muscle. But how many muscles are engaged in the production of that one sound? A great many, namely, the muscles of the vocal chords, the muscles of the back part of the mouth, of the tongue, the cheeks, the lips, and the muscles that expand and contract the chest. We will largely understate their number, and suppose that there are only 20 involved in the pronunciation of A, each one of which, as we have already supposed, is susceptible of only 3 distinct degrees of contraction. Now, 2 muscles, each one of which is susceptible of 3 degrees of contraction, can be made to contract together in 9 different combinations, consisting of one degree of the contraction of each muscle to each combination; 3 muscles will give 27 possible combinations, 4 muscles 81 possible combinations, and so on, in a geometrical ratio of increase, up to the supposed 20 muscles, with which there would be 3,113,884,401 possible combinations of muscular contractions. Now, in all this wilderness of possibilities, there is but one combination which can produce the sound of the letter A, and that one the child must find, although, according to the supposition, he knows nothing about it, and has no organic tendencies in the direction toward it. He can find it only by experiment. Each possible combination must be successively tried and rejected, until he comes to the right one. Assuming that his chances of hitting upon the right combination are equal to his chances of missing it, the number of experiments which he would have to make, before he would hit upon the right one, would be just one-half of 3,113,884,401, which is 1,556,942,200. Supposing, therefore, that the child makes 100 experiments in a minute, it would take him within a fraction of thirty years to attain the first successful utterance of the letter A.

But the child's task is not yet accomplished when he has succeeded in pronouncing the letter once. He must pronounce it again and again, before it is so completely within the reach of his will that he can pronounce it immediately, making automatically all the required muscular contractions of the combination the instant the volition calls for the letter. It is evident that, in the absence of all knowledge of those 20 muscles, and of all organic tendencies in the right direction (which could only be acquired by repeated successful experiments), it would be almost as difficult for the child to hit upon the right combination the second and the third time as the first; and, therefore, only after many successes would the required combination become automatic, and the utterance of the letter A really be so completely brought under the dominion of the will as to be classed among the voluntary movements. If, therefore, we again under-estimate the difficulties of the case, as we have done all along, and suppose that only 10 successful experiments would be necessary to accomplish the result—that is, to agglutinate into a unitary movement the required group or combination of muscular contractions, so that the group should be instantaneously and automatically adjusted the moment a volition is made for the letter A—we find that the child's lesson, the learning to pronounce a single letter at will, is a task which would require for its accomplishment 300 years of steady work, night and day, at the rate of 100 experiments every minute!

How insignificant, however, is the successful pronunciation at will of one letter, when we reflect that the child ultimately attains the voluntary control of, not merely one of the billions of possible combinations of 20 muscles, but that he attains the absolute voluntary command of all the 450 voluntary muscles of his body, individually and collectively, in all their possible combined, as well as isolated, contractions! In some of the combinations of muscular contractions which the child ultimately becomes capable of executing, nearly every one of the 450 voluntary muscles of the body participates; as, for example, in the throwing of a stone; and yet the wonderful combination is made and the movement executed with as much precision and promptness as the crooking of his finger. We have no hesitation in saying that, if all this had to be learned by the child, it would require a lifetime of many millions of years; and, as we know that the requisite knowledge or capacity is not a miraculous donation to the child, but must be the accumulated acquisitions of a slow process of experience of some kind, and at some time or other, we should be appalled by the magnitude of our own figures, did we not know that man is not the creature of to-day, but the child of the ages, incubated in the primitive submarine protoplasm, born as the simple monad, creeping for æons of time as the blind-worm upon its belly, swimming for untold ages as the fish of the sea, flying as a bird in the air for hundreds of thousands of years, and, for centuries without number, roaming the earth as a mammal, and walking the globe erect as a man. But, all this time, immense and inconceivable as it is, would be too insignificant to enable one individual, unaided and alone, to learn (were it accomplished by learning) to execute all those infinite muscular contractions, and combinations of contractions, of which we have spoken; and we are only helped out of the difficulty by a knowledge of the fact that, in the evolution of the power of voluntary motion and of the will, in the animal kingdom, during all the immensity of the past ages, the organized experiences and acquisitions of all the millions of individuals of each species of animal life were, by the process of reproduction and the law of heredity, so completely interchanged and shuffled up with each other that the organized experiences and acquisitions of each individual became the organized experiences and acquisitions of the species, and the organized experiences and acquisitions of the species became the organized experiences and acquisitions of each individual.

We are now prepared to make an approximate estimate as to how much of our command over our voluntary muscles is acquired by education and experience, and how much is the result of the simple maturation of an inheritance, which evolution had prepared and stored up for us. If, as we have already shown, many millions of years would be required to enable one individual to acquire as perfect a control of all the voluntary muscles of the body as we know that each adult human being has, how much of that could be acquired by the individual himself after birth? Supposing him to reach the height of his muscular capabilities at thirty years, and that only 3,000,000 years, instead of many millions, are, as we have shown, necessary to enable him to obtain that complete mastery over his voluntary muscles which he actually possesses in adult life, then his own individual acquirements would bear the same ratio to his inherited acquirements that 30 bears to 3,000,000, or that 1 bears to 100,000. Therefore, he inherits 99,999 parts, and learns but 1—a quantity so small as to dwindle into almost nothingness in the comparison.

An apparent objection to our conclusions is met with in the fact that the child does not use his 450 muscles, at birth, with the same ease, precision, and freedom, that he does in after-years; but, from the helplessness of the babe, which can scarcely be said to make a single voluntary movement, there is a gradual advance in the variety and extent of his control over his voluntary muscles, until we may say that, by the time he reaches adult life, he is completely master of his voluntary muscular system. If, then, it is true that we acquire by education and experience nothing, or almost nothing, of that vast department of mental acquisitions which is embraced under the term voluntary motion, yet it must be admitted that we seem to learn how to use our muscles, and it seems as if all our voluntary control over them were acquired by education and experience. It is but seeming, however; and, instead of our learning *how* to use our muscles, we simply learn that we *can* use them, in all the endless varieties of isolated and combined contractions of which they are capable. The *how* of their use is our vast organized inheritance; and it is this which gives even the child, as he matures, that sure, unerring tendency to the right movement to attain any desired end, and soon *teaches him* that he *can do what he wills to do*, thus obviating a resort to that infinitude of experiments which, as we have shown, would otherwise be absolutely necessary. It is the organized inheritance which takes the lead, and teaches the child that he can make the required voluntary movements, and not the child which teaches the organization how to make them. The newly-born babe is helpless and capable of making only a few instinctive or automatic movements, not for want of education and experience, but for want of organic *maturity*; and, hence, we see that some animals which are more matured at birth, or when hatched, than the human infant, walk, run, swim, or fly, as soon as they are born, or as soon as they escape from the egg; and the butterfly and those insects which emerge from the chrysalis *fully matured* need no experience or education whatever to enable them to command at will all their voluntary muscles; their organic maturity alone giving them at once full control over that department of their nature.

In the case of the child, it is impossible, either by observation or experiment, to separate the results of the maturation of the organization from the results of education and experience, for the obvious reason that the maturing of the child's nervous and muscular system proceeds, at a very rapid rate, simultaneous with its education and experience; and, therefore, were the point not already settled by the estimate which we have just made, it would be impossible to form even an approximate estimate as to how much of the child's progress is dependent upon his own acquisitions, and how much upon the ripening of an inherited organization. It is not possible, experimentally or otherwise, to isolate these two factors and their results from each other so as to ascertain, in that way, which factor is the largest and most important. The child's muscular education, the progress which he makes in his voluntary control over his muscles, and the maturing of his organization, all proceed simultaneously and inseparably together. Nevertheless, facts do occasionally crop out, here and there, confirmatory of the calculations already made, and the inferences drawn from them, if they needed confirmation. If our voluntary control over our muscles is not an educational acquirement, but is the result of the ripening of our organic inheritance, we would naturally expect an occasional exhibition of muscular agility, precision, and dexterity, and of complicated grouping and combinations of many muscles, far beyond any educated capacity which the individual is known to have acquired. This expectation is frequently realized in individuals when under the dominion of exalted emotions, in insane persons, and in persons when in mesmeric, somnambulic, trance, and other abnormal conditions, who often perform feats of agility, dexterity, and wonderful freedom and precision in the combined contractions of a great many muscles of the body, equaling the nimbleness and mobility of the ballet-dancer, the sure-footedness of the rope-walker, and the consummate skill of the trained acrobat, although they had no special training calculated to qualify them for the performance of such feats. In fact, in their normal states, they did not believe themselves capable of performing such feats, because they had not yet learned that the feats, marvelous as they seemed to themselves and others, were already accomplished facts, packed away in their organizations, awaiting the magic word, the real "*open sesame*," to command them to come forth. The records are loaded with such unused facts, that are simply labeled "abnormal," and then abandoned. It will generally be found, however, that the abnormal, simply from the fact that it is abnormal—an outlaw to all that is now considered fixed and established in science—is the key to a higher law and a broader generalization. A few illustrations will suffice :

Dr. Rush relates the case of a young man named Wilkison, in whom the habit of stammering was suspended during his mental derangement, but returned as soon as he began to mend.[1] It is evident that, in stammering, the groupings of muscular contractions which produce articulate sounds are very different from those which produce the sounds without stammering. From some cause, not yet understood, there is in stammering an interference with the correct muscular groupings which, we claim, are organic and inherited, and a series of random, confused, and semi-spasmodic muscular movements become mixed up with the correct groupings. In this instance, the mixture had continued from childhood up to manhood, a period long enough surely to have agglutinated them indissolubly together, if practice, habit, or education, ever caused such agglutinations, as some believe. It is evident, therefore, that this man not only had not learned or acquired by education the correct use of his muscles of articulation, but had seemingly acquired an incorrect use of them ; yet, the moment he became insane, the impediment was removed, the habits of a lifetime vanished, and his organically inherited command over those muscles asserted itself, and enabled him to do what he had never done before, and what, unless the views which we have presented are correct, must be acquired after birth, and can only be acquired after birth by long-continued practice.

The following case is related by Dr. Abercrombie : A lady laboring under some disease of the nervous system, not disclosed by an autopsy,

[1] Rush, "Medical Inquiries and Observations on Diseases of the Mind," p. 254.

as she recovered, exhibited, among other things, the following remarkable powers:

"After lying for a considerable time quiet, she would in an instant throw her whole body into a kind of convulsive spring, by which she was thrown entirely out of bed; and in the same manner, while sitting or lying on the floor, she would throw herself into bed, or leap on the top of a wardrobe fully five feet high. During the whole of these symptoms her mind continued entire, and the only account she could give of her extravagance was, a secret impulse which she could not resist." [1]

This case cannot be disposed of by saying that the movements were convulsive, because it is evident that they were definitely combined and adjusted to the production of a well-defined result—the landing of the patient's body either upon the floor, the bed, or the wardrobe—so that a certain amount of mentality or volition accompanied the result; this she herself was aware of, and called it a "secret impulse." It is also evident that the movements were very complex, and required a special and peculiar coördination of a great many muscles; in fact, nearly every voluntary muscle of the body. The only conclusion at which we can arrive is, that the patient, in the abnormal state into which disease had thrown her, was able to draw upon an inheritance of muscular capacity to which she had matured, but which she had not been called upon to use before.

Dr. Abercrombie also relates the following case: A young lady, fifteen years of age, was subject to attacks of catalepsy, in consequence of a fall from a horse.

"On one occasion, she was playing from a book a piece of music which was new to her, and had played a part of it, when she was seized with a cataleptic attack. During the paroxysm she continued to play this part, and repeated it five or six times in the most correct manner; but, when she recovered from the attack, she could not play it without the book." [2]

In this case the young lady was able to execute, in the cataleptic state, what she apparently had not learned and could not execute when out of that state. From this and similar cases it would seem that much of our inherited voluntary command over our muscles is ordinarily disguised or marked, as it were—held in abeyance—how or why we know not, and we are enabled to get glimpses of it during those states of mental and organic spontaneity and mobility which, for want of a better name, we call abnormal, and which often seem temporarily to put the individual *en rapport* with the secret chambers of his own boundless wealth—the countless treasures of ages of accumulation.

The following case, taken from the *Globe-Democrat*, of St. Louis, Missouri, is as remarkable, perhaps, as any of a similar character on record:

[1] Abercrombie, "Diseasse of the Brain and Spinal Cord," p. 292.

[2] Ibid., pp. 293–295.

"James H. Prior, of St. Louis, has an adopted daughter, of thirteen years, who performs wonderful gymnastic feats in her sleep. Finding her room vacant one night, Mr. Prior began a search, which resulted in discovering her walking along a narrow iron railing which protected a gallery running the entire width of the house. When she reached the end of the railing she deliberately turned and walked back. This she performed with grace and apparent carelessness. In the mean time Mr. Prior, fearing that if he moved it would startle the girl, and she would fall to the paved yard below, remained quiet while she continued her perilous walk. In a few moments she seemed to be satisfied, and, carefully stepping to a chair, reached the floor, and glided slowly by Mr. Prior, down the hallway into her apartment and bed, where she was soon sleeping sweetly. At another time, Mr. and Mrs. Prior found the girl had crawled through the skylight, and was promenading the length of the roof-ridge. She was walking with her hands hanging listlessly by her side, and her head inclined forward as if she were looking immediately in front of her feet. The moon was shining brightly, and the white, lithe form of the sleeping girl could have been seen a block distant. There was a chimney half-way to the ridge, and sometimes she made *détours* to the right or to the left, going completely around the obstruction, regaining the ridge and traversing its entire length. Once she leaned on a chimney, and seemed absorbed in meditation. Each time she reached the end of the roof it appeared to be her deliberate purpose to walk off, but she always checked herself when within a foot of the edge, and, slowly turning, carefully retraced her steps. Twice she descended on the incline of the roof, each time returning to the ridge very rapidly, as if she had met with something that excited her fears. Several times she looked up, as if gazing at the stars or listening to some distant sounds. Suddenly, while at the point of the ridge, which she had first reached, she began to descend in the direction of the skylight, taking each step with great caution and making slow progress. When she had nearly reached the opening Mr. Prior quietly withdrew. In a moment Laura followed, proceeding at once to the garret-stairs, and disappearing down the dark passage. Mr. and Mrs. Prior followed, keeping behind her as close as possible, but, before they could reach her, she was in her own room, and composing herself in bed."

Whatever voluntary muscular movements we may make, therefore—be they ever so new and wonderful to ourselves or to others—we make because we can; because they are already accomplished facts packed up in our inherited organization. The truth of this proposition makes its converse also true, and the proposition itself receives additional confirmation from the truth of the converse, namely, whatever muscular movements are beyond our voluntary control are so because they are not accomplished facts in our inherited organization. Take, for example, the familiar, schoolboy, muscular puzzle, which seems to be a very simple movement, and very easy of execution; yet we doubt whether it has ever been really mastered, even after the most protracted efforts, so that it could be executed with the automatic ease and dexterity with which we execute our voluntary movements. It is easy enough to extend the forefinger of the right hand, and revolve it rapidly so as to describe a cylinder as it moves; it is also easy to do the same thing with the forefinger of the left hand; and it is equally easy to revolve them both at once in the same direction; but the puzzle is to revolve them both at the same time, but in *opposite directions*, the points of the fingers facing each other. Much practice may enable one to execute it slowly, defectively, and awkwardly; never, however, with the same ease, freedom, and dexterity, with which we revolve either finger alone, or the two fingers together in the same direction. Again, it is not only difficult, but impossible, simply by a voluntary effort, or by any amount of practice, to roll one eye up and one down at the same time, or to turn both outward at the same time, beyond the parallelism of their axes. The muscular combination or coördination required in such movements is not organically possible, and no amount of education can make it so; otherwise, education would be a substitute for evolution and maturation.

The current ideas of the growth of voluntary motion and the will are based upon an ill-defined notion that the muscular and nervous systems were first developed, like a piece of complex machinery, and then the mind somehow came into *rapport* with it, or happened to be there, just at the right time, and commenced to learn how to work a certain part of it—for it is admitted that the rest can get along without the mind. But the truth is, the importance of the mind as a factor in the movements of the body is vastly overrated. It never really learns how to work even the limited portion of the organization which the current theories assign to it. When a child or even a man makes a certain voluntary movement for the first time, and practises it until he can execute it with ease and rapidity, has he learned how to do it? If so, he can tell how it is done. But, the fact is, he has learned nothing at all about the mechanism which he seems to handle so dexterously, and can give no account whatever as to how he does it—that is something which has staggered the most capable and profound students of voluntary motion and the will. Look at it. A child reaches out after a bright object and misses it. Does it know how or why it happened to miss it? It keeps reaching, fumbling, and trying, and now it grasps it. Does it know how or why? Does it know that now it opens an outlet or a valve of nervous discharge which then was closed; or, that it shuts one which it had left open; or, that it opens three instead of two or one; or, that it opens them one-half, one-third, or one-fourth, instead of full flood? Does it learn any of these things, and then treasure them up in the memory consciously or intentionally, so as to be able to do it again, next time, without balk or failure? The growth of a voluntary movement is an organic procedure, not such a mechanical process as that. That would, indeed, make the organization a machine for the mind to manipulate, instead of the mind being (as we think we can easily show) but *a symbolical representation in consciousness of the workings of certain parts of the organization—the brain.* Then, when we have mastered a voluntary movement, all that we have really learned is *that we can make it.*

But, again, a bright object is presented to a child. Its desire for it ultimates in a movement that misses it, and then in one that grasps it. In what respect do the mental accompaniments of the movement differ in the two cases? In nothing whatever. The mental phenomena which accompany both the failure and the success are a desire for the object and a volition for the movement. Next week or month, you hold the bright object before the child again, and he succeeds in grasping it every time; and still the mental accompaniments of the movement are the same—the same desire for the object, and the same volition for the movement—not for the wrong movement, even when the failure was made. Then, if the desire and the volition are precisely the same in both cases, why should one movement be a success and the other a failure? It is evident that the fact that the child has learned that he *can* make the movement does not contribute to the success, for the first success was made before he had learned that he could; and the knowledge that he *can* does not contribute to a future success, because it does not contribute in the least to a knowledge of *how* to do it. Then, where are we driven to? The mental accompaniments or phenomena do not (with a qualification which it is not important to explain here) contribute to the success of our voluntary movements. Therefore, we must look for the reason why one voluntary movement is a success and another a failure, in the phenomena of organization, and not in those of mind.

If the final conclusion above reached is true, there should be no difference, physiologically, between a voluntary and a reflex movement. And such we find to be the case. The essential physiological phenomena of a voluntary movement are, an impression upon a peripheral surface, conducted thence along certain nerves to a nervous centre which is thereby excited to a peculiar kind of molecular action, and that action generates what is called a nervous force, which is discharged through another set of nerves upon certain muscles, causing them to contract. The essential physiological phenomena of a reflex movement are precisely the same. The point of present interest in both cases is that peculiar molecular action of the nervous centres (which, as we have stated, is essentially the same in both cases) which generates the nervous force that is discharged upon the muscles, causing their contraction. Now, if there is no essential difference, physiologically, between a voluntary and a reflex movement, in what do they differ? Of course, the former is the latter with volition superadded, or the latter is the former with volition deducted. And what is volition? Volition is simply a peculiar molecular action of a nervous centre of motion reflected upon consciousness—translated into a state of consciousness—symbolized in consciousness. The mental part of the phenomena—the volition—being simply a state of consciousness—a consciousness of the molecular action—then, the molecular action is a condition precedent to that state of consciousness which is a symbolical representation of it. The molecular action, being precedent to the symbol of itself, cannot be determined or controlled by that symbol—that state of consciousness—that mental part of the phenomena which we call volition. Therefore, if from a voluntary movement we strike out the only mental part —the volition—which, as we have seen, is not a factor, what is left is as purely organic, and hence as purely reflex or automatic, as the movements of a decapitated frog upon the application of an external irritant. Of the truth of this we may satisfy ourselves by simply looking at the nature of a voluntary movement from another point of view. Thus, I will to move my arm, and it moves. The only voluntary part of that very complex operation is the volition itself. I do not intentionally and knowingly direct the nervous discharge along one set of nerves rather than another, or upon one set of muscles rather than another; nor do I knowingly and intentionally cause one set to contract and another to relax, or one to contract much, and another little, and another less. All these things, which are so numerous and complicated in that one movement, and which constitute the whole of the mechanism, are purely automatic, being not in the least dependent upon the mental part—the volition—although wholly dependent upon that organic activity of which the volition is a symbol in consciousness. It is easy to understand, therefore, that if the molecular action which generates the nervous force that causes a reflex movement could be symbolized in consciousness, that symbol could not be called anything but a volition—a mandate for the movement. As many reflex movements are movements which were once voluntary, and have become reflex by a withdrawal of them from the sphere of consciousness, to relate them again to consciousness would be to make them again voluntary. While it is very easy to understand how a reflex movement might thus be converted into, or restored back to, a voluntary movement, it is an actual fact that by dislocating consciousness from its connections with voluntary movements we at once make them reflex or automatic, as is the case, for example, in many habitual or oft-repeated movements, such as the fingering of the keys of a piano when the music is known by heart. The following singular case is also in point: Many years ago, a medical gentleman related to me a case which came under his own observation, namely, that of a lawyer, who, without any other perceptible physical or mental disorder, would, in the course of ordinary conversation, let slip one or another legal term between words and in sentences with which it had no connection whatever. They seemed to utter themselves without any volition on his part, and in fact he did not know that one was coming until it was pronounced. The muscular movements in such cases are wholly automatic, which means wholly organic, without any associated mental phenomena.

From the foregoing considerations it is evident that a scientific solution of the problem of voluntary motion (and that of the will which is based upon it) requires a full and separate consideration and explanation of four distinct branches of the subject, namely:

1. The genesis of the power of voluntary motion, or its differentiation from some mental power which preceded it ; and how it was differentiated.

2. The evolution of the power of voluntary motion considered as an organic procedure in the entire animal kingdom, by which it was developed from its earliest genesis up to its highest capabilities in man, as the result of such changes in the faculty, from any cause whatever, as were transmissible and transmitted by inheritance.

3. The maturation of the power of voluntary motion considered as an organic procedure in the individual (man, for instance), by which it develops or ripens through the gradations of evolution independently of the operation of any external cause, such as education and experience.

4. The acquisitions of the power of voluntary motion, or whatever is added to the maturing or matured faculty, by which it is enabled to do with greater ease, freedom, force, or dexterity, what, without evolution and maturation, it could not do at all, and could never be educated to do.

In view of these obvious facts, were we to venture a criticism of Bain's celebrated treatise on the will, we should say that his method is defective, inasmuch as he has disregarded those natural and important divisions of the subject which we have pointed out, each of which requires a separate treatment. The careful reader will be able to discover not a little confusion in that treatise, and will be able to trace it to the fact that the distinguished author has treated as a unit things which are so dissimilar ; and especially is this true of his method of dealing with maturation and acquisitions, by which the reader is led to believe that acquisition is maturation, and maturation is acquisition.

MONERA, AND THE PROBLEM OF LIFE.

By EDMUND MONTGOMERY, M. D.

I.—INTRODUCTORY—THE PROBLEM IN GENERAL.

Of late years the hypothesis of the gradual and continuous evolution of the universe and its parts has become the growing conviction of almost all scientific minds. The main drift of the new philosophy, the central aim of scientific exertion, is to establish by means of exact investigation the reality and true order of this natural development of things. After much anxious guess-work in which the emotions have been profoundly implicated, we begin at last calmly and positively to desire to know how deeply our existence is interwoven with the sensible world everywhere surrounding us. We wish to know whether we are, body and mind, the veritable heirs and trustees of these stupendous achievements of ever-toiling Nature; or whether we are merely passing strangers, endowed with a principle of life otherwise sustained, with an essence of being not vitally implicated in the general enchainment of temporal occurrences. On all sides we are fervently striving to gain assurance of, at least, this one leading position in our mysterious fate. To whatever sources of revelation seem available, there is put in every imaginable shape this decisive question: "Do we or do we not entirely belong to the actual state of things in which we at present find ourselves involved?"

This is evidently the real import of the momentous controversy now provoked anew, on deeper grounds than ever before, by the adoption of the evolution hypothesis on the part of Science. In all quarters of our globe, from every laboratory and study, where the investigation of any branch of Nature is methodically pursued, we hear the voice of Science proclaiming, with all but unanimous accord, one and the same truth, that through natural development, from lowest beginnings, has grown, step by step, all of which we can ever gain any knowledge. This is certainly a grave conclusion, coming as it does from the most cautious and reserved school of thinkers. If proved to be true it must, in course of time, necessarily subvert all former creeds, changing completely the groundwork of human faith, and prescribing to life new guiding principles. To mistake this inevitable issue of the grand contest entered upon by the students of Nature against the authority of their own mental inheritance would betray either short-sightedness or insincerity. Let none, then, remain in doubt that it is the serious intent of evolutionists so to unfold the system of Nature, the philosophy of synthesis, of organization, as to make it eventually the bearer on a strictly scientific foundation of all manner of truth. On all sides they are challenged to make good their assertions, and to show how we ourselves, with our exalted faculties, have come to be part and parcel of this same supposed onward flow of natural events.

The disciples of Science are accordingly everywhere at work to raise to the dignity of a consistent theory what is promiscuously held on the strength of much good evidence, though also in reliance upon the eventual verification of much vague foreshadowing: though it is incumbent upon us as evolutionists to prove our opinion, yet it must be admitted that at present we are far from having established a connected chain of evidence in support of it. We cannot deny that, when from the point of view of our present knowledge we attempt to survey the gradual ascent from lower to higher cosmical manifestations, we are abruptly checked at various critical points. The continuity of that surface, on which our understanding is wont to skim the depths of reality, presents sudden chasms. We experience one such sharp mental recoil when we endeavor smoothly to glide from the inorganic into the organic world. For, whatever may be asserted to the contrary, Science does not yet exactly comprehend the transition from lifelessness to life.

Nor can it account for, or even follow with any degree of precision, the stages of transformation leading from apparent uniformity of structure to diversity of organization. The origin of life, and the conditions which have gradually given rise to organization, are essential evolutional moments, as yet in the twilight of mere fanciful conjecture. Their penetration and elucidation would yield the data for the solution of what may be called the physical phase of the problem of life.

But, further on, in pursuance of evolutional continuity, we encounter a still deeper mystery, separating most profoundly the world of matter from the world of mind. We are all aware that this strange contrast of matter and thought, of the extended and the inextended, has ever constituted a fundamental dualism in human experience. Philosophy in every one of its aspects is mainly the result of an effort to imagine or to recognize the connection which necessarily must obtain between the ideal and the real. But there has been far too much imagining, and too little recognition, in the endeavor. So, till quite lately, in the history of human thought, but very slight advance was made in the solution of the central puzzle, concerning ideality and reality. Modern Science, disgusted at the waste of so much precious energy and earnestness, given up to the elaboration of mere whimsical and visionary interpretations, set out with the positive intention to evade in its investigations any contact with this constant stumbling-block of certitude. But the antagonistic powers of outwardness and inwardness are too intimately blended in Nature to admit of any such artificial severance, however skillfully attempted.

Scientists are becoming more and more conscious that, even in their least complicated suppositions and inquiries, both those elements of the actual world are always inextricably involved. Before the steadfast glance of Science, the eternal, adamantine atoms, questioned as to the essence of their subsistence and resistance, dissolve into unextended, immaterial centres of force. Before the steadfast glance of Science, the inscrutable forces, with their ideal sweep, traced to the immediate seat of their activity, resolve themselves into the discrete multiplicity and absolute impenetrability of adamantine atoms. Surely, if with witches "fair is foul and foul is fair," with us benighted mortals confusion seems to reign still more supreme, for, to our profoundest thinkers, matter is force and force is matter; motion somehow is sensation, and sensation somehow motion. And yet how can we aspire ever clearly to comprehend the fundamental identity of such disparate manifestations as matter and mind?

Naturalists are aware of and openly acknowledge this mysterious polarity of phenomena, this double subsistence—one in reality and at the same time also in ideality. To the former mode of existence they give the name of motion, the latter they call sensation—motion being the generalized fact of outwardness, of objectivity; sensation being the generalized fact of inwardness, of subjectivity.

But Science does not yet understand, nor does it pretend to understand, the enigma. Like all previous systems of knowledge, it fails to detect the actual concatenation, the necessary connection or continuous transition, by which these two seemingly heterogeneous experiences are bound together and unified in reality. It does not conceive how motion can possibly generate sensation, or indeed how motion and sensation can in any way be related to each other. Yet, to the vindication of the hypothesis of evolution, it is quite indispensable to establish either the essential identity of motion and sensation, or the gradual transformation of one of these modes of existence into the other. For how can evolution maintain its pretensions to universality, if the ideal world remains foreign to it—a mysteriously correlated entity, merely in close correspondence with the outer world, but having with it no genuine and intrinsic sameness of actuality?

The penetration and elucidation of this ancient dilemma of motion and sensation would furnish the data for the solution of what may be called the psychical phase of the problem of life.

But intermediate between these two extreme aspects of the problem —the one demanding the explanation of the origin of vitality and organization; the other the proof of the identity or direct phenomenal continuity of motion and sensation—there is disclosed by the requirements of the evolution hypothesis a third essential and very peculiar aspect of the same problem. As the experience of sensation, the state of so-called feeling is an exclusive attribute of vitality; it is evident that, granting the evolution hypothesis, feeling must make its appearance and take its rise at some definite moment in the course of organization. The demonstration of the specific conditions of organization, which constitute the starting-point of feeling or subjective experience, would furnish the initial data for the solution of what we may call the physico-psychical phase of the problem of life.

We have now gained some information regarding the ground which has to be accurately explored before the hypothesis of continuous development can be said to be adequately established. Having indicated the exact points at which our scientific appreciation meets with the most abrupt and startling breaks in the supposed continuity, we find ourselves in a favorable position to estimate what, above all, has to be accomplished before evolution can take the field as a consistent monistic system.

We have to show how life originates and how organization takes its rise; we have to demonstrate how in the course of organic development the state which we call feeling is established; and we have, finally, to prove that this feeling is in essence identical with that which is felt. How are we to set about this seemingly hopeless and endless task? Are we to rummage the vast stores of accumulated facts in search of the missing links? Assuredly, had they been forged and ready for the purpose, more competent and assiduous searchers would have discovered them long ago.

Are we, in our trial to establish the necessary connections, simply to draw upon our innate power of synthesis, again once more to stimulate the much-jaded faculty of mental constructiveness? Assuredly, if the material for the verification of any logical supposition had been extant, the master-minds, who have so admirably dealt with this great subject of synthetical continuity, would have left no material chasm unbridged. Are we to find what we are in need of by laying open to inspection the subtile intricacy of the sanctuary of life, by minutely investigating the intimate composition and working of the mysterious organ of centralization? Dazzled by the wonders of this marvelous fabric, the consummated fruit of the mighty tree of life, there is assuredly danger that we shall fail to catch any glimpses of its dark and lowly origin.

It is very natural, then, and appropriate, that, seeking a way out of our scientific perplexity, we should direct attention to the study of vitality in its least complicated forms, which manifest the properties of life, and at the same time do not confuse us with structural entanglements. For, wherever we find fixity of differentiated parts already established, there the difficulty begins. The organism gains the appearance of a mechanical contrivance, and we feel at once puzzled as to what is driving and what is driven in the living engine. We desire, then, if possible, to become acquainted with life before it has assumed any definite shape, before the manifoldness of its relations has acquired any degree of stability, or settled morphological expression.

The least complicated forms of life now known are perhaps motionless, non-nucleated corpuscles, which are observed to grow and to multiply by division. But vitality in these forms displays itself so torpidly, or at least so clandestinely, that microscopic investigation is incompetent to detect the nature of the changes that constitute their vital activity. Besides, these motionless corpuscles are probably all inclosed in a membranous envelope, which special structure must be regarded as an organic complication undesirable for our purpose.

Haeckel was the first to point out the most fascinating of all primitive beings; and he was the first also to recognize their true import in biology. He named them, on account of the entire homogeneity of their structure, Monera. It is now well known that monera consist of nothing but a flake or globule of uniform viscid material. Yet these unorganized specks of matter are most truly alive, for they are seen to move, to nourish themselves, to react on outward impressions, and to propagate their kind.

Here, then, we have all the fundamental properties of life, without any of its morphological complications. By dispensing, for once, with all elaborate equipment, and by executing her principal performances with such deliberate distinctiveness and openness, it is as if Nature were here purposely inviting us to penetrate her vital mysteries.

If we can only gain an actual insight into the conditions upon which these various well-defined vital phenomena are dependent, if we can succeed in establishing their direct relation, their immediate continuity with the rest of the world, then we cannot possibly be far from having reached the solution of the first phase of our problem.

There can be no manner of doubt that the secrets of the origin of vitality, and of the rise of organization, must all lie encompassed in these most unsophisticated dots of living material. What more enticing prospect for scientific investigation could be found? The nature of vital phenomena, if not disclosed even here in its plainest mode of manifestation, must ever remain incomprehensible. It is the fundamental truth of living reality, in all its native force, which in this unorganized and quickened matter appeals to our understanding, and it needs but candor, simplicity, and courage, to become initiated into the mystery of vitality. Let us, then, endeavor to cast away the incumbrance of so much foreknowledge, misleading as it has proved. If at all attainable, here it is, with our diminutive specimens of vitality, that true insight is to be gained. At any rate, we cannot leave the inquiry till we know, or till we have become fully convinced, that vital phenomena, even in their elements, are impervious to human knowledge.

Having for the last four years concentrated his whole attention on the manifestations of primitive life, and reached results which he deems important, the present writer, in a succeeding and fuller article, will attempt to convey to the general reader some idea of what he has gained by these studies.

COMPOSITE PORTRAITS.[1]

By FRANCIS GALTON, F. R. S.

I SUBMIT to the Anthropological Institute my first results in carrying out a process that I suggested last August in my Presidential Address to the Anthropological Subsection of the British Association at Plymouth, in the following words:

"Having obtained drawings or photographs of several persons alike in most respects, but differing in minor details, what sure method is there of extracting the typical characteristics from them? I may mention a plan which had occurred both to Mr. Herbert Spencer and myself, the principle of which is to superimpose optically the various drawings and to accept the aggregate result. Mr. Spencer suggested to me in conversation that the drawings reduced to the same scale might be traced on separate pieces of transparent paper and secured one upon another, and then held between the eye and the light. I have attempted this with some success. My own idea was, to throw faint images of the several portraits, in succession, upon the same sensitized photographic plate. I may add that it is perfectly easy to superimpose optically two portraits by means of a

[1] Abstract of a paper read before the London Anthropological Institute, April 30, 1878.

stereoscope, and that a person who is used to handle instruments will find a common double eye-glass fitted with stereoscopic lenses to be almost as effectual and far handier than the boxes sold in shops."

Mr. Spencer, as he informed me, had actually devised an instrument, many years ago, for tracing mechanically longitudinal, transverse, and horizontal sections of heads on transparent paper, intending to superimpose them and to obtain an average result by transmitted light.

Since my address was published, I have caused trials to be made, and have found as a matter of fact that the photographic process of which I there spoke enables us to obtain with mechanical precision a generalized picture; one that represents no man in particular, but portrays an imaginary figure, possessing the average features of any given group of men. These ideal faces have a surprising air of reality. Nobody who glanced at one of them for the first time would doubt its being the likeness of a living person. Yet, as I have said, it is no such thing; it is the portrait of a type, and not of an individual.

I begin by collecting photographs of the persons with whom I propose to deal. They must be similar in attitude and size, but no exactness is necessary in either of these respects. Then by a simple contrivance I make two pinholes in each of them, to enable me to hang them up one in front of the other, like a pack of cards, upon the same pair of pins, in such a way that the eyes of all the portraits shall be as nearly as possible superimposed; in which case the remainder of the features will also be superimposed nearly enough. These pinholes correspond to what are technically known to printers as "register-marks." They are easily made; a slip of brass or card has an aperture cut out of its middle, and threads are stretched from opposite sides, making a cross.

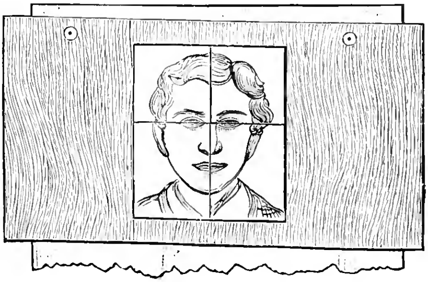


Fig. 1.

Two small holes are drilled in the plate, one on either side of the aperture. The slip of brass is laid on the portrait with the aperture over its face. It is turned about until one of the cross-threads cuts the pupils of both the eyes, and it is further adjusted until the other thread divides the interval between the pupils in two equal parts. Then it is held firmly, and a prick is made through each of the holes. The portraits being thus arranged, a photographic camera is directed upon them. Suppose there are eight portraits in the pack, and that under existing circumstances it would require an exposure of eighty seconds to give an exact photographic copy of any one of them. The general principle of proceeding is this, subject in practice to some variation of details, depending on the different brightness of the several portraits: We throw the image of each of the eight portraits in turn upon the same part of the sensitized plate for ten seconds. Thus, portrait No. 1

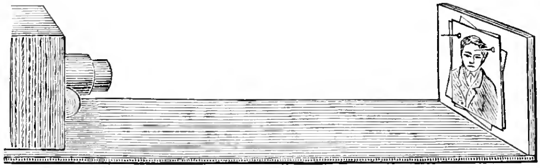


Fig. 2.

is in the front of the pack; we take the cap off the object-glass of the camera for ten seconds, and afterward replace it. We then remove No. 1 from the pins, and No. 2 appears in the front; we take off the cap a second time for ten seconds, and again replace it. Next we remove No. 2, and No. 3 appears in the front, which we treat as its predecessors, and so we go on to the last of the pack. The sensitized plate will now have had its total exposure of eighty seconds; it is then developed, and the print taken from it is the generalized picture of which I speak. It is a composite of eight component portraits. Those of its outlines are sharpest and darkest that are common to the largest number of the components; the purely individual peculiarities leave little or no visible trace. The latter being necessarily disposed equally on both sides of the average, the outline of the composite is the average of all the components. It is a band, and not a fine line, because the outlines of the components are seldom exactly superimposed. The band will be darkest in its middle whenever the component portraits have the same general type of features, and its breadth or amount of blur will measure the tendency of the components to deviate from the common type. This is so for the very same reason that the shot-marks on a target are more thickly disposed near the bull's-eye than away from it, and in a greater degree as the marksmen are more skillful. All that has been said of the outlines is equally true as regards the shadows; the result being that the composite represents an averaged figure, whose lineaments have been softly drawn. The eyes come out with appropriate distinctness, owing to the mechanical conditions under which the components were hung.

A composite portrait represents the picture that would rise before the mind's eye of a man who had the gift of pictorial imagination in an exalted degree. But the imaginative power even of the highest artists is far from precise, and is so apt to be biased by special cases that may have struck their fancies, that no two artists agree in any of their typical forms. The merit of the photographic composite is its mechanical precision, being subject to no errors beyond those incidental to all photographic productions.

I submit several composites made for me by Mr. H. Reynolds. The first set of portraits are those of criminals convicted of murder, manslaughter, or robbery accompanied with violence. It will be observed that the features of the composites are much better looking than those of the components. The special villainous irregularities in the latter have disappeared, and the common humanity that underlies them has prevailed. They represent, not the criminal, but the man who is liable to fall into crime. All composites are better looking than their components, because the averaged portrait of many persons is free from the irregularities that variously blemish the looks of each of them. I selected these for my first trials because I happened to possess a large collection of photographs of criminals through the kindness of Sir Edmund Du Cane, the Director-General of Prisons, for the purpose of investigating criminal types. They were peculiarly adapted to my present purpose, being all made of about the same size and taken in much the same attitudes. It was while endeavoring to elicit the principal criminal types by methods of optical superimposition of the portraits, such as I had frequently employed with maps and meteorological traces,[1] that the idea of composite figures first occurred to me.

The other set of composites are made from pairs of components. They are selected to show the extraordinary facility of combining almost any two faces whose proportions are in any way similar.

It will, I am sure, surprise most persons to see how well-defined these composites are. When we deal with faces of the same type, the points of similarity far outnumber those of dissimilarity, and there is a much greater resemblance between faces generally than we who turn our attention to individual differences are apt to appreciate. A traveler, on his first arrival among people of a race very different from his own, thinks them closely alike, and a Hindoo has much difficulty in distinguishing one Englishman from another.

The fairness with which photographic composites represent their components is shown by six of the specimens. I wished to learn whether the order in which the components were photographed made any material difference in the result, so I had three of the portraits arranged successively in each of their six possible combinations. It will be observed that four at least of the six composites are closely alike. I should say that in each of this set the last of the three components was always allowed a longer exposure than the second, and the second than the first, but it is found better to allow an equal time to all of them.

The stereoscope, as I stated last August in my address at Plymouth,

[1] "Conference at the Loan Exhibition of Scientific Instruments," 1878. Chapman & Hall. Physical Geography Section, p. 312. "On Means of combining Various Data in Maps and Diagrams," by Francis Galton, F. R. S.

affords a very easy method of optically superimposing two portraits, and I have much pleasure in quoting the following letter, pointing out this fact as well as some other conclusions at which I also had arrived. The

FIG. 3.

The accompanying woodcut is as fair a representation of one of the composites as is practicable in ordinary printing. It was photographically transferred to the wood, and the engraver has used his best endeavor to translate the shades into line engraving. This composite is made out of only three components, and its threefold origin is to be traced in the ears, and in the buttons to the vest. To the best of my judgment the original photograph is a very exact average of its components; not one feature in it appears identical with that of any one of them, but it contains a resemblance to all, and is not more like to one of them than to another. However, the judgment of the wood-engraver is different. His rendering of the composite has made it exactly like one of its components, which, it must be borne in mind, he had never seen. It is just as though an artist drawing a child had produced a portrait closely resembling its deceased father, having overlooked an equally strong likeness to its deceased mother, which was apparent to its relatives. This is to me a most striking proof that the composite is a true combination. (I trust that the beauty of the woodcut will not be much diminished by the necessarily coarse process of newspaper-printing.)

letter was kindly forwarded to me by Mr. Darwin; it is dated last November, and was written to him by Mr. A. L. Austin from New Zealand, thus affording another of the many curious instances of two persons being independently engaged in the same novel inquiry at nearly the same time, and coming to similar results:

"INVERCARGILL, NEW ZEALAND, *November* 6, 1877.

"TO CHARLES DARWIN, ESQ.

"SIR: Although a perfect stranger to you, and living on the reverse side of the globe, I have taken the liberty of writing to you on a small discovery I have made in binocular vision in the stereoscope. I find by taking two ordinary *carte-de-visite* photos of two different persons' faces, the portraits being about the same sizes, and looking about the same direction, and placing them in a stereoscope, the faces blend into one in a most remarkable manner, producing in the case of some ladies' portraits in every instance a *decided improvement* in beauty. The pictures were not taken in a binocular camera, and therefore do not stand out well, but, by moving one or both until the eyes coincide in the stereoscope, the pictures blend perfectly. If taken in a binocular camera for the purpose, each person being taken on one-half of the negative, I am sure the results would be still more striking. Perhaps something might be made of this in regard to the expression of emotions in man and the lower animals, etc. I have not time or opportunities to make experiments, but it seems to me something might be made of this by photographing the faces of different animals, different races of mankind, etc. I think a stereoscopic view of one of the ape tribe and some low-caste human face would make a very curious mixture; also in the matter of crossing of animals and the resulting offspring. It seems to me something also might result in photos of husband and wife and children, etc. In any case the results are curious, if it leads to nothing else. Should this come to anything, you will no doubt acknowledge myself as suggesting the experiment, and perhaps send me some of the results. If not likely to come to anything, a reply would much oblige me. Yours very truly,

"A. L. Austin, C. E., F. R. A. S."

Dr. Carpenter informs me that the late Mr. Appold, the mechanician, used to combine two portraits of himself, under the stereoscope. The one had been taken from an assumed stern expression, the other with a smile, and this combination produced a curious and effective blending of the two.

Convenient as the stereoscope is, owing to its accessibility, for determining whether any two portraits are suitable in size and attitude to form a good composite, it is nevertheless a makeshift and imperfect way of attaining the required result. It cannot of itself combine two images; it can only place them so that the office of attempting to combine them may be undertaken by the brain. Now the two separate impressions received by the brain through the stereoscope do not seem to me to be relatively constant in their vividness, but sometimes the image seen by the left eye prevails over that seen by the right, and *vice versa*. All the other instruments I am about to describe accomplish that which the stereoscope fails to do; they create true optical combinations. As regards other points in Mr. Austin's letter, I cannot think that the use of a binocular camera for taking the two portraits intended to be combined into one by the stereoscope would be of importance. All that is wanted is that the portraits should be nearly of the same size. In every other respect I cordially agree with Mr. Austin.

The best instrument I have as yet contrived and used for optical superimposition is a "double-image prism" of Iceland spar. The latest that I have had were procured for me by Mr. Tisley, optician, 172 Brompton Road. It has a clear aperture of a square, half an inch in the side, and when held at right angles to the line of sight will separate the ordinary and extraordinary images to the amount of two inches, when the object viewed is held at seventeen inches from the eye. This is quite sufficient for working with *carte-de-visite* portraits. One image is quite achromatic, the other shows a little color. The divergence may be varied and adjusted by inclining the prism to the line of sight. By its means the ordinary image of one component is thrown upon the extraordinary image of the other, and the composite may be viewed with the naked eye or through a lens of long focus, or through an opera-glass (a telescope is not so good) fitted with a sufficiently long draw-tube to see an object at that short distance with distinctness. Portraits

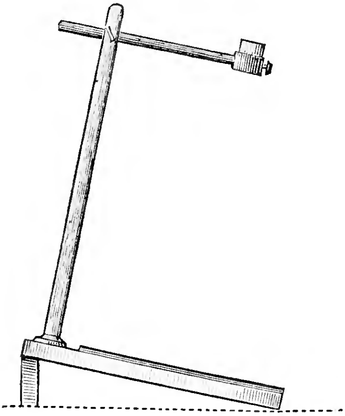


Fig. 4.

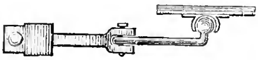


Fig. 5.

Fig. 6.

Fig. 4 shows the simple apparatus which carries the prism, and on which the photograph is mounted. The former is set in a round box which can be rotated in the ring at the end of the arm, and can be clamped when adjusted. The arm can be rotated, and can also be pulled out or in if desired, and clamped. The floor of the instrument is overlaid with cork covered with black cloth, on which the components can easily be fixed by drawing-pins. When using it one portrait is pinned down and the other is moved near to it, overlapping its margin if necessary, until the eye looking through the prism sees the required combination; then the second portrait is pinned down also. It may now receive its register-marks from needles fixed in a hinged arm, and this is a more generally applicable method than the plan with cross-threads, already described, as any desired feature—the nose, the ear, or the hand—may thus be selected for composite purposes. Let *A*, *B*, *C*. . . . *Y*, *Z*, be the components. *A* is pinned down, and *B*, *C*. . . . *Y*, *Z*, are successively combined with *A*, and registered. Then, before removing *Z*, take away *A* and substitute any other of the already registered portraits, say *B*, by combining it with *Z*; lastly, remove *Z* and substitute *A* by combining it with *B*, and register it.

Fig. 5 shows one of three similarly-jointed arms, which clamp on to the vertical rod. Two of these carry a light frame covered with cork and cloth, and the other carries Fig. 6, which is a frame having lenses of different powers set into it, and on which, or on the third frame, a small mirror, inclined at 45°, may be laid. When a portrait requires foreshortening it can be pinned on one of these frames and be inclined to the line of sight; when it is smaller than its fellow it can be brought nearer to the eye and an appropriate lens interposed; when a right-sided profile has to be combined with a left-handed one, it must be pinned on one of the frames and viewed by reflection from the mirror in the other. (The apparatus I have drawn is roughly made, and, being chiefly of wood, is rather clumsy, but it acts well.)

of somewhat different sizes may be combined by placing the larger one farther from the eye, and a long face may be fitted to a short one by inclining and foreshortening the former. The slight fault of focus thereby occasioned produces little or no sensible ill-effect on the appearance of the composite.

The front and profile faces of two living persons sitting side by side or one behind the other, can be easily superimposed by a double-image prism. Two such prisms, set one behind the other, can be made to give four images of equal brightness, occupying the four corners of a rhombus whose acute angles are 45°. Three prisms will give eight images; but this is practically not a good combination, the images fail in distinctness, and are too near together for use. Again, each lens of a stereoscope of long focus can have one or a pair of these prisms attached to it, and four or eight images may be thus combined.

Another instrument I have made consists of a piece of glass inclined at a very acute angle to the line of sight, and of a mirror beyond it, also inclined, but in the opposite direction to the line of sight. Two rays of light will therefore reach the eye from each point of the glass; the one has been reflected from its surface, and the other has been first reflected from the mirror, and then transmitted through the glass. The glass used should be extremely thin, to avoid the blur due to double reflections; it may be a selected piece from those made to cover microscopic specimens. The principle of the instrument may be further developed by interposing additional pieces of glass successively less inclined to the line of sight, and each reflecting a different portrait.

I have tried many other plans; indeed, the possible methods of optically superimposing two or more images are very numerous. Thus I have used a sextant (with its telescope attached); also strips of mirrors placed at different angles and their several reflections simultaneously viewed through a telescope. I have also used a divided lens, like two stereoscopic lenses brought close together, in front of the object-glass of a telescope.

I have not yet had an opportunity of superimposing images by placing glass negatives in separate magic-lanterns, all converging upon the same screen; but this or even a simple dioramic apparatus would be very suitable for exhibiting composite effects to an audience, and if the electric light were used for illumination, the effect on the screen could be photographed at once. It would also be possible to construct a camera with a long focus, and many slightly-divergent object-glasses, each throwing an image of a separate glass negative upon the same sensitized plate.

The uses of composite portraits are many. They give us typical pictures of different races of men, if derived from a large number of individuals of those races taken at random. An assurance of the truth of any of our pictorial deductions is to be looked for in their substantial agreement when different batches of components have been dealt with, this being a perfect test of truth in all statistical conclusions. Again, we may select prevalent or strongly-marked types from among the men of the same race, just as I have done with two of the types of criminals by which this memoir is illustrated.

Another use of this process is to obtain by photography a really good likeness of a living person. The inferiority of photographs to the best works of artists, so far as resemblance is concerned, lies in their catching no more than a single expression. If many photographs of a person were taken at different times, perhaps even years apart, their composite would possess that in which a single photograph is deficient. I have already pointed out the experience of Mr. Appold to this effect. The analytical tendency of the mind is so strong that, out of any tangle of superimposed outlines, it persists in dwelling preferably on some one of them, singling it out and taking little heed of the rest. On one occasion it will select one outline, on another a different one. Looking at the patterns of the papered walls of our room we see, whenever our fancy is active, all kinds of forms and features; we often catch some strange combination which we are unable to recall on a subsequent occasion, while later still it may suddenly flash full upon us. A composite portrait would have much of this varied suggestiveness.

A further use of the process would be to produce, from many independent portraits of an historical personage, the most probable likeness of him. Contemporaneous statues, medals, and gems, would be very suitable for the purpose, photographs being taken of the same size, and a composite made from them. It will be borne in mind that it is perfectly easy to apportion different "weights" to the different components. Thus, if one statue be judged to be so much more worthy of reliance than another that it ought to receive double consideration in the composite, all that is necessary is to double either the time of its exposure or its illumination.

The last use of the process that I shall mention is of great interest as regards inquiries into the hereditary transmission of features, as it enables us to compare the average features of the product with those of the parentage. A composite of all the brothers and sisters in a large family would be an approximation to what the average of the product would probably be if the family were indefinitely increased in number, but the approximation would be closer if we also took into consideration those of the cousins who inherited the family likeness. As regards the parentage, it is by no means sufficient to take a composite of the two parents; the four grandparents and the uncles and aunts on both sides should be also included. Some statistical inquiries I published on the distribution of ability in families[1] give provisional data for determining the weight to be assigned in the composite to the several degrées of relationship. I should, however, not follow those figures in the present case, but would rather suggest for the earlier trials, first to give equal "weights" to the male and female sides; thus the father and a brother of the male parent would count equally with the father and a brother of the female parent. Secondly, I should "weight" each parent as 4, and each grandparent and each uncle and aunt as 1; again, I should weight each brother and sister as 4, and each of those cousins as 1 who inherited any part of the like-

[1] "Hereditary Genius," p. 317. Column D. Macmillan, 1869.

ness of the family in question. The other cousins I should disregard. The weights, as previously mentioned, would be bestowed by giving proportionate periods of exposure.[1]

Composites on this principle would undoubtedly aid the breeders of animals to judge of the results of any proposed union better than they are able to do at present, and in forecasting the results of marriages between men and women they would be of singular interest and instruction. Much might be learned merely by the frequent use of the double-image prism, as described above, which enables us to combine the features of living individuals when sitting side by side into a single image.

I have as yet had few opportunities of developing the uses of the composite photographic process, it being difficult without much explanation to obtain the requisite components. Indeed, the main motive of my publishing these early results is to afford that explanation, and to enable me to procure a considerable variety of materials to work upon. I especially want sets of family photographs, all as nearly as possible of the same size and taken in the same attitudes. The size I would suggest for family composites is that which gives one-half of an inch interval between the pupil of the eye and the line that separates the two lips. The attitudes about which there can be no mistake are: full face, an exact profile, say, always showing the right side of the face, and an exact three-quarters, always showing the left; in this, the outer edge of the right eyelid will be only just in sight. In each case the latter should look straight before him. Such portraits as these go well into *cartes de visite*, and I trust that not a few amateur photographers may be inclined to make sets of all the members of their family, young and old, and of both sexes, and to try composites of them on the principles I have described. The photographs used for that purpose need not be in the least injured, for the register marks may be made in the case into which they are slipped, and not in the photographs themselves.—*Nature.*

[1] Example: There are 5 brothers or sisters and 5 cousins whose portraits are available; the total period of desired exposure is 100 seconds. $5 \times 4 + 5 = 25$; $\frac{100}{25} = 4$; which gives $4 \times 4 = 16$ seconds for each brother or sister, and 4 seconds for each cousin $(5 \times 16 + 5 \times 4 = 100)$.

ILLUSTRATIONS OF THE LOGIC OF SCIENCE.

By C. S. PEIRCE,
ASSISTANT IN THE UNITED STATES COAST SURVEY.

SIXTH PAPER.—DEDUCTION, INDUCTION, AND HYPOTHESIS.

I.

THE chief business of the logician is to classify arguments; for all testing clearly depends on classification. The classes of the logicians are defined by certain typical forms called syllogisms. For example, the syllogism called *Barbara* is as follows:

S is M; M is P:
Hence, S is P.

Or, to put words for letters—

Enoch and Elijah were men; all men die:
Hence, Enoch and Elijah must have died.

The "is P" of the logicians stands for any verb, active or neuter. It is capable of strict proof (with which, however, I will not trouble the reader) that all arguments whatever can be put into this form; but only under the condition that the *is* shall mean "*is* for the purposes of the argument" or "is represented by." Thus, an induction will appear in this form something like this:

These beans are two-thirds white;
But, the beans in this bag are (represented by) these beans;
∴ The beans in the bag are two-thirds white.

But, because all inference may be reduced in some way to *Barbara*, it does not follow that this is the most appropriate form in which to represent every kind of inference. On the contrary, to show the distinctive characters of different sorts of inference, they must clearly be exhibited in different forms peculiar to each. *Barbara* particularly typifies deductive reasoning; and so long as the *is* is taken literally, no inductive reasoning can be put into this form. *Barbara* is, in fact, nothing but the application of a rule. The so-called major premise lays down this rule; as, for example, *All men are mortal.* The other or minor premise states a case under the rule; as, *Enoch was a man.* The conclusion applies the rule to the case and states the result: *Enoch is mortal.* All deduction is of this character; it is merely the application of general rules to particular cases. Sometimes this is not very evident, as in the following:

All quadrangles are figures,
But no triangle is a quadrangle;
Therefore, some figures are not triangles.

But here the reasoning is really this:

Rule.—Every quadrangle is other than a triangle.
Case.—Some figures are quadrangles.
Result.—Some figures are not triangles.

Inductive or synthetic reasoning, being something more than the mere application of a general rule to a particular case, can never be reduced to this form.

If, from a bag of beans of which we know that $\frac{2}{3}$ are white, we take one at random, it is a deductive inference that this bean is probably white, the probability being $\frac{2}{3}$. We have, in effect, the following syllogism:

Rule.—The beans in this bag are $\frac{2}{3}$ white.
Case.—This bean has been drawn in such a way that in the long run the relative number of white beans so drawn would be equal to the relative number in the bag.
Result.—This bean has been drawn in such a way that in the long run it would turn out white $\frac{2}{3}$ of the time.

If instead of drawing one bean we draw a handful at random and conclude that about $\frac{2}{3}$ of the handful are probably white, the reasoning is of the same sort. If, however, not knowing what proportion of white beans there are in the bag, we draw a handful at random and, finding $\frac{2}{3}$ of the beans in the handful white, conclude that about $\frac{2}{3}$ of those in the bag are white, we are rowing up the current of deductive sequence, and are concluding a rule from the observation of a result in a certain case. This is particularly clear when all the handful turn out one color. The induction then is:

These beans were in this bag.
These beans are white.
∴ All the beans in the bag were white.

Which is but an inversion of the deductive syllogism.

Rule.—All the beans in the bag were white.
Case.—These beans were in the bag.
Result.—These beans are white.

So that induction is the inference of the *rule* from the *case* and *result*.

But this is not the only way of inverting a deductive syllogism so as to produce a synthetic inference. Suppose I enter a room and there find a number of bags, containing different kinds of beans. On the table there is a handful of white beans; and, after some searching, I find one of the bags contains white beans only. I at once infer as a probability, or as a fair guess, that this handful was taken out of that bag. This sort of inference is called *making an hypothesis.* It is the inference of a *case* from a *rule* and *result.* We have, then—

DEDUCTION.

Rule.—All the beans from this bag are white.
Case.—These beans are from this bag.
∴ *Result.*—These beans are white.

INDUCTION.

Case.—These beans are from this bag.
Result.—These beans are white.
∴ *Rule.*—All the beans from this bag are white.

HYPOTHESIS.

Rule.—All the beans from this bag are white.
Result.—These beans are white.
∴ *Case.*—These beans are from this bag.

We, accordingly, classify all inference as follows:

Inference.

Deductive or Analytic. — Synthetic.

Synthetic: Induction. — Hypothesis.

Induction is where we generalize from a number of cases of which something is true, and infer that the same thing is true of a whole class. Or, where we find a certain thing to be true of a certain proportion of cases and infer that it is true of the same proportion of the whole class. Hypothesis is where we find some very curious circumstance, which would be explained by the supposition that it was a case of a certain general rule, and thereupon adopt that supposition. Or, where we find that in certain respects two objects have a strong resemblance, and infer that they resemble one another strongly in other respects.

I once landed at a seaport in a Turkish province; and, as I was walking up to the house which I was to visit, I met a man upon horseback, surrounded by four horsemen holding a canopy over his head. As the governor of the province was the only personage I could think of who would be so greatly honored, I inferred that this was he. This was an hypothesis.

Fossils are found; say, remains like those of fishes, but far in the interior of the country. To explain the phenomenon, we suppose the sea once washed over this land. This is another hypothesis.

Numberless documents and monuments refer to a conqueror called Napoleon Bonaparte. Though we have not seen the man, yet we cannot explain what we have seen, namely, all these documents and monuments, without supposing that he really existed. Hypothesis again.

As a general rule, hypothesis is a weak kind of argument. It often inclines our judgment so slightly toward its conclusion that we cannot say that we believe the latter to be true; we only surmise that it may be so. But there is no difference except one of degree between such an inference and that by which we are led to believe that we remember the occurrences of yesterday from our feeling as if we did so.

II.

Besides the way just pointed out of inverting a deductive syllogism to produce an induction or hypothesis, there is another. If from the truth of a certain premise the truth of a certain conclusion would necessarily follow, then from the falsity of the conclusion the falsity of the premise would follow. Thus, take the following syllogism in *Barbara:*

Rule.—All men are mortal.
Case.—Enoch and Elijah were men.
∴ *Result.*—Enoch and Elijah were mortal.

Now, a person who denies this result may admit the rule, and, in that case, he must deny the case. Thus:

Denial of Result.—Enoch and Elijah were not mortal.
Rule.—All men are mortal.
∴ *Denial of Case.*—Enoch and Elijah were not men.

This kind of syllogism is called *Baroco*, which is the typical mood of the second figure. On the other hand, the person who denies the result may admit the case, and in that case he must deny the rule. Thus:

Denial of the Result.—Enoch and Elijah were not mortal.
Case.—Enoch and Elijah were men.
∴ *Denial of the Rule.*—Some men are not mortal.

This kind of syllogism is called *Bocardo*, which is the typical mood of the third figure.

Baroco and *Bocardo* are, of course, deductive syllogisms; but of a very peculiar kind. They are called by logicians indirect moods, because they need some transformation to appear as the application of a rule to a particular case. But if, instead of setting out as we have here done with a necessary deduction in *Barbara*, we take a probable deduction of similar form, the indirect moods which we shall obtain will be—

Corresponding to *Baroco*, an hypothesis;
and, Corresponding to *Bocardo*, an induction.

For example, let us begin with this probable deduction in *Barbara:*

Rule.—Most of the beans in this bag are white.
Case.—This handful of beans are from this bag.
∴ *Result.*—Probably, most of this handful of beans are white.

Now, deny the result, but accept the rule:

Denial of Result.—Few beans of this handful are white.
Rule.—Most beans in this bag are white.
∴ *Denial of Case.*—Probably, these beans were taken from another bag.

This is an hypothetical inference. Next, deny the result, but accept the case:

Denial of Result.—Few beans of this handful are white.
Case.—These beans came from this bag.
∴ *Denial of Rule.*—Probably, few beans in the bag are white.

This is an induction.

The relation thus exhibited between synthetic and deductive reasoning is not without its importance. When we adopt a certain hypothesis, it is not alone because it will explain the observed facts, but also because the contrary hypothesis would probably lead to results contrary to those observed. So, when we make an induction, it is drawn not only because it explains the distribution of characters in the sample, but also because a different rule would probably have led to the sample being other than it is.

But the advantage of this way of considering the subject might easily be overrated. An induction is really the inference of a rule, and to consider it as the denial of a rule is an artificial conception, only admissible because, when statistical or proportional propositions are considered as rules, the denial of a rule is itself a rule. So, an hypothesis is really a subsumption of a case under a class and not the denial of it, except for this, that to deny a subsumption under one class is to admit a subsumption under another.

Bocardo may be considered as an induction, so timid as to lose its amplifiative character entirely. Enoch and Elijah are specimens of a certain kind of men. All that kind of men are shown by these instances to be immortal. But instead of boldly concluding that all very pious men, or all men favorites of the Almighty, etc., are immortal, we refrain from specifying the description of men, and rest in the merely explicative inference that *some* men are immortal. So *Baroco* might be considered as a very timid hypothesis. Enoch and Elijah are not mortal. Now, we might boldly suppose them to be gods or something of that sort, but instead of that we limit ourselves to the inference that they are of *some* nature different from that of man.

But, after all, there is an immense difference between the relation of *Baroco* and *Bocardo* to *Barbara* and that of Induction and Hypothesis to Deduction. *Baroco* and *Bocardo* are based upon the fact that if the truth of a conclusion necessarily follows from the truth of a premise, then the falsity of the premise follows from the falsity of the conclusion. This is always true. It is different when the inference is only probable. It by no means follows that, because the truth of a certain premise would render the truth of a conclusion probable, therefore the falsity of the conclusion renders the falsity of the premise probable. At least, this is only true, as we have seen in a former paper, when the word probable is used in one sense in the antecedent and in another in the consequent.

III.

A certain anonymous writing is upon a torn piece of paper. It is suspected that the author is a certain person. His desk, to which only he has had access, is searched, and in it is found a piece of paper, the torn edge of which exactly fits, in all its irregularities, that of the paper in question. It is a fair hypothetic inference that the suspected man was actually the author. The ground of this inference evidently is that two torn pieces of paper are extremely unlikely to fit together by accident. Therefore, of a great number of inferences of this sort, but a very small proportion would be deceptive. The analogy of hypothesis with induction is so strong that some logicians have confounded them. Hypothesis has been called an induction of characters. A number of characters belonging to a certain class are found in a certain object; whence it is inferred that all the characters of that class belong to the object in question. This certainly involves the same principle as induction; yet in a modified form. In the first place, characters are not susceptible of simple enumeration like objects; in the next place, characters run in categories. When we make an hypothesis like that about the piece of paper, we only examine a single line of characters, or perhaps two or three, and we take no specimen at all of others. If the hypothesis were nothing but an induction, all that we should be justified in concluding, in the example above, would be that the two pieces of paper which matched in such irregularities as have been examined would be found to match in other, say slighter, irregularities. The inference from the shape of the paper to its ownership is precisely what distinguishes hypothesis from induction, and makes it a bolder and more perilous step.

The same warnings that have been given against imagining that induction rests upon the uniformity of Nature might be repeated in regard to hypothesis. Here, as there, such a theory not only utterly fails to account for the validity of the inference, but it also gives rise to methods of conducting it which are absolutely vicious. There are, no doubt, certain uniformities in Nature, the knowledge of which will fortify an hypothesis very much. For example, we suppose that iron, titanium, and other metals exist in the sun, because we find in the solar spectrum many lines coincident in position with those which these metals would produce; and this hypothesis is greatly strengthened by our knowledge of the remarkable distinctiveness of the particular line of characters observed. But such a fortification of hypothesis is of a deductive kind, and hypothesis may still be probable when such reënforcement is wanting.

There is no greater nor more frequent mistake in practical logic than to suppose that things which resemble one another strongly in some respects are any the more likely for that to be alike in others. That this is absolutely false, admits of rigid demonstration; but, inasmuch as the reasoning is somewhat severe and complicated (requiring, like all such reasoning, the use of A, B, C, etc., to set it forth), the reader would probably find it distasteful, and I omit it. An example, however, may illustrate the proposition: The comparative mythologists occupy themselves with finding points of resemblance between solar phenomena and the careers of the heroes of all sorts of traditional stories; and upon the basis of such resemblances they infer that these heroes are impersonations of the sun. If there be anything more in their reasonings, it has never been made clear to me. An ingenious logician, to show how futile all that is, wrote a little book, in which he pretended to prove, in the same manner, that Napoleon Bonaparte is only an impersonation of the sun. It was really wonderful to see how many points of resemblance he made out. The truth is, that any two things resemble one another just as strongly as any two others, if recondite resemblances are admitted. But, in order that the process of making an hypothesis should lead to a probable result, the following rules must be followed:

1. The hypothesis should be distinctly put as a question, before making the observations which are to test its truth. In other words, we must try to see what the result of predictions from the hypothesis will be.

2. The respect in regard to which the resemblances are noted must be taken at random. We must not take a particular kind of predictions for which the hypothesis is known to be good.

3. The failures as well as the successes of the predictions must be honestly noted. The whole proceeding must be fair and unbiased.

Some persons fancy that bias and counter-bias are favorable to the extraction of truth—that hot and partisan debate is the way to investigate. This is the theory of our atrocious legal procedure. But Logic puts its heel upon this suggestion. It irrefragably demonstrates that knowledge can only be furthered by the real desire for it, and that the methods of obstinacy, of authority, and every mode of trying to reach a foregone conclusion, are absolutely of no value. These things are proved. The reader is at liberty to think so or not as long as the proof is not set forth, or as long as he refrains from examining it. Just so, he can preserve, if he likes, his freedom of opinion in regard to the propositions of geometry; only, in that case, if he takes a fancy to read Euclid, he will do well to skip whatever he finds with A, B, C, etc., for, if he reads attentively that disagreeable matter, the freedom of his opinion about geometry may unhappily be lost forever.

How many people there are who are incapable of putting to their own consciences this question, "Do I want to know how the fact stands, or not?"

The rules which have thus far been laid down for induction and hypothesis are such as are absolutely essential. There are many other maxims expressing particular contrivances for making synthetic inferences strong, which are extremely valuable and should not be neglected. Such are, for example, Mr. Mill's four methods. Nevertheless, in the total neglect of these, inductions and hypotheses may and sometimes do attain the greatest force.

IV.

Classifications in all cases perfectly satisfactory hardly exist. Even in regard to the great distinction between explicative and ampliative inferences, examples could be found which seem to lie upon the border between the two classes, and to partake in some respects of the characters of either. The same thing is true of the distinction between induction and hypothesis. In the main, it is broad and decided. By induction, we conclude that facts, similar to observed facts, are true in cases not examined. By hypothesis, we conclude the existence of a fact quite different from anything observed, from which, according to known laws, something observed would necessarily result. The former, is reasoning from particulars to the general law; the latter, from effect to cause. The former classifies, the latter explains. It is only in some special cases that there can be more than a momentary doubt to which category a given inference belongs. One exception is where we observe, not facts similar under similar circumstances, but facts different under different circumstances—the difference of the former having, however, a definite relation to the difference of the latter. Such inferences, which are really inductions, sometimes present nevertheless some indubitable resemblances to hypotheses.

Knowing that water expands by heat, we make a number of observations of the volume of a constant mass of water at different temperatures. The scrutiny of a few of these suggests a form of algebraical formula which will approximately express the relation of the volume to the temperature. It may be, for instance, that v being the relative volume, and t the temperature, the few observations examined indicate a relation of the form—

$$v = 1 + at + bt^2 + ct^3.$$

Upon examining observations at other temperatures taken at random, this idea is confirmed; and we draw the inductive conclusion that all observations within the limits of temperature from which we have drawn our observations could equally be so satisfied. Having once ascertained that such a formula is possible, it is a mere affair of arithmetic to find the values of a, b, and c, which will make the formula satisfy the observations best. This is what physicists call an *empirical formula*, because it rests upon mere induction, and is not explained by any hypothesis.

Such formulæ, though very useful as means of describing in general terms the results of observations, do not take any high rank among scientific discoveries. The induction which they embody, that expansion by heat (or whatever other phenomenon is referred to) takes place in a perfectly gradual manner without sudden leaps or innumerable fluctuations, although really important, attracts no attention, because it is what we naturally anticipate. But the defects of such expressions are very serious. In the first place, as long as the observations are subject to error, as all observations are, the formula cannot be expected to satisfy the observations exactly. But the discrepancies cannot be due solely to the errors of the observations, but must be partly owing to the error of the formula which has been deduced from erroneous observations. Moreover, we have no right to suppose that the real facts, if they could be had free from error, could be expressed by such a formula at all. They might, perhaps, be expressed by a similar formula with an infinite number of terms; but of what use would that be to us, since it would require an infinite number of coefficients to be written down? When one quantity varies with another, if the corresponding values are exactly known, it is a mere matter of mathematical ingenuity to find some way of expressing their relation in a simple manner. If one quantity is of one kind—say, a specific gravity—and the other of another kind—say, a temperature—we do not desire to find an expression for their relation which is wholly free from numerical constants, since if it were free from them when, say, specific gravity as compared with water, and temperature as expressed by the centigrade thermometer, were in question, numbers would have to be introduced when the scales of measurement were changed. We may, however, and do desire to find formulas expressing the relations of physical phenomena which shall contain no more arbitrary numbers than changes in the scales of measurement might require.

When a formula of this kind is discovered, it is no longer called an empirical formula, but a law of Nature; and is sooner or later made the basis of an hypothesis which is to explain it. These simple formulæ are not usually, if ever, exactly true, but they are none the less important for that; and the great triumph of the hypothesis comes when it explains not only the formula, but also the deviations from the formula. In the current language of the physicists, an hypothesis of this importance is called a theory, while the term hypothesis is restricted to suggestions which have little evidence in their favor. There is some justice in the contempt which clings to the word hypothesis. To think that we can strike out of our own minds a true preconception of how Nature acts, is a vain fancy. As Lord Bacon well says: "The subtlety of Nature far exceeds the subtlety of sense and intellect: so that these fine meditations, and speculations, and reasonings of men are a sort of insanity, only there is no one at hand to remark it." The successful theories are not pure guesses, but are guided by reasons.

The kinetical theory of gases is a good example of this. This theory is intended to explain certain simple formulæ, the chief of which is called the law of Boyle. It is, that if air or any other gas be placed in a cylinder with a piston, and if its volume be measured under the pressure of the atmosphere, say fifteen pounds on the square inch, and if then another fifteen pounds per square inch be placed on the piston, the gas will be compressed to one-half its bulk, and in similar inverse ratio for other pressures. The hypothesis which has been adopted to account for this law is that the molecules of a gas are small, solid particles at great distances from each other (relatively to their dimensions), and moving with great velocity, without sensible attractions or repulsions, until they happen to approach one another very closely. Admit this, and it follows that when a gas is under pressure what prevents it from collapsing is not the incompressibility of the separate molecules, which are under no pressure at all, since they do not touch, but the pounding of the molecules against the piston. The more the piston falls, and the more the gas is compressed, the nearer together the molecules will be; the greater number there will be at any moment within a given distance of the piston, the shorter the distance which any one will go before its course is changed by the influence of another, the greater number of new courses of each in a given time, and the oftener each, within a given distance of the piston, will strike it. This explains Boyle's law. The law is not exact; but the hypothesis does not lead us to it exactly. For, in the first place, if the molecules are large, they will strike each other oftener when their mean distances are diminished, and will consequently strike the piston oftener, and will produce more pressure upon it. On the other hand, if the molecules have an attraction for one another, they will remain for a sensible time within one another's influence, and consequently they will not strike the wall so often as they otherwise would, and the pressure will be less increased by compression.

When the kinetical theory of gases was first proposed by Daniel Bernoulli, in 1738, it rested only on the law of Boyle, and was therefore pure hypothesis. It was accordingly quite naturally and deservedly neglected. But, at present, the theory presents quite another aspect; for, not to speak of the considerable number of observed facts of different kinds with which it has been brought into relation, it is supported by the mechanical theory of heat. That bringing together bodies which attract one another, or separating bodies which repel one another, when sensible motion is not produced nor destroyed, is always accompanied by the evolution of heat, is little more than an induction. Now, it has been shown by experiment that, when a gas is allowed to expand without doing work, a very small amount of heat disappears. This proves that the particles of the gas attract one another slightly, and but very slightly. It follows that, when a gas is under pressure, what prevents it from collapsing is not any repulsion between the particles, since there is none. Now, there are only two modes of force known to us, force of position or attractions and repulsions, and force of motion. Since, therefore, it is not the force of position which gives a gas its expansive force, it must be the force of motion. In this point of view, the kinetical theory of gases appears as a deduction from the mechanical theory of heat. It is to be observed, however, that it supposes the same law of mechanics (that there are only those two modes of force) which holds in regard to bodies such as we can see and examine, to hold also for what are very different, the molecules of bodies. Such a supposition has but a slender support from induction. Our belief in it is greatly strengthened by its connection with the law of Boyle, and it is, therefore, to be considered as an hypothetical inference. Yet it must be admitted that the kinetical theory of gases would deserve little credence if it had not been connected with the principles of mechanics.

The great difference between induction and hypothesis is, that the former infers the existence of phenomena such as we have observed in cases which are similar, while hypothesis supposes something of a different kind from what we have directly observed, and frequently something which it would be impossible for us to observe directly. Accordingly, when we stretch an induction quite beyond the limits of our observation, the inference partakes of the nature of hypothesis. It would be absurd to say that we have no inductive warrant for a generalization extending a little beyond the limits of experience, and there is no line to be drawn beyond which we cannot push our inference; only it becomes weaker the further it is pushed. Yet, if an induction be pushed very far, we cannot give it much credence unless we find that such an extension explains some fact which we can and do observe. Here, then, we have a kind of mixture of induction and hypothesis supporting one another; and of this kind are most of the theories of physics.

V.

That synthetic inferences may be divided into induction and hypothesis in the manner here proposed,[1] admits of no question. The utility and value of the distinction are to be tested by their applications.

[1] This division was first made in a course of lectures by the author before the Lowell Institute, Boston, in 1866, and was printed in the "Proceedings of the American Academy of Arts and Sciences," for April 9, 1867.

Induction is, plainly, a much stronger kind of inference than hypothesis; and this is the first reason for distinguishing between them. Hypotheses are sometimes regarded as provisional resorts, which in the progress of science are to be replaced by inductions. But this is a false view of the subject. Hypothetic reasoning infers very frequently a fact not capable of direct observation. It is an hypothesis that Napoleon Bonaparte once existed. How is that hypothesis ever to be replaced by an induction? It may be said that from the premise that such facts as we have observed are as they would be if Napoleon existed, we are to infer by induction that *all* facts that are hereafter to be observed will be of the same character. There is no doubt that every hypothetic inference may be distorted into the appearance of an induction in this way. But the essence of an induction is that it infers from one set of facts another set of similar facts, whereas hypothesis infers from facts of one kind to facts of another. Now, the facts which serve as grounds for our belief in the historic reality of Napoleon are not by any means necessarily the only kind of facts which are explained by his existence. It may be that, at the time of his career, events were being recorded in some way not now dreamed of, that some ingenious creature on a neighboring planet was photographing the earth, and that these pictures on a sufficiently large scale may some time come into our posession, or that some mirror upon a distant star will, when the light reaches it, reflect the whole story back to earth. Never mind how improbable these suppositions are; everything which happens is infinitely improbable. I am not saying that *these* things are likely to occur, but that *some* effect of Napoleon's existence which now seems impossible is certain nevertheless to be brought about. The hypothesis asserts that such facts, when they do occur, will be of a nature to confirm, and not to refute, the existence of the man. We have, in the impossibility of inductively inferring hypothetical conclusions, a second reason for distinguishing between the two kinds of inference.

A third merit of the distinction is, that it is associated with an important psychological or rather physiological difference in the mode of apprehending facts. Induction infers a rule. Now, the belief of a rule is a habit. That a habit is a rule active in us, is evident. That every belief is of the nature of a habit, in so far as it is of a general character, has been shown in the earlier papers of this series. Induction, therefore, is the logical formula which expresses the physiological process of formation of a habit. Hypothesis substitutes, for a complicated tangle of predicates attached to one subject, a single conception. Now, there is a peculiar sensation belonging to the act of thinking that each of these predicates inheres in the subject. In hypothetic inference this complicated feeling so produced is replaced by a single feeling of greater intensity, that belonging to the act of thinking the hypothetic conclusion. Now, when our nervous system is excited in a complicated way, there being a relation between the elements of the excitation, the result is a single harmonious disturbance which I call an emotion. Thus, the various sounds made by the instruments of an orchestra strike upon the ear, and the result is a peculiar musical emotion, quite distinct from the sounds themselves. This emotion is essentially the same thing as an hypothetic inference, and every hypothetic inference involves the formation of such an emotion. We may say, therefore, that hypothesis produces the *sensuous* element of thought, and induction the *habitual* element. As for deduction, which adds nothing to the premises, but only out of the various facts represented in the premises selects one and brings the attention down to it, this may be considered as the logical formula for paying attention, which is the *volitional* element of thought, and corresponds to nervous discharge in the sphere of physiology.

Another merit of the distinction between induction and hypothesis is, that it leads to a very natural classification of the sciences and of the minds which prosecute them. What must separate different kinds of scientific men more than anything else are the differences of their *techniques*. We cannot expect men who work with books chiefly to have much in common with men whose lives are passed in laboratories. But, after differences of this kind, the next most important are differences in the modes of reasoning. Of the natural sciences, we have, first, the classificatory sciences, which are purely inductive—systematic botany and zoölogy, mineralogy, and chemistry. Then, we have the sciences of theory, as above explained—astronomy, pure physics, etc. Then, we have sciences of hypothesis—geology, biology, etc.

There are many other advantages of the distinction in question which I shall leave the reader to find out by experience. If he will only take the custom of considering whether a given inference belongs to one or other of the two forms of synthetic inference given on page 472, I can promise him that he will find his advantage in it, in various ways.

POISONS OF THE INTELLIGENCE—HASHEESH.[1]

By CHARLES RICHET.

HASHEESH is the extract of Indian hemp. This extract, mixed with different aromatics and vegetable oils, forms *dawamesk*, a sort of nauseous confection taken before a meal. Then there is the hasheesh smoked in pipes or in cigarettes, and this is the form in which the drug is most commonly taken in the East. The aqueous extract is known as *hafioun;* it is more active than the other two preparations. It takes nearly four parts of dawamesk to make one of hafioun. It is

[1] Translated and condensed by J. Fitzgerald, A. M.

very difficult to find out any more concerning the Oriental modes of preparing hasheesh; still, though our pharmaceutical information be insufficient, we are pretty familiar with the psychic effects of the drug. I have taken it myself again and again in various doses, and have administered it to many of my friends, and whatever I shall have to say concerning its properties will be based upon my own observations. Taken in moderate doses, it produces a kind of intoxication that is very pleasant, highly advantageous for a correct knowledge of intellectual phenomena, and at the same time free from serious consequences. The worst that is to be expected when one takes either dawamesk or hafioun in suitable quantities is slight disorder of the digestion, and a little sense of heaviness and of cerebral excitation.

If one has not been told what to expect, the first effects of hasheesh pass by unnoticed; these consist of a certain motor and sensor excitability of the spinal cord. There is a twitching in the nape of the neck, the back and the legs, and a shivering that extends over the whole body. It is as though there were puffs of hot and cold air rising to the head; but withal there is a vague sense of comfortableness, and one finds himself in a state of great good-humor, as is the case of most persons after the absorption of a certain amount of alcohol. By degrees the excitation of the spinal cord produces effects that are more characteristic, as muscular exertion of every kind, walking, stretching, dancing, lifting heavy weights; but meantime the mind is calm. Suddenly, however, on hearing some chance remark, the patient is seized with a fit of laughing without any apparent cause, and this continues for a length of time. This having passed, he comes to himself again, and recognizes the first effects of the poison.

Ideas now come crowding on his brain, one following another with bewildering rapidity. Thoughts come and go without any apparent law of succession or concomitance, but in reality they are governed by the immutable laws of the association of ideas and impressions. The patient thinks the persons he sees around him very slow and dull. Language is not swift enough to give expression to his rapid thoughts. There is, as it were, an hypertrophy of ideas. What in the normal state would cause very trifling discomfort, now becomes an unbearable evil, and the patient cries and begs for commiseration. With the air of a tragic actor he will tell you that it rains, or that the wind blows. One's self-esteem is magnified, and he looks down with scorn upon the ignorance of others.

Thus, then, to say nothing as yet of the change in sensation, the moral person is entirely transformed. I am not aware that the resemblance of these phenomena to those of hysteria has ever been noticed. In general, hysterical women are very intelligent, with brilliant ideas and a lively imagination; but their mental activity labors under two defects, namely, the exaggeration of the feelings and the absence of will. The same thing is seen in the use of hasheesh.

But there are other phenomena that are still more characteristic of hasheesh, especially its effects on our notions of time and space. Under its influence, time seems to be of interminable length. Between two clearly-conceived ideas the patient descries a host of others that are indeterminate and incomplete, and of which he is only dimly conscious; but he is filled with admiration at their number and vastness. Now we measure time by the memory of the ideas that have passed through the mind, and hence an instant appears immensely long to one under the hasheesh influence. Suppose, as is common enough in the use of this drug, that in the space of one second fifty different thoughts enter the brain; now, since in the normal state it requires several minutes to conceive fifty different thoughts, the inference will be that many minutes have gone by. Seconds become years, and minutes become ages.

This illusion has no parallel; yet in dreaming, or rather in that intermediate state which is neither sleeping nor waking, we experience something similar. I recollect having been at work one day with a friend, and, as I felt drowsy, asking him to let me sleep for a few minutes. On awaking, I was assured by him that I had slept hardly a second; and yet in that brief time I had had a very complicated dream, and, in consequence of the multiplicity of my thoughts, the time had appeared to be of considerable length. So, if a person be awakened by some sudden, loud noise, he will oftentimes, in the fraction of a second, pass in imagination through scenes and adventures of a very complicated nature. A like illusion may be procured at will by shutting the eyes while one is riding in a carriage: under such circumstances the journey will appear to have no end; on opening the eyes from time to time, and observing the landmarks, the progress will seem to be extremely slow.

But in dreaming and in sleep this illusion as to the lapse of time is vague and ill-defined. Under the influence of hasheesh, on the contrary, it becomes singularly definite. Nor is the illusion of the sight less astonishing, which causes inconsiderable distances to appear enormously great. I do not know whether this illusion has been observed under any other conditions than those of hasheesh-poisoning, nor can I offer any rational explanation of it. It is difficult even to describe it. It causes a bridge, an avenue, to stretch out to unheard-of lengths. On going up a ladder, the rounds appear to reach up to the sky. A river whose opposite bank is in sight becomes an arm of the sea. And, besides these two illusions of space and time, which by-the-way often persist twenty-four hours or more, there are other illusions of the strangest kind imaginable. Hallucinations, on the contrary, are infrequent, though one remarkable instance has been observed by Dr. Moreau, of Tours.

It is oftentimes very hard to draw the distinction between illusion and hallucination, but nevertheless there is a difference between these two manifestations of morbid psychic activity. When an insane patient sees at his elbow a walking, talking spectre, he has an hallucination. But if in a dark forest, at night, one takes some deformed trunk for a ghost, he has an illusion. Illusion presupposes an actual sensation, the perception of which is exaggerated and erroneous, whereas hallucination comes spontaneously without requiring a sensation to give rise to it. Now, under the hasheesh influence, the sensations are exaggerated so as to produce endless illusions. The slightest sound becomes a crash, and we hear the fall of waters, the roar of cataracts, the blare of trumpets, or brilliant harmonies. I have seen persons, naturally almost insensible to music, lifted by a few musical notes into an ecstasy such as we read of in the lives of saints. But, for a description of all these sensations, I would refer the reader to the brilliant pages of Théophile Gautier's "Club des Hachichins."

I will not go over ground trod by Gautier, but will content myself with touching upon another point of psychological interest. We will suppose the illusion to be stronger than anything noticed in the foregoing instances; that instead of being a simple disorder of the perceptive faculties, it affects the conceptive powers. Under normal conditions, external impressions awaken manifold ideas in our minds; besides the association of ideas, there is association of impressions with ideas. For instance, a certain taste, smell, or sound, gives rise to a multitude of conceptions that follow one another according to the direction we may be pleased to give them. The faculty of attention enables us to check the uprising of the conceptions called forth by the taste, smell, or sound. Often, while attention is fixed on an object, we neither hear nor see what is passing without. In reality we do see and hear, but these sensations are obliterated, and pass out of the mind without leaving a trace behind. In the use of hasheesh, in virtue of the loss of will, the intensity of the perceptions, and the excitation of the brain, every external impression calls forth a series of delirious conceptions, and there is no check.

Dr. Moreau lays great stress on the resemblance subsisting between these hasheesh illusions and the systematic delirium of the insane. In most lunatics the delirious idea has its origin in fact, in a sensation, a pain, an impression from without. This forms for them the logical basis of a system of erroneous judgments. If, for instance, they suffer from nausea or gastric pains, they say they have been poisoned; that their enemies have mixed poison with their food. Precisely the same thing is found in the use of hasheesh. Every sensation immediately calls forth an insane thought, or rather a thousand such thoughts. Hence it really appears as though the veil were rent in twain, and that by the use of this drug we are enabled to witness the mind itself at its work. The mysterious and silent travail which in the normal state produces our thoughts and judgments is no longer either mysterious or silent: we can see how the whole is connected, and can look on while ideas are being evolved. But, unfortunately, under the hasheesh influence one is no longer master of his own thoughts, and must, perforce, follow them in their disorderly course. Here we observe close resemblance between the three states of dreaming, insanity, and hasheesh intoxication. In all these external impressions are all-powerful, and the mind is subject, unchecked, to the excitation of the senses.

One great difference between intoxication by hasheesh and that by alcohol and chloroform is that in the former, when the dose is light, memory is intact: one remembers with marvelous exactitude all that he saw, did, or said. But if the dose be strong, the loss of memory is complete; then, too, there is delirium, wild delirium. In such doses hasheesh is dangerous, though I do not think a single case of death from this cause has ever been recorded in Europe. But sometimes the delirium has continued for several days, and assumed serious proportions. No one should take hasheesh without having some person to care for him while under the influence of the drug; oftentimes the hasheesh gives such a sense of lightness and agility that a person will attempt to fly by leaping out of a window.

In the East hasheesh is in very general use. It is nearly always smoked in large pipes, which are passed from mouth to mouth. The smoke is very agreeable, possessing a peculiar aromatic odor. On entering certain Arab *cafés* at Cairo or at Damascus, one perceives this penetrating odor, which gently intoxicates even those who do not smoke. In this mild dose hasheesh produces a sort of sleepiness, during which external objects assume fantastic forms, and all is like a dream. The monotonous, nasal music has a gentle, tranquilizing effect during this sleep. On the walls of the *café* are rudely-pictured camels, grotesque human forms, or the surface is marked with lines, quadrangles, and triangles. In the minds of the hasheesh-smokers these rude pictures awaken delightful illusions, and they fancy themselves to be transported to Mohammed's paradise. To further amuse the indolence of the customers, a chanter drones out a long story, semi-religious, semi-heroic. The tale is in couplets, and between the couplets the music strikes up again its interminable rhythm. Now and then a smoker will rise staggering to his feet, and will give expression by yells to the delight with which he contemplates some fantastic image that he sees. The rest of the company then laugh uproariously, but anon will greet the last speaker with "Allah be with thee! Allah be praised!" Never shall I forget this spectacle, which, in a dark corner of the noisy bazaars of Damascus, with the dim light of a smoky lamp, to the sound of the tambourine and guitar with three cords, enabled me to understand one side of Oriental life.

SKETCH OF THOMAS ALVA EDISON.

BY G. M. SHAW.

THIS remarkable inventor, of whom the public has recently heard so much, is still a young man, having been born in 1847 at Milan, Erie County, Ohio. His mother was of Scotch parentage, but born in Massachusetts; she was finely educated, literary and ambitious, and had been a teacher in Canada. Young Edison's only schooling came from his mother, who taught him spelling, reading, writing, and arithmetic. He lost his mother in 1862, but his father, a man of vigorous constitution, is still living, aged seventy-four. When he was seven years old, his parents removed to Port Huron, Michigan. The boy disliked mathematics, but was fond of reading, and, before he was twelve years old, had read the "Penny Cyclopædia," Hume's "England," and Gibbon's "Rome." He early took to the railroad, and became a newsboy on the Grand Trunk line, running into Detroit. Here he had access to a library, which he undertook to read through; but, after skimming over many hundred miscellaneous books, he adopted the plan of select reading on subjects of interest to him. Becoming interested in chemistry, he bought some chemicals, and fixed up a laboratory in one of the cars. An unfortunate combustion of phosphorus one day came near setting fire to the train, and the consequence was, that the conductor kicked the whole thing out. He had obtained the exclusive right to sell papers on the road, and employed four assistants; but, not satisfied with this, he bought a lot of second-hand type, and printed on the cars a little paper of his own, called the *Grand Trunk Herald*. Getting acquainted with the telegraph-operators along the road, he took a notion to become an operator himself. In his lack of means and opportunities, he resorted to the expedient of making his own apparatus at home. A piece of stove-wire, insulated by bottles, was made to do service as the line-wire. The wire for his electro-magnets he wound with rags, and in a similar way persevered until he had the crude elements of a telegraph; but the electricity being wanting, and as he could not buy a battery, he tried rubbing the fur of cats' backs, but says that electricity from this source was a failure for telegraphic purposes.

About two months afterward, as a train was switching on to a side-track at Mount Clemens Station, the station-agent's little boy, two years old, crept on to the track ahead of the cars. Edison saw the danger, sprang to the ground, and barely succeeded in saving the youngster. Its father, the station-master, being a poor man, could not show his gratitude by a money reward, but offered to teach young Edison telegraph-operating. He gladly seized the chance, and for five months we see him going back to Mount Clemens, at the close of his day's work, to labor nights in learning to be an operator. At the end of this time he was able to go into the telegraph-office at Port Huron. Here he worked for six months, and then went to Stratford, Canada, as night-operator. He soon after went to Adrian, Michigan, where, in addition to his telegraph-office, he had a small shop and tools, to which he turned his hand at odd moments for the purpose of repairing instruments. This situation he lost by violating some rule while absorbed in his workshop, but in two months after appeared in Indianapolis, where he came out with his first invention, an automatic repeater—an arrangement for transferring a message from one wire to another without the aid of an operator. From this place he went in turn to Cincinnati, Memphis, Louisville, New Orleans, and back again to Cincinnati, where we find him in 1867, at the age of twenty, absorbed in projects of invention. His utter negligence of dress and appearance, his insatiable thirst for reading, and his enthusiastic attempts to solve what appeared to others impossible, together with his willingness to work at all hours of the day or night, earned him the name of "Looney," by which he was best known for many years. Reaching his office here one night and finding it "on strike," he took in the situation, and went to work, keeping it up all night, working to his utmost, receiving the press dispatches. For this act he was raised from a salary of $65 to $105 per month, and given the best line in the office. While here he conceived the idea, afterward perfected in Boston, of sending two messages at the same time over the same wire. His "everlasting experiments" were looked upon with disfavor by the management, and the imagined neglect of his work caused so much dissatisfaction that he quit the office and returned home to Port Huron.

Here he soon received a call from the manager of the Boston office to be the Boston operator on the "crack" New York wire. The manager knew him, but the appearance there of the very similitude of a green country gawky raised a shout of laughter at his expense, which almost unnerved him, and, to make the matter worse, before he had time to compose himself, he was shown his place to make a trial. The position was the dread of operators; the New York man was one of the fastest senders in the country, delighted in victims, and in this instance sat at his instrument with a grim satisfaction, waiting to open on the "new man," and chuckling with his Boston comrades over their expected fun. They commenced, and the New York man crowded his sending-speed to his utmost, with never a "break" by the new man receiving. At the end of the message, the astonished and exhausted New York operator adds, "Who the deuce *are* you, anyhow?" to which the new man at Boston promptly replies, "I'm Tom Edison—shake hands."

We can make but brief mention of a few of the many incidents connected with Mr. Edison's history. In the Boston office one of his first efforts was at "internal improvement." The office was infested with cockroaches. He set up an apparatus for their automatic destruction. Mr. Edison's *forte* is automatic contrivances. He arranged strips of metal around the bottom of the walls in the room, and connected them with the opposite poles of a battery, so that when the bugs stepped from one to the other, they closed the circuit and their lives at one operation, and made room for others.

In Boston Mr. Edison fixed up a small shop and continued his experiments, which he put into such practical shape that he saw more money in them than in his salary. He worked out the idea of his duplex telegraph, and went to Rochester in 1870 to test it between that place and Boston. The effort failed, though Mr. Edison says it ought to have succeeded. He then came to New York, scarcely knowing what to do next. He hung around the office of the Gold Indicator Company, studying their cumbersome apparatus. One day some part of it failed in a time of excitement; Mr. Edison offered to remedy it; he was laughed at incredulously; but the case was desperate, and he was allowed to try. He succeeded; and the managers, ready to perceive the value of such a man, made him superintendent. He introduced improved apparatus, invented the gold printer, put up a private line, and finally sold it to the Gold and Stock Company, together with his services, or the privilege of having the first option to buy his telegraphic inventions. He was now fully launched on a tide of success. To furnish his instruments, he established a factory in Newark, New Jersey, employing three hundred men. As a manufacturer he was not a success. If he had an order for any of his inventions, and, after having made a part or all of them, he invented an improvement, nothing would do but he must incorporate it, even though at his own expense. At last, finding that the close attention demanded by his manufacturing business was incompatible with the freedom demanded for invention, he abandoned it, and, two years ago, bought a site for an experiment-shop at Menlo Park, on the Pennsylvania Railroad, twenty-four miles from New York, a mere flag-station, with about a dozen houses, mostly his own and his workmen's.

On the crown of a knoll, and looking, for all the world, like a country meeting-house, minus the steeple, and with the addition of a porch, is a long two-story white frame building, in the middle of a little lot, surrounded by a white picket-fence. This is Mr. Edison's shop. On the ground-floor, as you enter, is a little front-office, from which a small library is partitioned off. Next is a large square room with glass cases filled with models of his inventions. In the rear of this is the machine-shop, completely equipped, and run with a ten-horse-power engine. The upper story occupies the length and breadth of the building, 100 × 25 feet, is lighted by windows on every side, and is occupied as a laboratory. The walls are covered with shelves full of bottles containing all sorts of chemicals. Scattered through the room are tables covered with electrical instruments, telephones, phonographs, microscopes, spectroscopes, etc. In the centre of the room is a rack full of galvanic batteries. On one of the tables is a phonograph, run by steam-power, with a belt through the floor to the machine-shop, and beside it a copy of Poe's poems. In the rear of the room is a fine pipe-organ, with an open Moody and Sankey book on it. At the opposite end of the room stands Mr. Edison, telling the writer that there is no philosopher like Herbert Spencer, no writer like Victor Hugo, and no poet like Edgar A. Poe.

The Associated Press wires run through his laboratory, and anon he picks up his telephone and chats with Philadelphia, or with Prof. Barker, at the University of Pennsylvania. When visitors call to see him, they are most likely to inquire for Mr. Edison from the man himself—a boyish face, an unostentatious manner, a careless dress, and, in fact, the unchanged whole that formerly put in an appearance as the new man at the Boston office. The crowd of farm-boys that come over to see the wonderful talking-machine find him as ready to gratify their curiosity as the more pretentious "professor." While carrying on his manufacturing at Newark, he married, and—well, Dot and Dash are the nicknames of the little girl and boy that come every once in a while to "see the wheels go round."

We cannot here speak at length of his numerous inventions. He owns one hundred and fifty patents, but of these only about a dozen are of real value, the others are taken out to guard all approaches to the valuable patents. Among his pet patents are his quadruplex telegraphy, by which four messages may be sent at the same time over the same wire; his electric pen, for multiplying copies of letters or drawings, and which consists of a tubular pen in which a needle plays with a sewing-machine-like motion driven by electricity, which perforates the lines drawn with it, the perforated sheet being afterward inked and used in a press; the ink is pressed through the minute perforations and leaves on another sheet a finely-dotted tracing like the original. His carbon telephone and the phonograph are, perhaps, the most marvelous of his inventions.

When Mr. Gray brought out his musical telephone, which set students to experimenting in that direction, Mr. Edison was trying to improve the Reuss telephone, the invention of a German. Mr. Gray's apparatus gave promise of furnishing a method of multiplex telegraphy—a subject in which Mr. Edison, as we have seen, was interested. Between Mr. Gray and Mr. Edison an understanding was arrived at by which Mr. Edison was to leave Mr. Gray to carry out his invention unmolested in the direction of multiplex telegraphy; while Mr. Gray, on the other hand, would not interfere with Mr. Edison's attempt to make a speaking apparatus. While Mr. Edison had all but succeeded in making the electro-magnet telephone, Mr. Bell hit it and brought it out at the Centennial. Mr. Edison acknowledged himself fairly anticipated, and began to experiment with a view to finding a substance that would be elastic, so to speak, to the passage of a current of electricity—that is, whose resistance to a current would vary with pressure. He began at one end of his stock of chemicals and tried every one of them—some two thousand—but met with no satisfactory result. Finally, when everything was exhausted, and he was looking around for what next to try, an assistant brought him a piece of broken lamp-chimney with an incrustation of lampblack: this was scraped off, pressed into a little cake, and tried. He had at last discovered what he was in search of. By placing it between two plates of metal connected with the opposite poles of the battery, and making one of the plates large, to receive the force of sound-waves, this varying pressure would make the carbon cake more or less elastic to the passage of the current of electricity, and the invention of the transmitting part of a new telephone—all his own—was complete. For the receiving part nothing was necessary but an ordinary electro-magnet with a diaphragm. Experiments with this "carbon telephone," as it is called, are unfolding every day its marvelous sensitiveness, as shown in its microphonic manifestations, which have been exciting so much wonder. No less successfully is it being brought to measure the pressure caused by infinitesimal heat—for instance, that received by us from the stars.

Coming, lastly, to the phonograph: while experimenting on an automatic transmitter in the early part of last winter, Mr. Edison tried tin-foil, instead of paper, to receive the indentations of the Morse recorder, and was surprised to see how readily it received them. These indentations, passing under another needle, were to repeat the message automatically to another wire. A few days after, while handling a telephone, the fancy seized him to fix a needle-point to a diaphragm, and see whether the vibration of the diaphragm when spoken against would cause the needle to prick his finger. It did. Then he wondered what sort of an indentation this would make in a slip of paper. He tried it, and, sure enough, there was the semblance of an indented track! What would be the effect of drawing this slip under the point again, following the working of the automatic transmitter? He tried that, and the result was one which almost made him wild. A sound like the stifled cry of words seeking birth came from the diaphragm. No sleep or food until he had made a grooved cylinder, put a piece of tin-foil instead of paper on it, attached the diaphragm, and shouted into it, when, upon turning the crank, the words came back with a marvelous elocution, and the phonograph was a success.

Mr. Edison has recently received the honorary title of Ph. D. from Union College.

EDITOR'S TABLE.

RELIGION AND SCIENCE AT VANDERBILT UNIVERSITY.

IT is not yet three years since we published an abridgment of the address delivered by Dr. Deems at the inauguration of Vanderbilt University, in Nashville. The speaker chose "Science and Religion" as a subject befitting the occasion, and from his intimate relations with the founder of the institution, and the share he is supposed to have had in determining the arrangement, his discourse was regarded as in some sense official and authoritative in foreshadowing the spirit of its administration. Dr. Deems said: "This recent cry of a conflict between Religion and Science is fallacious and mischievous to the interests of both science and religion, and would be most mournful if we did not believe that in the very nature of things it is to be ephemeral. Its genesis is to be traced to the weak foolishness of some professors of religion, and the weak wickedness of some professors of science." From which it is to be inferred that Vanderbilt University, at all events, would lend no countenance to this mischievous fallacy.

We protested at the time against regarding a controversy that has raged for centuries, that goes down to the very roots of human belief, and that is now more widely and intensely discussed than ever before, as "ephemeral." And we likewise protested against that superficial view of the causes of this conflict which ascribes them to the foolishness of religionists or the wickedness of scientists. We said that the cause of the warfare must be sought in the relations of the two subjects, meaning thereby the progressive nature of scientific knowledge and the fixedness of religious belief. That which is advancing must come in collision with that which is stationary, if the latter stands in the pathway of the former. And there are but two possible ways of avoiding collisions: either the moving body must stop, or the stationary body must get out of the way. Science will not cease to advance with its work, come what may, and let who will be hurt. It cannot pause, it cannot compromise. Its business is the study of Nature; its object to find out the utmost truth. It points to the vast body of modern knowledge which it has established, and to the conquest of Nature which that knowledge has conferred, as witnesses to the validity and beneficence of its great tasks, and as a presage of further triumphs in the future. The command is often and loudly given to Science to halt, but it would be just as sensible to order the Gulf Stream to halt, or to stay the course of Nature itself. The only question, then, is, whether Religion will take its unyielding theology out of the way, or wait to have it crushed and cast aside. At any rate, nothing is more futile than to resolve the conflict between Religion and Science into a mere question of decorum, propriety, or temper, between the parties engaged.

But, though much remains to be done before this warfare terminates, great progress has undoubtedly been made toward a better understanding, and more pacific relations between the parties. The spirit of liberality has already become so strong among the more intelligent portions of the community that demonstrations of bigotry on the part of theological bodies are pretty certain to incur a general condemnation. It was therefore not without considerable surprise that we heard of the recent action of Vanderbilt University in repudiating the views of Dr. Deems's inaugural address. It has illustrated "the weak foolishness of some professors of religion" with a promptness and a shamelessness that shows how deep and intense is the living feeling of hostility to Science that animates large portions of the theological party. Vanderbilt University decides not to take its old traditions out of the way, but to fight the progress of Science by the same policy of bigotry, intolerance, and proscription, that has been employed for centuries by the same party in doing the same thing. The faculty of the institution have dismissed from his chair the Professor of Historical Geology and Zoölogy, on account of the opinions he holds concerning the antiquity of the human race.

The reader will find a notice in its place of Prof. Winchell's pamphlet on "Adamites and Preadamites," the publication of which has been made the occasion of his exclusion from the university. It will be seen that Prof. Winchell has simply accepted the views that now prevail in the scientific world regarding the time that men have inhabited the earth. The old notions upon the subject are now no longer entertained by intelligent men, because the scientific evidence is overwhelmingly against them. How long the human race has occupied the globe is an open question, but two things are settled: 1. That man has a much higher antiquity than theology has been in the habit of teaching, and has been currently believed; and, 2. That the investigation belongs entirely to science, and must be pursued and determined on the basis of scientific evidence. Prof. Winchell argues the subject strictly as a scientist, but in no spirit of antagonism to religion or to the authority of the Bible. His argument, indeed, is rather an attempt to harmonize the teachings of Scripture with the conclusions of science; a task which he had previously undertaken in a more general way, by the publication of an able book on "The Reconciliation of Science and Religion." But he has met with the not unusual treatment of peacemakers, who miscalculate the temper of the strife they would compose. The stupid Southern Methodists that control the university, it seems, can learn nothing. The fight over the antiquity of the earth has but just closed. The theologians battled long and fiercely against the geologists on this question, but have been so utterly routed that hardly a man of them can now be found who holds to the old belief. Prof. Silliman led the scientific movement upon that subject in this country, and so profound was the theological alarm that eminent doctors of divinity implored him with tears to desist from the impious crusade, because, if successful, it would be certain to destroy the Christian college with which he was associated. That institution had the good sense not to disturb the distinguished teacher in his work, but to abide by the results of investigation; and who can now be found so foolish as to regret its course? But half a century later, when an analogous question arises, Vanberbilt University adopts a different policy, follows the exploded precedents of past centuries, and puts forth its power to muzzle, repress, silence, and discredit the independent teachers of scientific truth.

There are features about this case that call for further strictures. The action of Vanderbilt University is not a little aggravating when we consider how the institution originated, and this consideration will throw some further light on the present phase of the conflict between Religion and Science. For there is a sense of honor in which it may be claimed that Mr. Vanderbilt's donations and endowments belong preeminently to science. How did he come by his wealth? It was by reaping the magnificent harvests of profit that had grown up from the toilsome and unselfish labors of men of science. He owed his fortune to the enterprising use of steamships and railways, which were made possible by the steam-engine, a machine produced by the scientific labors of many discoverers and inventors, accumulated through generations. Mr. Vanderbilt's millions were the ultimate but none the less direct consequence of the self-sacrificing exertions of men of creative genius, working in poverty, obscurity, and difficulty, with heroic devotion, to construct a mechanism which they saw was to become potent in the future, and which has fulfilled their anticipations by revolutionizing modern society and giving to civilization the greatest impulse it has ever received from any single agency. It is therefore by no means a piece of far-fetched sentimentality to claim that, when the results of their work had ripened to almost fabulous acquisitions of wealth, some portion of it, at least, should be devoted to the advancement of the interests of science. Of course, Mr. Vanderbilt had the right—the legal right—to do what he pleased with his money; but if we recognize any higher consideration, any sentiment of justice, if we assume that there are such things as moral indebtedness and obligations of honor in the distribution of surplus wealth for public objects, then was the great harvester of millions by steam-travel bound to do something liberal and fair for the encouragement and promotion of the great, beneficent work of scientific investigation, which issues in such large advantages to the world.

And this was the more incumbent upon the rich custodian of the fruits of inventive genius, because so little of the scattered wealth of the rich finds its way into these channels. It is here that we see science and religion in practical rivalry, with the almost universal defeat of science. When rich old men and old women are about to distribute their wealth and die, science has but a sorry chance, and the Church generally has its own way. Where a dollar is got in such cases for the promotion of the study of Nature, and the elucidation of those laws upon which the amelioration of the condition of humanity most vitally depends, thousands are obtained by the representatives of ecclesiasticism for the propagation of faith. Religious societies abound in wealth, and scientific societies starve. If there is a scientific society in New York that owns a roof for shelter we do not know of it; yet, if we rightly remember the figures of the census, $53,000,000 are invested in its churches. We refer to these facts simply to illustrate the preponderance of theological influence and agencies over those that are available for the service of science, and to show the disadvantage at which science is placed in the struggle for means to carry on its work.

But although some portion, at least, of the immense wealth of Mr. Vanderbilt was morally mortgaged to the use of that class of men by whom it was in reality created, we are not aware that he ever in the slightest degree recognized such a claim. Some hundreds of thousands of dollars, however, were got out of him to found a sectarian university. But, though Mr. Vanderbilt had no care for science, one would have thought that the trustees and faculty of the institution which he endowed might have gracefully acknowledged that something was specially and honorably due from them to the interests of science, and have shaped the policy of the university accordingly. They might, at least, have been decently up to the times in the spirit of its management. An old educational establishment hampered by traditions, and running in the deep ruts of long-settled habit, has some excuse, perhaps, for guiding its course by the illiberal precedents of the past; but Vanderbilt University was a new organization, opening fresh with the last quarter of the nineteenth century, and free to shape its course in full harmony with the enlightenment of the age. The spirit of the age and the progress of science, however, mean very little to the "weak foolishness" of the sort of Methodist theologians who have the institution in charge. They begin far behind the age, and are already old in bigotry and intolerance. They illustrate that hostility to science which belongs to low theological instincts, and now exhibit before the world the curious spectacle of an educational body into whose hands has fallen the wealth that the labors of scientific men have called into existence, and who use that wealth, not for the promotion and encouragement of scientific thought, but to hinder, defeat, and crush it.

AMERICAN INFLUENCE IN CIVILIZATION.

In his masterly discourse on "Civilization and Science," the second installment of which is herewith printed, Prof. Du Bois-Reymond refers to the question as to how civilization is to be measured, or by what tests we are to determine the height to which humanity has attained at any given time. Some say that this standard is furnished by the plastic arts, others by religion, others by literature, others by forms of government, and others by the diffusion of education. It will no doubt be a long while before parties entertaining different views upon this subject come to agreement; meantime, we hold, with the German professor, that the best criterion of the position which a nation has gained in the scale of civilization is the contributions which its men of thought have made toward the understanding and the conquest of Nature, and the popular and public appreciation that has been reached regarding this kind of intellectual labor. How does the community regard a man who gives his life to the investigation of the principles and laws, of the order of things, in the midst of which he finds himself placed, under the impulse, first of all, of the desire to know the truth, and, secondarily, to secure those large and benign results which come from the understanding of the method of Nature? What is the feeling entertained toward this class of men? Are they held in high honor, and encouraged in their labors, or are they treated with indifference, neglect, or contempt?

The question here is one of the degree of intellectual appreciation of different objects, and the relative intensity of the national feelings by which these objects are secured. In complex modern societies there will, of course, be found men devoted to different ideals, and a certain amount of popular favor or regard will be accorded to them all. But which of them receives the highest consideration, and what are the predominant national passions? Prof. Du Bois-Reymond, in considering the history of science in relation to civilization, calls our attention to the growth of the utilitarian spirit, which is gradually substituting immediate, practical, wealth-yielding studies for the more elevated, disinterested, and ennobling intellectual pursuits which have been cherished in past times. He points out that there is a decline of interest in this loftier work, under adverse pressures, that are increasing in intensity in the existing age, until they threaten the perversion and degradation of civilization itself. This influence he recognizes as strengthening in Europe, but as so predominating in this country that it is now generally known by the term Americanization. It is not so much that Americans are inappreciative of the real claims of liberal culture, or of the interests and requirements of scientific study, as that they are so overwhelmingly absorbed in material utilities that the finer and purer inspirations of study are dampened, smothered, and suppressed. There may be a verbal recognition of the high claims of science, and many compliments turned to its heroic devotees, but the real feeling is evinced in exclamations of wonder at the curious eccentricity of mind that can forego the solid advantages of working for wealth, and prefer mental occupations that lead to empty honor and certain poverty.

An historical illustration will perhaps bring out more clearly this view, which is now coming to be regarded as so peculiarly American. There lived in England, in the last century, a man of science, named Henry Cavendish, who was born in 1731, and died in 1810. He was a gentleman of fine cultivation, an excellent mathematician, a profound electrician, and a most acute and ingenious chemist. He published many papers, containing results of recondite investigations and the most important discoveries. He was not only a great original thinker, but a most indefatigable and accurate experimenter, and one of his main lines of research was the chemical constitution of the atmosphere. He made no less than 500 analyses of the air, and it is to him that we owe our chief knowledge of the composition of the breathing medium. Now, there is not an American that will not commend all this as most proper and admirable. But there is another side to the case. Henry Cavendish was a man of enormous wealth, for which he cared absolutely nothing. He was one of the greatest proprietors of stock in the Bank of England, and when on one occasion his balance had accumulated to $350,000, and the directors, thinking it too much capital to lie unproductive, asked him if they should not invest it, he simply replied, "Lay it out, if you please." That small portion of his wealth which he could make use of in his investigations was so used, but he did not allow the remainder of it to divert his thoughts in the slightest degree from the unremitting prosecution of his scientific labors. He died worth $7,000,000, which was an immense sum of money at the beginning of this century, but he had not the slightest interest in those objects for which wealth is generally prized. Now, the whole case being given, to the eye of the typical American, Henry Cavendish will be regarded as a fool. "With all that money," the representative American would say, "I could keep a yacht, and a stud of fast horses, and build a church, and endow a college, and send a dozen missionaries to the heathen, and run a whole political campaign at my own expense; and you say this odd creature actually spent life in the smudge and stenches of a chemical laboratory, puttering with gases, and worried about the composition of the air!"

We do not here exaggerate the vulgar passion of Americans for money, and their relative and consequent indifference to other things. The country does not breed Cavendishes, and, if one should appear, he would stand a first-rate chance of getting into a lunatic asylum, as the bare fact of his indifference to riches would be held as *prima-facie* evidence of an unsound mind! The science that gives promise of immediate results, that can be turned into money, is appreciated; that which aims only at the extension of scientific truth wins little support. Prof. Tyndall devoted the profits of his lectures in this country, all the results of six months' labor, to assist in promoting the education of such young men as possess a talent for physical researches, and wish to qualify themselves for pursuing the work. It was a noble object, and one that had been nowhere provided for. Prof. Tyndall did not propose to found a school of research, but to help young men to avail themselves of the best institutions already existing for the acquisition of a special culture, the culture needed to carry on successful original inquiries. There have been many applications to the trustees of the Tyndall fund for aid to young men of genius and aptitude for research, which, if it could have been granted, would have given them a career, and told in the most effectual way toward the extension of scientific knowledge. But the sum consecrated by Prof. Tyndall to this important end was not adequate to the wants of a nation. It was a large gift for a scientific professor without wealth, and, by the wise directions of the donor, it will be productive of large and lasting good, but it was given also to call emphatic attention to a neglected field of education, well worthy of the consideration of generous persons who desire to be certain that their benefactions will be well directed and confer real benefit. We do not say that Prof. Tyndall desired to set an example to anybody, but only that he contributed what was in his power to give an impulse to science in this country in a direction that was most needed; but how little Americans care for the object he had in view is shown by the fact that, amid all the multitudinous donations, gifts, and squanderings of wealth, on all sorts of objects, not a dollar has yet been added to the Tyndall fund for the promotion of scientific research by helping to train capable and ambitious young men for the work!

The country is characterized by the mad pursuit of wealth and the worship of riches; but this is not the worst, for along with this sordid passion there go the most vulgar and ignoble ideals of the uses of wealth. That ignorant, low-minded men, who become millionaires by inheritance or speculation, should spend their money in tawdry ostentation is to be expected; but the worst is, that gentlemen of sobriety, cultivation, and earnestness of character, who have large means at their disposal, should bestow them in charities that often do more harm than good, or in endowing professorships or building institutions that give notoriety to their names, and are of but little other use. Meantime, the country stands arraigned before the world for its lack of interest in those higher developments of thought which have given origin to civilization, and for giving their most powerful impulse to tendencies which threaten the deterioration of society and the degeneracy and debasement of civilization itself.

THE LATE MR. GEORGE S. APPLETON.

Since the appearance of the last number of this magazine, one of the company of brothers by whom it is published has passed away. Most of our readers have, no doubt, been informed by the newspapers that Mr. George S. Appleton died July 7th, at the age of fifty-seven. His unexpected death has been a painful shock to the relatives and intimate friends, by whom he was much beloved, and who are now left with only the consolatory memory of his many excellences of character. A few memorial words in regard to him will be appropriate in this place.

Mr. Appleton was a gentleman of marked mental accomplishments, such as are but rarely met with in the common walks of practical life. He was liberally educated, his early tastes and aptitudes for study being favored by attendance upon the best schools at home, and more completely developed by a four years' course at a German university. He was a wide and careful reader, but, as he designed to devote himself to the publishing business, he was specially interested in lingual studies, being a critical student of English and a master of the German, French, and Italian languages. He also gave early and prominent attention to the subject of art, was familiar with its history, and a discriminating critic in several of its principal departments.

But, though a man of refinement, of elegant culture, and fastidious tastes, Mr. Appleton did not allow æsthetic feeling to narrow his nature, or to impair his interest in the more robust and solid work of modern science, and in those broad and serious inquiries which characterize the present age. He read with appreciation and heartily welcomed those powerful contributions to the advance of modern thought which have so deeply impressed the mind of our time, and which the house to which he belonged has done so much to make familiar to the reading public of this country. Never forgetting as a business-man that books are made to be sold, he also never forgot that they are the great means of popular enlightenment and elevation, and that publishers have a duty to society in respect to the character of the works which they disseminate.

It is, moreover, proper to remark here that Mr. Appleton was a man of deep and sincere religious feelings, and earnestly devoted to the duties of Christian worship; but his faith was too settled and serene to suffer any disturbance from that onward movement of knowledge which is so apt to excite alarm in men of restricted views and less firmness of religious conviction. Mr. Appleton illustrated in an eminent degree that largeness of sympathy and breadth of thought by which pure religious devotion is harmonized with intellectual progress, and with an intelligent solicitude for the amelioration of the secular interests of mankind. Conservative in disposition and habits, and no enthusiast, he was still much interested in all rational social improvements, and his influence was thrown in favor of every measure that can exalt and purify the public taste, and diffuse sound and useful information among the people. We are happy to add that he was a regular and critical reader of The Popular Science Monthly, cordially approving its distinctive objects, and frequently favoring its conductors with valuable and important suggestions.

Mr. Appleton was a man of quiet and retiring manners, sensitive and modest to a degree that was often misinterpreted into coldness of nature; but those who knew him well understood that beneath a reserved and unobtrusive exterior there beat a warm heart that was ever animated by a kindly solicitude for the welfare of all who came within the reach of his influence. Although strict in the administration of business, he was watchful for those who needed care and encouragement, and many of his employés bear grateful testimony to his wise and kindly forethought in circumstances where the ministrations of genuine friendship are invaluable. The character of the man in his intercourse with his associates is well summed up by the remark of one who had been long and closely connected with him, that "his good words without flattery, and his honest comments without circumlocution," always inspired respect, confidence, and the truest esteem.

LITERARY NOTICES.

Adamites and Preadamites, or a Popular Discussion concerning the Remote Representatives of the Human Species and their Relation to the Biblical Adam. By Alexander Winchell, LL. D. Syracuse, N. Y.: John T. Roberts. Pp. 52. Price, 15 cents.

This pamphlet is as readable as it is instructive. It is spicy in style, meaty in matter, and straightforward in its logic. As an introduction to the study of the antiquity of man, with an important side-bearing upon the old doctrines that have been entertained upon the subject, it is decidedly the best thing that we have met with. The discussion was originally contributed by Prof. Winchell to the *Northern Christian Advocate*, and now appears in ten chapters, the scope of which is indicated by their titles, as follows: Chapter I., "A Sagacious Dutchman;" II., "Dispersion of the Noachites;" III., "The Black Races not Adamites;" IV., "The Negro preadamic;" V., "The Negro preadamic"—continued; VI., "Scheme of Prehistoric Times;" VII., "Retrospective of Primeval Man in Europe;" VIII., "Antiquity of Man;" IX., "Origin of Man;" X., "Patriarchal Chronology."

It will be gathered from these heads of his arguments that Prof. Winchell is considering the question of man's antiquity upon the earth from the point of view of the common Christian belief that the whole human race is descended from the Scripture Adam. This he denies, affirming that the black races have a much higher antiquity than the period to which Adam is historically assigned, and who, in so far as he was a progenitor of races, must be regarded as only the father of the white or superior races. In the first chapter, entitled "A Sagacious Dutchman," Prof. Winchell calls attention to a small book that appeared in Paris in 1665, written by a Dutch ecclesiastic, named La Peyrère, on the unheard-of subject, indicated by its title of "Præadamitæ." Prof. Winchell says that La Peyrère was the first to promulgate to the world the idea of preadamite men. Of course, the sciences of ethnology and anthropology were at that time unknown, and the inquiry was therefore conducted entirely as a theological one—all questions being Bible-questions, and the meaning of the Bible being extracted according to the canons of grammar. The case was strongly made out by the Dutch doctor, and, although it could be argued in no other way at the time, Prof. Winchell takes occasion to characterize the method because there are plenty of learned men with whom it is still in vogue. Upon this point he says:

"There are doctors high in authority among us at this day, who maintain that grammatical structure and Hebrew usage are sufficient to light the way to the meaning of the darkest passages of revelation. I suppose a knowledge of Hebrew history and usages is admitted to shed its light upon interpretation, because the text is generally occupied with Jewish affairs. But the inspired writers have sometimes plunged into the midst of the profound and mysterious facts of science; why not, then, summon *all our knowledge* to the task of evoking the meaning of the text? I maintain, against the narrow and pernicious dogma that the Bible is sufficient everywhere to interpret itself, that, on the contrary, it was ordained to be interpreted under the concentrated light of all the learning which has been created by a God-given intelligence in man. I believe that the Bible was written for all time, and that its meaning is so deep and so rich that the accumulated learning of the latest generation of men will be unable to exhaust it."

Prof. Winchell then proceeds to discuss the question on its purely scientific basis, or in the light of modern facts, as disclosed by ethnological and archæological research. He concludes that the profound divergency of the races of mankind, as now known, and the demonstrated divergency that had been reached in the earliest historic periods, make the conclusion impossible that, if all the races of men had one origin, that origin can be brought within anything like the usually assigned period of six thousand years. Scientific evidence "forces this alternative conclusion upon us. If human beings have existed but six thousand years, then the human races had *separate beginnings*, as Agassiz long since maintained—each race in its own geographical area. But if all human beings are descended from one stock, then the starting-point was *more than six thousand years back*, as Huxley and the evolutionists generally maintain, and the Duke of Argyll and other anti-evolutionists equally maintain."

"Now, every person remains free to contemn a logical difficulty, and commiserate the unfortunate facts for being opposed to his belief. But my training has been such that logic and facts still command a degree of respect. Nor am I enough of an actor to play the part of an idiot. If I can avoid a difficulty I shall not dash ont my brains against it. Let us consider Adam the father of the white and dusky races. These, then, are Adamites; and have a chronology extending back about six thousand years—perhaps all the time we require. The black races, then, are preadamites; and there is no objection to allowing all the time requisite for their divergence from some common stock. This view recognizes the unity of man—the possession of 'one blood' by all the races, one moral and intellectual nature, and one destiny; it recognizes Adam as the progenitor of the nations which form the theme of biblical history; it explains sundry biblical allusions and implications—for instance, the wife found by Cain in the land of Nod; Cain's fear of violence from others when condemned to the life of a 'fugitive and a vagabond;' the antithesis of the 'sons of God' and the 'daughters of men;' it validates the biblical chronology; it satisfies the demands of facts. The only objection outstanding against this view is the authority of an opinion formed two or three thousand years ago, by men who also held the opinion that witches ride broomsticks through the air, and that the stars were created two days before Adam, though some of them are so distant that their light has been a hundred thousand years in reaching us!"

Prof. Winchell, of course, takes the ground that the older or black race is of an inferior type to the subsequent or, as he calls them, the Adamic races; and to the objection that the negro is not inferior to the white man he makes the following reply:

"1. If, when the sun is shining brightly, a man tells me it is dark, I can only pronounce him blind. The inferiority of the negro is a fact everywhere patent. I imply here only inferiority of intelligence, the instrument of self-helpfulness and of all civilization. I need not argue the fact; *circumspice*. But when this inferiority is conceded, we always hear the appeal to 'unfavorable conditions.' This leads me to note, 2. The African Continent has always been *favorably* conditioned. In the first place, it had a land connection with Asia and the seats of ancient civilization. It even had a remote civilization planted within its own borders; and the fires of Egyptian civilization have never been extinct; while for two thousand years the enlightenment of Europe has been within accessible distance. In the second place, the salubrity of the climate, the fertility of the soil, the vast hydrographic system of lakes and rivers, have all conspired to give the interior of the continent natural conditions unsurpassed by those of the site of any civilization which ever existed. Thirdly, the indigenous productions of Africa have supplied other conditions of human advancement. There exist two native cereals, negro millet and Caffre corn, which supply material for bread. There are the edible 'bread-roots' and also 'earth-nuts,' which are adequate to supply the daily food of whole villages. As to fruit-trees, there are the doom-palm, the oil-palm, and the 'butter-tree.' Moreover, for thousands of years the way has been open, as wide as the continent, for the introduction of the cereals of Asia. In fact, they have long been known to the natives; and maize, the manioc-root, and sugar-cane, as well as wheat and barley, have spread far toward the interior. There, too, have been domesticated animals, received, probably, from the Egyptians in a domesticated state; but no native animal has ever been domesticated. The Aryans of India employed the elephant as a beast of burden; but the African elephant was never utilized. These are not the conditions under which a whole race could be crushed into a process of degeneracy. 3. Comparison with other races shows the negro's inferiority. The Egyptian civilization was reared on the African Continent by the side of the barbarous negro, and under the same conditions. If the materials of civilization were introduced from Asia, it was certainly easier for the negro to introduce them from Egypt. America is not naturally superior in its physical conditions to Africa. Its only cereal is maize. Its principal edible roots are the mandioca and the potato; and the feeble llama and vicuna are the only native animals capable of domestication as beasts of burden. Yet the civilization of the Nahuatl nations of Mexico, the Quiches of Central America, the Mayas of Yucatan, and the Aymaras and Quichuas of Peru, had become, both in respect to intellectual and industrial advances, and judicial, moral, and religious conceptions, almost a stage of true enlightenment. The glaring fact of negro inferiority in respect to social conditions cannot be explained by any appeal to adverse conditions. Such are the ethnological facts and the coördinated circumstances. But in proof of my position I make another point: 4. The anatomical structure of the negro is inferior. The lean shanks, the prognathous profile, the long arms (which do not always exist), the black skin, the elongated and oblique pelvis—these are *all* characteristics in which, so far as the negro diverges from the white man, he approximates the African apes. The skull also is inferior in structure and in capacity, and in the relative expansion of its different regions. Among whites, the relative abundance of 'cross-heads' (having permanently unclosed the longitudinal and transverse suture on the top of the head) is one in seven; among Mongolians, it is one in thirteen; among negroes, it is one in fifty-two. This peculiarity is supposed by some to favor the prolonged development of the brain. In any event, it is most frequent in the highest races. Again, the prevailing form of the negro head is dolichocephalous; that of civilized races is mesocephalous and brachycephalous. That is, it lacks the breadth which we find associated with executive ability. The broadest negro skull does not reach the average of the Germans, nor does the best Australian skull, let me add, reach the average of the negro. Finally, the capacity of the negro cranium is inferior. Assuming 100 as the average capacity of the Australian skull, that of the negro is 111.6, and that of the Teuton 124.8. Now, no fact is better established than the general relation of intellect to weight of brain. Welker has shown that the brains of twenty-six men of high intellectual rank surpassed the average weight by fourteen per cent. Of course, quality of brain is an equally important factor; and hence not a few men with brains even below the average have distinguished themselves for scholarship. But this does not abolish the rule; nor does it prove that the racial inferiority of the negro brain, in respect to size, is not to be taken as an index of racial inferiority in respect to intelligence and the capacity for civilization; and this all the more, since the quality of the negro brain is also inferior.

"I am not responsible for the inferiority of the negro. I am responsible if I ignore the facts. I am culpable if I hold him to the same standard as the white man. My appeals to him must be of a widely-different character from my appeals to the Aryan Hindoo, or the Mongoloid American savage. The ethnological facts have their application in all missionary efforts."

Of the subsequent discussion on "Primeval Man in Europe," and "The Antiquity of Man," we have no room to speak. Prof. Winchell deduces a general view, which harmonizes all the phases of evidence, and though contravening the old traditions, must be accepted in proportion as men esteem truth to be more desirable than error. He says:

"This scheme of prehistoric times, embracing only a few conjectural features, weaves in all the facts of history and science. If it traverses old opinions, we need not mourn. New truths are better than old errors. Fact is worth more than opinion. Certainty is more desirable than confidence. Progressive knowledge implies much unlearning. The loss of a belief, like the death of a friend, seems a bereavement: but a false belief is only an enemy in a friend's cloak. It is only truth which is divine; and, if we embrace an error, we shall not find it ratified in the oracles of divine truth. We who hold to the valid inspiration of the sacred records may feel assured that nothing will be found affirmed therein which collides with the final verdict of intelligence. Nor has the color of the first man any concern with a simple religious faith. If our creed embodies a dogma which enunciates what is really a conclusion, true or false, based on scientific evidence—that is, evidence brought to light by observation and research—that may be exscinded as an excrescence. All such subjects are to be settled by scientific investigation—not by councils of the Church. Ecclesiastical faith has had a sorry experience in the attempt to sanctify popular opinions. A faith that has had to surrender the geocentric theory and the denial of antipodes, and of the high geological antiquity of the world, should have learned to discriminate between religious faiths and scientific opinions. Religious faith is more enduring than granite. Scientific opinion is uncertain; it may endure like granite or vanish like a summer cloud. Religious faith is simple, pure, and incorruptible; scientific opinion is a compound of all things, corruptible and incorruptible. Let us not adulterate pure faith with corruptible science. An unadulterated faith can be defended by the sturdiest blows of reason and logic; a corrupt faith puts reason and logic to shame."

Principles and Practice of Teaching. By James Johonnot. New York: D. Appleton & Co. Pp. 395. Price, $1.50.

As it is now the latest, so Prof. Johonnot's new work on education is undoubtedly the best manual of school guidance that has yet been prepared. It is better adapted to the present condition of educational progress than any other teachers' manual that we have yet seen. Two things have come prominently forward in the recent development of thought with reference to the work of instruction: 1. Science is gaining a more liberal recognition in our courses of study, and is more and more coming to be the chief thing; and, 2. Teachers are compelled to give more attention to psychological science as an indispensable prerequisite to the intelligent management of school-work. There is still need enough for advancement in both these directions, for there are plenty of schools that are hardly beyond the middle ages in their appreciation of science, and plenty of teachers who are as ignorant of the laws of mind as the untutored savage. But these considerations are surely though slowly emerging into confessed prominence, and are beginning to take that controlling position in the philosophy of education which is bound to be universally conceded to them in the not very distant future.

Prof. Johonnot is by no means a blind admirer of things established in our educational systems. He clearly sees that the whole subject is in movement, that in many respects current education is profoundly imperfect, that a critical spirit widely prevails in regard to it, and that there is plenty of work for reformers in bringing the general practice into harmony with principles that have been definitely worked out. He is not only a practical educator of large experience in the special work of training teachers, but he has his independent views of what is needed, and how to attain it; and his work will accordingly be found fresh, suggestive, and stimulating, to all teachers and school officials who are devoted to organizing and carrying out the best plans of instruction. That he has reached anything like a finality in the policy of school management he would be the last to claim; but we must cordially concede to him the merit of having grasped the problem of practical culture in its latest exigencies and newest developments. In a growing and unfolding subject, methods must be tentative and proximate: it is enough if they are better than their predecessors. Prof. Johonnot has well digested for us the latest theoretical wisdom regarding the principles of teaching, and he has embodied these in an improved system of practice, which has stood the test of experience. Having unfolded the general principles of culture in the earlier and chief portions of his work, the author devotes the last hundred pages to laying down courses of study, general and special. This is the constructive part, which is ever the most difficult and liable to criticism, because of its conflict with preëxisting habits; but there can be no doubt that this portion of his volume involves a marked advance on previous practice. We have seen no popular scheme of study in which Nature is so confessedly the groundwork on which the whole fabric of mental cultivation is to rest, and in which science is so intimately interwoven with the constant course of school-work. Hitherto, scientific studies have been too much looked upon as secondary, intrusive, and to be superinduced upon a preëstablished scheme; they are here made the starting-point, and incorporated in the plan of studies as an essential and fundamental element. In thus contributing to the better organization of school exercises, this book meets an urgent need of the times which cannot fail to be appreciated by many teachers.

The Psycho-Physiological Sciences and their Assailants: Being a Response by Alfred R. Wallace, of England; Prof. J. R. Buchanan, of New York; Darius Lyman, of Washington; Epes Sargent, of Boston, to the Attacks of Prof. W. B. Carpenter, of England, and Others. Boston: Colby & Rich. Pp. 216.

This is the counterblast of the spiritualists against the lectures of Dr. Carpenter on spiritualism, mesmerism, etc. For three hundred years the devotees of scientific knowledge have been laboring to disentangle the natural from the supernatural, which had previously been so mixed up in the traditions of learning that "Nature," as a system of uniform and verifiable laws, was unknown. The progress of science has, in fact, consisted simply in tracing out and giving expression to these regularities and uniformities of the natural world. The spiritualists go back on all this, and declare it to be a false process and a spurious progress. They claim that the supernatural is to be included in the natural, and aver that they can investigate it and work out its laws so that they shall be a part of proper and legitimate science. They maintain, indeed, that they have already done this; but the difficulty is, that the whole scientific world denies it. Nor is there the slightest prospect that they will be able to convince scientific men of the validity of their claims on the basis of anything as yet accomplished. What they may do in the future we shall not presume to say; but we think they will have to be content to go on working out such results as they find possible, and trusting to time for that recognition which they so vehemently demand shall be accorded to them now. They make much complaint of the inhospitality of the scientific mind to what they call new truth, and this complaint we consider as wholly groundless. Prejudices, no doubt, arise from intense preoccupation in special lines of scientific labor, so that the physicist, for example, fails in appreciation of the biologist, while the chemist is indifferent to the work of the sociologist; yet in these diverse and widely-separated departments there is still sufficient liberality of spirit to leave all investigators unmolested in their special work. Why should the spiritualists wax wroth and imprecate Science and scientific men, because they will not drop their own researches and come over to help exploit the wonders of the preternatural sphere? If they cannot appreciate such marvelous things, why not leave them with due commiseration to wriggle and squirm in their congenial materialistic mud? Let the spiritualists go on and get out something worthy of attention, and it will be sure to get attention in due time.

The Native Flowers and Ferns of the United States, in their Botanical, Horticultural, and Popular Aspects. By Thomas Meehan, Professor of Vegetable Physiology to the Pennsylvania State Board of Agriculture, Editor of the *Gardener's Monthly*, etc. Illustrated by Chromo-lithographs. Boston: L. Prang & Co. Pp. 16. Fifty cents per number.

Botanical works with good colored illustrations have hitherto been far too expensive for general use; but the perfection now attained in the art of chromo-lithography makes possible a new departure in pictorial botany. The series now projected, the first two numbers of which are before us, show that a very considerable degree of fidelity and naturalness in the representation of flowers is already secured by the chromo-lithographic process, and we may safely assume, from the skill and enterprise of the publishers, that they will attain still greater perfection as the work proceeds. Its editorial management is in the very best hands. Mr. Meehan is the conductor of the principal garden magazine of the country; and his thorough familiarity with botany, and his long practical acquaintance with horticulture, qualify him in a peculiar manner for the management of such an enterprise as this. The work will, therefore, combine great beauty of execution in the colored illustrations with a careful, trustworthy, and judicious text. Accompanying each plate there is a brief technical description, and three or four pages of general information in regard to the plant in question, its genus, geographical distribution, and mode of growth. The work is not offered as a complete illustrated flora of North America, the extent and expense of which would put it beyond popular reach, and prolong its publication for many years. Its scope is therefore limited to a selection of the most beautiful and interesting native flowers and ferns of the United States, preference being given to those most worthy of cultivation and available for garden decoration. After speaking of the difficulty of preparing a thoroughly systematic scientific work on the American flora, the editor remarks:

"It must not be inferred from this, however, that the present work is absolutely without system. It will be seen that the selection made for these two volumes covers a wide range of country, and offers a number of representatives of leading genera, chosen with reference to their various habits and to different geographical centres. These volumes are therefore absolutely complete in themselves, and may be said to give a good general idea of the floral wealth of our country. Those who are satisfied with the knowledge thus obtained may rest here. But it is hoped that the more enthusiastic lovers of flowers will welcome the succeeding volumes, which it is proposed to publish after the conclusion of this series. Each of the following series is also to consist of two volumes, and to form a complete whole by itself."

In the preparation of the work Mr. Meehan has had the important advantage of freely using the unrivaled facilities of the botanical garden at Cambridge, which he cordially acknowledges, as also the assistance kindly given him by various eminent botanists. The work is elegant, attractive, and meritorious, and we think it is certain to have a large patronage.

Experimental Science Series for Beginners. II. Sound: A Series of Simple, Entertaining, and Inexpensive Experiments in the Phenomena of Sound, for the Use of Students of Every Age. By Alfred Marshall Mayer, Professor of Physics in the Stevens Institute of Technology. New York: D. Appleton & Co. Pp. 181.

The second volume of this admirable series of books is now published, and its author is to be congratulated for more than fulfilling the promise of the opening volume. No less than one hundred and thirty experiments in sound are given, all of which are original in the simplified means by which the effects are produced. They, moreover, cover the whole ground of acoustics in so complete a manner that the pupil who goes through the volume, making all the experiments, will get an actual and living knowledge of the science, such as he can never acquire by reading any number of larger works. A list of apparatus to be used in the experiments on sound is given at the close of the volume, and can be purchased complete at the cost of $27.50. But, as Prof. Mayer remarks in the preface, "the student may find it cheaper to hunt up the materials, and then make his own apparatus; but so many have desired to have the sets ready for use, that I have complied with their request. Of course, it will be understood that the instrument-maker must be paid for the time taken in finding the objects in the market, and for the labor and skill spent in making the apparatus, and in packing it in convenient boxes."

Matter and Motion. By J. Clerk Maxwell, M. A., LL. D. New York: D. Van Nostrand. Pp. 224.

This monograph, by the eminent physicist and professor of Cambridge, is one of the best things that have yet appeared in Van Nostrand's "Science Series." Like everything from Clerk Maxwell, it is clear, and, although the general treatment of dynamics is mathematical, there are many valuable definitions and much information in the book that will be available for the general reader

Comparative Psychology; or, The Growth and Grades of Intelligence. By John Bascom. New York: G. P. Putnam's Sons. Pp. 291. Price, $1.50.

This small but thoughtful volume deserves to be very cordially commended to the students of psychological science. Though a controversial work, it is free from narrowness and the usual effects of partisan discussion, and it is written by a thinker who can appreciate views with which he disagrees, and freely acknowledges his indebtedness to the party with which he is, nevertheless, at radical issue. Of the two great schools of philosophy, the intuitional and the empirical, one holding that mental faculties are immediate *a priori* gifts to intelligent creatures, and the other that they are results of development through experience, the author of this volume holds with the first; but he acknowledges that it has been written to elucidate problems and carry out inquiries "that would hardly have been suggested but for the empirical philosophy." The object of the book is admirably stated in the following extract from the author's preface:

"The advocates of the empirical philosophy are wont to criticise the intuitional philosophy in two respects: first, as overlooking the relation between the mature mind and the mind of the infant—between rudimentary and developed powers; and, second, as overlooking the still more important connection between the intelligence of to-day and that of remote previous periods, between the intelligence of man and that of animals, and of the earlier human life from which it has been derived We grant these points to be well taken, especially the latter. Without tracing the history of intelligence, we are not prepared to decide what is primitive and what is acquired; what is original material and what is the deposit of growth. The empiricist cannot be fully and fairly met without traveling with him these spaces of evolution, and determining at least their general facts and laws. This I have undertaken in the present volume. It is my purpose to test the nature and extent of the modifications put upon human psychology by its relations in growth to the life below it; and, in doing this, to reach a general statement of each stage of development."

A philosophical writer of our time could hardly occupy himself with a more pertinent problem than is here presented. It has been the reproach of the *a priori* method that it has ignored the subject of mind in its lower or comparative manifestations. It has neither worked from the base of fundamental organic conditions, nor has it systematically recognized them, and for this reason the method was probably losing its hold upon the scientific mind of the period. Clearly aware of this deficiency, Dr. Bascom has addressed himself to the task of supplying it, and his book will do much to rescue the subject from the reproach into which it had fallen.

Wisconsin Geological Survey. Report for 1877. By J. C. Chamberlin, Chief Geologist. Madison: Atwood print. Pp. 95.

The survey of Wisconsin is now completed, and the results will soon be in readiness for publication. The final report will form three volumes, with maps, of which one volume, with atlas, has already appeared. During the season of 1877, eleven surveying parties were in the field. The survey suffered a serious loss by the accidental death of Mr. Moses Strong, an enthusiastic young mining engineer, of brilliant attainments, who lost his life by the capsizing of his canoe while ascending the rapids of the Flambeau River.

State Regulation of Vice: Regulation Efforts in America. The Geneva Congress. By Aaron M. Powell. New York: Wood & Holbrook. Pp. 127. Price, $1.

Mr. Powell does not believe in the state regulation of vice, and gives his reasons in this book. The subject is considered from the point of view of the philanthropist and reformer, rather than from that of social science.

Mineralogy. By J. H. Collins, F. G. S. With 579 Illustrations. New York: G. P. Putnam's Sons. Pp. 206. Price, $1.50.

This little manual is remarkable for the profuseness and neatness of its crystallographic illustrations. It is designed for practical working miners, quarrymen, field-geologists, and the students of the science classes in connection with the department of science and art in England.

Geographical Surveys west of the 100th Meridian, in Charge of Lieutenant G. M. Wheeler, Engineer U. S. Army. Part II., Vol. IV. Paleontology. Letter-press, pp. 365, with 83 Plates. Washington: Government Printing-Office.

The present installment of Lieutenant Wheeler's Report consists of a memoir, by

E. D. Cope, on extinct vertebrata from New Mexico. The fossils here described and determined represent four geological periods, in basins that had not previously been explored, viz., the Trias, the Eocene, the Loup-Fork Epoch, and the Postpliocene of the Sandia Mountains. The first vertebrate fossils ever determined from the Trias of the Rocky Mountains are included in this memoir. Of the high intrinsic value of Prof. Cope's work there is no need for us to say anything: his memoirs on the paleontology of our Western Territories are authoritative documents throughout the world of science. But we cannot refrain from commending the truly admirable lithographic plates by which the text is illustrated and adorned.

The Future of Sanitary Science. An Address before the Sanitary Institute of Great Britain. By B. W. Richardson, M. D. Macmillan & Co. Pp. 47. Price, 25 cents.

Dr. Richardson has become the prophet of our sanitary future, and discourses of its prospects in this pamphlet in his peculiar style. He does not fail to magnify his calling, and presents its claims in a quite extraordinary way, saying: "All political troubles have a physiological cause. To the statesman not less than to the physician, physiology is the only true source of knowledge. A society such as ours, therefore, possessing as it does professed physiological skill, may render most important service by tracing out for the legislator the simplest scientific means for removing atmospheric impurities, and by preparing for that sanitary future when men universally shall breathe purity even with their freedom."

Cerebral Hyperæmia: The Result of Mental Strain or Emotional Disturbance. By William A. Hammond, M. D. New York: G. P. Putnam's Sons. Pp. 108. Price, $1.

This is a very important little monograph by an eminent medical authority, who has had large special experience in all that pertains to morbid conditions of the brain. The reason for and character of his little book are thus well represented by the author in his preface:

"The disease which is considered in the ensuing pages is more common, according to my experience, than any other affection of the nervous system. It is especially an outgrowth of our civilization, and of that restless spirit of enterprise and struggle for wealth so characteristic of the American people. It is an easily preventable disorder, not for this purpose requiring extensive hygienic operations, but simply the acts of the individual in using his or her brain with the same regard for its well-being as is ordinarily extended by the humane carter to the muscular system of his horse. The brain of man is strong: it will endure a terrible amount of ill-usage; but there are limits to the abuse which may be inflicted upon it with impunity, and few there be who do not pass them.

"It is, perhaps, too much to expect the emotions to be entirely under the control of the individual, nor is it desirable that we should be reduced to the condition of intellectual automata, moved always by reason and judgment, and never by feeling. But it is entirely within the power of every one, by that self-discipline so seemly in all, to obtain such a degree of mastery over unworthy or excessive passions as will prevent them dominating over the whole mind and body, to the detriment of both.

"Ill-regulated emotions are even more prolific of brain-disorders than severe mental labor, and many a person considered to be suffering from what is called nervous prostration or exhaustion is simply the subject of emotional disturbance and a consequent condition of cerebral hyperæmia."

First Principles of Agriculture. By Henry Tanner, F. C. S. New York: Macmillan & Co. Pp. 95.

This is a very good little summary of elementary scientific facts and principles relating to agriculture. The difficulty about it is that it is too small—a mere primer; but those who want an introduction to the subject, to be followed by the use of larger works, will find it serviceable. Scientific agriculture, from the complexity of all its problems and the obscurity of many of them, requires to be studied with some thoroughness, in fact to be mastered, before it can be made practically and safely available.

A Dictionary of Music and Musicians. Edited by George Grove, D. C. L. Vol. I., Part II. New York: Macmillan & Co. Pp. 127. Price, $1.25.

The second number of this elaborate work is now ready, and its topics range from Ballad to Boïeldieu. Its character is well sustained, and the admirable sketch of Beethoven, with the analysis of his music, is alone worth the price of the work.

PUBLICATIONS RECEIVED.

Elements of Dynamic. Part I. Kinematic. By W. K. Clifford. London and New York: Macmillan. Pp. 230. $2.50.

The Speaking Telephone, Talking Phonograph, and other Novelties. By G. P. Prescott. New York: D. Appleton & Co. Pp. 431. $3.

Physics of the Infectious Diseases. By Dr. C. A. Logan. Chicago: Jansen, McClurg & Co. Pp. 212. $1.50.

A Course in Arithmetic. By F. W. Bardwell. New York: Putnams. Pp. 166.

Physical Technics. By Dr. J Frick. Philadelphia: Lippincott. Pp. 467. $2.50.

Visions: A Study of False Sight. By Dr. E. H. Clark. Boston: Houghton, Osgood & Co. Pp. 333. $1.50.

Report on Forestry. By F. B. Hough. Washington: Government Printing-Office. Pp. 650.

Manual of the Apiary. By Prof. A. J. Cook. Chicago: T. G. Newman & Son. Pp. 286. Paper, $1 cloth, $1.25.

Annual Record of Science and Industry. By S. F. Baird. New York: Harpers. Pp. 494. $2.

The Ethics of Positivism. By G. Barzellotti. New York: Somerby. Pp. 327. $2.

Ferns of Kentucky. By J. Williamson. Louisville: J. P. Morton & Co. Pp. 154. $2.

Sequel to "Essays." By C. E. Townsend. New York: Somerby. Pp. 102.

Practical Chemistry for Medical Students. By M. M. P. Muir. London and New York: Macmillan. Pp. 64. 60 cents.

Report of the Ohio Commissioner of Common Schools. Columbus: Nevins & Myers print. Pp. 384.

Report of the Wisconsin Board of Health. Madison: Atwood print. Pp. 200.

The Railway in its Relation to Public and Private Interests. By Simon Sterne. New York: Press of the Chamber of Commerce. Pp. 38.

Chronic Aural Discharges. By Dr. J. J. Chisholm. Reprint from the *North Carolina Medical Journal*. Pp. 10.

Facial Neuralgia. By Dr. J. Martine Kershaw. St. Louis: Schroback & Co. print. Pp. 66.

The Hessian Fly. By Prof. A. J. Cook. Pp. 14.

Uniform Non-Local Time. By S. Fleming. Ottawa, Can.: The Author. Pp. 32.

Deep-Sea Soundings. By Lieutenant-Commander J. F. Jewell, U. S. N. Claremont, N. H.: Claremont Manufacturing Co. print. Pp. 63.

Report of the Executive Board of the Rochester City Board of Health. Rochester, N. Y.: *Democrat and Chronicle* print. Pp. 27.

Metric Weights and Measures for Medical Purposes. Washington: Government Printing-Office. Pp. 40.

Opinion of the Ohio Attorney-General on the Powers of Boards of Education. Columbus: Nevins & Myers. Pp. 24.

Quarterly Report of the Chief of the Bureau of Statistics. Washington: Government Printing-Office. Pp. 126.

Certain Symptoms of Nervous Exhaustion. By Dr. G. M. Beard. Reprint from the *Virginia Medical Monthly*. Pp. 24.

The Army of the Republic. By Henry Ward Beecher. New York: *Christian Union* print. Pp. 23. 10 cents.

How to spend the Summer. New York: *Christian Union* print. Pp. 105. 25 cents.

The Law of Population. By A. Besant. New York: A. K. Butts. Pp. 47.

POPULAR MISCELLANY.

Archæological Researches in the Great American Bottom.—The alluvial plain known as the "Great American Bottom," lying on the east side of the Mississippi, in Illinois, between Alton on the north and Chester on the south, and having an average width of eight or nine miles, is a region of wonderful fertility now, and the remains of ancient occupation there abundantly found prove that the mound-builders were not blind to the agricultural value of this remarkable tract. It was indeed "one of their greatest seats of empire," in the language of Mr. H. R. Howland, who has published, in the Bulletin of the Buffalo Society of Natural Sciences, an account of certain notable archæological researches made in the "American Bottom." The mounds in this tract seem to have been divided into three principal groups: one lying within the limits of East St. Louis; another on the banks of Long Lake, twelve miles northward; and the third—one of the most extraordinary groups in this country—between Indian Lake and Cahokia Creek, some six miles from the Mississippi, and eight miles to the northeast of East St. Louis. In this last group is the great Cahokia Mound, by far the most important monument left by the mound-builders. The several groups are connected by lines of mounds at irregular intervals, and the total number is at least two hundred. Some two or three years ago Mr. Howland, having learned that one of the mounds in the second group was being removed to procure material for road-making, repaired to the spot and found the work of destruction already well advanced. In the mean time some interesting discoveries had been made. At the height of four or five feet above the base of the mound the workmen came upon a considerable deposit of human bones, and on the same level were discovered a number of valuable relics, many of them wrapped in a sort of matting. This was made of a coarse, cane-like fibre, simply woven without twisting, the flat strands measuring about one-eighth inch in width. Among the articles found were several tortoise-shells of beaten copper. One of these was about one sixty-fourth of an inch thick, two and one-eighth inches long, and thirteen-sixteenths of an inch in height; this was the largest one of three in the author's possession. Their shape is remarkably true, the workmanship evincing delicate skill. Each tortoise-shell appears to have been originally covered with several wrappings, first a woven cloth of vegetable fibre, then a softer, finer fabric of rabbit's hair apparently, next a membranaceous coating, finally a layer of non-striated muscular fibre—possibly intestine or bladder. Besides these singular objects are two specimens of the lower jaw of the deer, the part which contains the teeth being incased in a thin covering of copper, and the whole wrapped in the same manner as the tortoise-shells. Other relics found in the same mound—specimens of handicraft, sea-shells from the Gulf of Mexico, etc.—give evidence of the high grade of technical skill and the far-reaching intercourse of the prehistoric people who, in the long forgotten past, inhabited the Great American Bottom.

Age of the Ohio "Forest-Beds."—The "forest-bed" of the Ohio geological formation is a "layer of carbonaceous matter, with logs and stumps, and sometimes upright trees." It everywhere rests upon true glacial drift, and in it are found remains of mammoth, mastodon, and their contemporaries. The deposit overlying this "forest-bed" in Ohio is, by Dr. Newberry, described as lacustrine drift, but Mr. W. J. McGee, in the *American Journal of Science*, shows that in Northeastern Iowa this same "forest-bed" is overlaid by *true glacial drift*, and therefore that it must be of interglacial age. In the region just named the uppermost deposit, overlying the "forest-bed," is beyond the shadow of a doubt glacial drift very slightly or not at all modified, and exhibiting no distinct stratification. The only difference between the upper and lower parts is that the lower part contains a larger proportion of gravel and worn bowlders from the immediate vicinity. The upper part contains no bowlders, indeed, except those of granite, syenite, quartzite, and other metamorphic rocks from far to the northward. These, however, are quite abundant. In some fields it has been necessary to remove dozens of bowlders of one hundred pounds' weight and upward from each acre before the land could be ploughed. Some also are quite large, reaching scores of tons in weight. Glacier-marked bowlders are rare, however. Perhaps one in a thousand shows plainly grooves and deep scorings; but many others are less distinctly marked. Still not more than one-tenth exhibit any other marks of glacial action than a rounded form.

Medico-Psychological Rubbish. — Dr. Maudsley's *Journal of Medical Science* quotes the following passage from the *British Medical Journal* as an example of the rubbish that passes current in medico-psychological matters: "One of the most curious facts connected with madness is the utter absence of tears amid the insane. Whatever the form of madness, tears are conspicuous by their absence, as much in the depression of melancholia or the excitement of mania as in the utter apathy of dementia. If a patient in a lunatic asylum be discovered in tears, it will be found that it is either a patient commencing to recover, or an emotional outbreak in an epileptic who is scarcely truly insane; while actually insane patients appear to have lost the power of weeping; it is only returning reason which can once more unloose the fountains of their tears. Even when a lunatic is telling one in fervid language how she has been deprived of her children, or the outrages that have been perpetrated on herself, her eye is never even moist. The ready gush of tears which accompanies the plaint of the sane woman contrasts with the dry-eyed appeal of the lunatic. It would indeed seem that tears give relief to feelings which, when pent up, lead to madness. It is one of the privileges of reason to be able to weep. Amid all the misery of the insane, they can find no relief in tears."

The Devil and the Oak-Trees.—A legend current among the peasants of Unterinnthal (Tyrol) accounts as follows for the sinuous outline of oak-leaves (we translate the legend from *Die Natur*): The wicked old fiend one day would tempt the good God, and so asked if he would grant him a trifling request. With a smile, the Lord answered, "What you ask will be granted so soon as the oaks have lost all their leaves." The *Gottsei beiuns* (literally, "God-be-with-us"—in old times people did not like to name the devil, lest he should appear) was delighted, and eagerly longed for the coming of autumn; but the oak-leaf gave no sign of falling. So the devil, somewhat disappointed, deferred his hope to winter. Winter came, but still the leaves clung fast to the oaks, though they rustled all yellow and brown in the wind. Satan had then to comfort himself with the thought that at least they would fall in the spring. But when joyous Spring came, making its progress through the verdant fields, first young leaves began to sprout, and not until these had grown to considerable size did the old ones drop off. Then the prince of darkness knew that his request would never be granted, for the oak never loses *all* its leaves at once. So in his rage he rushed howling and roaring at the oak-trees, and with his claws tore the leaves to pieces, and we, to this day, only see the shreds.

A Big Fish-Worm.—The people who inhabit the highlands of Southern Brazil have a firm belief in the existence of a gigantic earthworm fifty yards or more in length, five in breadth, covered with bones as with a coat-of-mail, and of such strength as to be able to uproot great pine-trees as though they were blades of grass, and to throw up such quantities of clay in making its way underground as to dam up streams and divert them into new courses. This redoubtable monster is known as the "Minhocao." Dr. Fritz Müller, who has for some years resided in Brazil, studying in particular the entomology of that country, has thought it worth his while seriously to investigate the grounds of this popular belief, and has published the result of his researches in a German periodical, from which *Nature* has taken the gist of his communication. As will be seen, he is inclined to admit, with considerable allowance, the truth of the popular stories. The evidence of the existence of the Minhocao is of this kind: About eight years ago one of these monsters made its appearance in the neighborhood of Lages, but perhaps it will be safer to say that it "is reported to have made its appearance." One Francisco de Amaral Varello, at a place distant ten kilometres from that town, saw, lying on the bank of the Rio das Caveiras, an animal nearly one metre in thickness, not very long, and with a snout like a pig. He went to call his neighbors, but when he returned to the rescue the animal had disappeared, and the party saw only the trench it had made in disappearing under the earth. A week later a similar trench was seen at the distance of some six kilometres from the former one. One F. Kelling, a German, from whom Dr. Müller got this information, was at the time a merchant at Lages, and he saw these trenches. Another German, E. Odebrecht, while surveying a line of road from Itajahy into the highlands of Santa Caterina several years ago, crossed a broad, marshy plain traversed by an arm of the Marombas River, where his progress was much impeded by "devious winding trenches which followed the course of the stream, and occasionally lost themselves in it." These trenches he is now inclined to believe to be the work of the Minhocao. Other testimony, relating to five or six earlier apparitions of the Minhocao, is cited, but we have no room to give it here. To Dr. Müller the conclusion appears inevitable that in the above-named region of Brazil "long trenches are met with, which are undoubtedly the work of some living animal. It might be suspected," he adds, "to be a gigantic fish allied to *Lepidosiren* and *Ceratodus*; 'the swine's snout' would show some resemblance to *Ceratodus*, while the other characters show rather an analogy to *Lepidosiren*. In any case," he concludes "it would be worth while to make further investigations about the Minhocao, and, if possible, to capture it for a zoölogical garden."

Aurora Borealis.—From statistics of the aurora borealis collected by H. Fritz, and extending from 1846 to the present year, we learn that out of 2,035 days in the months from August to April, on which auroras were seen, 1,107 were aurora-days in Finland, and that of these 1,107 auroras 794 were simultaneously visible in Europe and America, 101 only in Europe, and 212 were visible only in Finland. During the same period and within the same months, 928 auroras were seen in Europe or America which were invisible in Finland. These statistics further serve to show the geographical distribution of auroras, which is as follows: The zone of greatest frequency and intensity begins near Barrow Point (latitude 72° north), on the northern coast of America; thence it passes across the Great Bear Lake toward Hudson Bay, which it crosses at latitude 60° north, passing over Nain on the coast of Labrador, keeping south of Cape Farewell. Its further course is between Iceland and the Faroe Isles, to the vicinity of North Cape in Norway, and thence into the Arctic Sea. Thence it probably passes round Nova Zembla and Cape Isheljuskin, approaches the north coast of Asia in the eastern part of Siberia, in the longitude of Nizhni Kolymsk, and thence returns to Barrow Point.

Analogies of Plant and Animal Life.—Some very interesting analogies of plant and animal life are pointed out by Mr. Francis Darwin in a recent lecture. In the first stage of individual existence—the egg or the germ—the analogy is perfect; it is no less so in the stage just succeeding. Among animals there are great differences as to the degree of development attained by the young ones before they enter the world. For instance, a young kangaroo is born in a comparatively early stage of development, and is merely capable of passive existence in its mother's pouch, while a young calf or lamb soon leads an active existence. Or compare a human child, which passes through so prolonged a condition of helplessness, with a young chicken, which runs about and picks up grain as soon as it quits the shell. As analogous cases among plants Mr. Darwin cites the mangrove and the tobacco-plant. The ripe seed of the mangrove is not scattered about, but remains attached to the capsule still hanging on the mother-plant. In this state the seeds germinate and the roots grow out and down to the sea-level, and the plant is not deserted by its mother until it has got well established in the mud. For the conditions of life against which the young mangrove has to make a start are unfavorable enough. The most intrepid seedling might well cling to its parent on finding that it was expected to germinate in soft mud daily flooded by the tide. Perhaps, adds the author, the same excuse may be offered for the helplessness of babies—the more complicated the conditions of life, the greater dependence must there be of offspring on parent. Compare a young tobacco-plant with a young mangrove. All the help the seedling tobacco receives from its parent is a very small supply of food. This it uses up in forming its first pair of leaves, and it has then nothing left by way of reserve, but must depend on its own exertions for subsistence—that is to say, it must itself manufacture starch (which is the great article of food required by plants) from the carbonic acid in the air. In this respect it is like a caterpillar which is formed from the contents of the egg, but has to get its own living as soon as it is born.

The Construction and Erection of Lightning-Rods.—Dr. R. J. Mann lately summed up in a series of aphorisms the fundamental conditions to be observed in the construction of lightning-rods. We have not room here for the whole series, but select a few of the most important. The main stem of a *copper* lightning-conductor should never be less than $\frac{4}{10}$ of an inch diameter; this dimension is not sufficient for a building more than eighty feet high. Galvanized iron may be used instead of copper, but then the diameter must be greater in the ratio of 6.7 to 2.5, the conducting capacity of iron being to that of copper as 14 to 77. A galvanized iron-rope conductor should never be less than $\frac{8}{10}$ of an inch diameter; a galvanized iron strip should be 4 inches wide and $\frac{1}{8}$ of an inch thick. A lightning-rod must be continuous and unbroken from end to end. A rod need not be attached to a building by insulated fastenings; metal clamps may be safely employed, provided the rod be of good conducting capacity and otherwise efficient. Above, the rod must terminate in metal points, well projected into the air; these points should be multiple and perfectly sharp. The bottom of the conductor must be carried down into the earth and be connected with it by a surface-contact of large extent. All large masses of metal in a building should be metallically connected with the lightning-rod, except when they are liable to be occupied by people during a thunder-storm—an iron balcony, for instance. In such cases it is better not to have the iron connected with the conductor, for there is some risk of persons standing on the balcony furnishing a path for the lightning to the rod.

North American Archæology.—The directors of the Smithsonian Institution contemplate the publication of an exhaustive work on the antiquities of North America, and earnestly invite the coöperation of archæologists and of all who may be possessed of information concerning the aboriginal history of North America. The ancient monuments to be described in the work are mounds and earthworks, shell-heaps, cave and cliff dwellings, masonry, sculptured slabs or carved images, inscriptions, and rock-paintings, graves and cemeteries, aboriginal quarries, and salt-works, *caches* or deposits of objects in large quantities, workshops or places of ancient aboriginal industry, ancient roads or trails, reservoirs and aqueducts. In addition to original records and descriptions of the objects here enumerated, the Smithsonian Institution desires to obtain copies of all books, memoirs, pamphlets, extracts from periodicals, and newspaper clippings, having any relation whatever to American archæology. Information is further solicited concerning all collections of American antiquities, *however small*, whether in private hands or in public museums. Any one can obtain, on application to the Smithsonian Institution, its "Circular in Reference to American Archæology," in which are stated in detail the different subjects concerning which specific information is wanted.

A New Fact in Natural History.—In the books of Leviticus and Deuteronomy it is forbidden to eat any creature living in the waters that "hath not fins and scales." Of such animals it is written: "They shall be an abomination unto you; ye shall not eat of their flesh, but ye shall have their carcasses in abomination." Christians, at least modern Christians, are not wont to hold oysters as "unclean" and "an abomination," notwithstanding the very high authority on which they are so declared to be in the Holy Scriptures. But the Jew still obeys the divine command, as of old; hence the devout Hebrew knows nothing, from personal observation, of the delicate flavor of the oyster, and no doubt that savory bivalve has oftentimes been a stumbling-block and a scandal for the weaker ones of the children of Israel. But a truly wonderful discovery has been made by a learned rabbi in England, which takes the oyster out of the class of things forbidden, and makes it as harmless to the conscience as, doubtless, it will be grateful to the palate of the Jew. This rabbi has read Mr. Darwin's works, and read them to some purpose, for he finds that, "in consequence of the theories" of that famous naturalist, "oysters are plants, and may therefore be eaten by Jews." We hasten to add that as yet the rabbi's views are merely matters of private opinion, and hence no safe guide for consciences; but a grand council will before long be summoned to render authoritative judgment in the matter. Its decision will be awaited with no little interest. It is to be hoped that the vegetable side will prevail. One strong argument in its favor is the notorious fact that oysters are *planted*, the result of course being the *oyster-plant*.

Peculiarities of Vision.—Mr. Galton, in his paper on "Composite Portraits" (*see* page 465 of this number), observes that "the two separate impressions received by the brain through the stereoscope do not seem to be relatively constant in their vividness, but sometimes *the image seen by the left eye prevails over that seen by the right, and vice versa.*" This remark has elicited from a correspondent of *Nature* a communication in which he describes a very curious defect in his own eyesight. This correspondent's right eye is fairly long-sighted, but the left eye is short-sighted. Print which is read distinctly by the one at the distance of eighteen inches, cannot be easily read by the other at a distance of over eight and a quarter inches. The result of this is, that the right—the long-sighted eye—closes involuntarily when he reads. Again, when he looks intently at a distant view, the left or short-sighted eye shuts occasionally. When both eyes are open he has two separate images presented to the brain, one blurred and indistinct, even for faces a yard distant, and the other clearly defined for objects at ordinary distances. "How is it," he asks, "that my brain or mind rejects the blurred image, and chooses the distinct one? . . . . If I get a particle of dust in the good eye, or close it, I immediately see the blurred image. . . . This blurred image always appears at a higher level than the other. Things appear as a rule," he adds, "much flatter to me than to people who enjoy binocular vision. I know this because I have a pair of spectacles so arranged as to equalize my sight. When I put them on, objects like trees put on a delightful fullness and roundness to which I am usually quite a stranger. I may add that two of my brothers have a similar defect of vision."

The Cactus as a Lava-Breaker.—A citation, in the bulletin of the Torrey Botanical Club, from Dr. Peters, the famous asteroid-hunter, gives an interesting fact in relation to the doctor's earlier days, when he ate prickly pears, or the fruit of the Indian-fig cactus, on the sides of Mount Etna. He describes the lava-beds as covered with impenetrable patches of *Opuntia ficus Indica*, the Indian fig-cactus. These patches are the result of economic planting, with the intention of producing soil on the lava-beds. The Sicilian throws down a handful of soil, then drops upon this a bit of the cactus, which immediately roots. The effect of this cactus-growth is to facilitate the weathering of the rock, and thus make soil. The next step, after clearing off the cactus, is to plant fig-trees. In this way the lava-beds of Mount Etna are transformed into fruitful gardens.

A New Septic Organism. — Mr. Dallinger lately gave, before the London Royal Society, an interesting account of the life-history of a peculiar microscopic organism discovered by him in certain decomposing fluids. This organism never exceeds the $\frac{1}{4000}$ of an inch in long diameter; in shape it is oval; at its anterior extremity it has a head-like protrusion bearing a delicate flagellum. From the sides of the shorter or front segment of the oval project two long flagella, and these, as a rule, trail behind, one on each side. It swims rapidly, but has also the capacity of anchoring both of its lateral flagella to the floor of the microscope-stage, or to a decomposing mass in the drop of liquid in which it is examined under the microscope. By steadily observing it in the free-swimming condition, it may be seen to undergo self-division, the division beginning in the front flagellum, and proceeding until, by longitudinal fissure, a new lateral flagellum is made for each half. There are now two perfect organisms. The author confined his attention for some time continuously to one of the segmental portions, and succeeded in tracing the process to its ultimate results. Having so observed a number of the self-dividing organisms, he found that in the majority of cases, when the process of fissure ceased, there was simultaneous exhaustion of vital action, and death; but in a certain proportion of cases, in which fissure was not so long continued, there was a change to the amœboid condition, the lateral flagella being absorbed, and the body becoming oval with anterior flagellum only. It now swims easily, but only in a straight line. It soon comes in contact with a colony of the organism in the perfectly flagellate condition, attaches itself to one of them, which soon unanchors, and both swim away. In course of time their movements become sluggish; the sarcode of their bodies is palpably blending, they become quite still, except for amœboid movements, and then become one oval mass. After three or four hours this pours out minute specks, which appear to develop into the adult form and size. The temperature of 142° Fahr. is fatal to the perfect organism; the "speck," germ, or spore, can bear with impunity a temperature of 250° Fahr.

NOTES.

The schooner Eothen, carrying the expedition to search for the relics of Sir John Franklin's party, sailed from New York on Wednesday, June 19th, under the command of Captain Thomas F. Barry, whose discovery of spoons bearing Sir John's crest, in the hands of an Esquimaux tribe, was the occasion of fitting out this expedition. Lieutenant Schwatka, Third U. S. Cavalry, will command the search-party, and will have for guide and interpreter Joseph Eberbing, "Esquimaux Joe" of Polaris fame. The

Eothen will touch first at Whale Point, in Hudson Bay, and there recruit a force of Esquimaux to reënforce the search-party; from Whale Point the schooner will proceed to Beach Point, Repulse Bay, one hundred and forty miles north. Thence the search-party will proceed inland by sleds five or six hundred miles to a point in the northern portion of Boothia Felix, where the last survivors of the Erebus and Terror crews are said to have perished, and where, according to the natives, their bodies are buried.

Rediscovery of a lost *Sphæria* is noticed by the bulletin of the Torrey Botanical Club. This fungus, the *S. barbirostris*, was discovered by Dufour in the department of Landes, France, over forty years ago. Since then no specimen has been found until lately, when Mr. J. B. Ellis rediscovered it on some maple-bark at Vineland, New Jersey.

Among some insects sent to Prof. Lockwood, of Freehold, New Jersey, as damaging the wheat, he identified that terrible microscopic hemipteran, the chinch-bug. The specimens came from Morris County. The Hessian fly is unusually troublesome this year in New Jersey.

In a recent lecture before the Natural History Society of Harvard College, Prof. J. D. Whitney asserted that the "Calaveras skull" is undoubtedly of Pliocene age. Chemical analysis had shown it to be a true fossil, its organic matter being almost entirely lost, and the lime phosphate replaced by carbonate. Prof. Whitney had himself chiseled away from the skull the substance of the matrix in which it was imbedded when found in the strata underlying Table Mountain.

The *Polytechnic Review* mentions the discovery, in South America, of a species of fibrous plant suitable for paper-making. The specific nature of the plant and the locality of its growth are kept secret. It is asserted that a No. 50 thread of the fibre "cannot be broken by the strength of ordinary fingers without snapping." The plant grows wild, and is, when full grown, taller than a man, in some cases even higher than a man on horseback. In the natural state it is of a brown color, but is easily bleached to pure white.

A series of grammars of Indo-Germanic languages is announced as forthcoming from the press of a Leipsic publishing-house. There will be eight grammars in the series—namely, Indian, Iranic, Greek, Italic, German, Irish, Lithuanian, and Slavic. The Indian grammar will be by Prof. W. D. Whitney, of Yale College, and he has gone to Europe to see the work through the press.

Dr. Brown-Séquard has been appointed the successor of Claude Bernard in the professorship of Physiology in the College of France—an eminently well-merited appointment. Dr. Brown-Séquard is a native of Mauritius, born in 1818, soon after that island had been taken from the French and made a British possession. His father, Dr. Edward Brown, was a native of Philadelphia, and his mother a native of Mauritius and of French origin. He is eminent as an investigator of brain and nerve organization.

It has been observed by Pasteur that some bacteria are killed by a temperature of 109° Fahr. This fact he uses to explain the impossibility of inoculating birds with anthrax or carbuncle. But if the temperature of birds be lowered artificially, they would, he inferred, be inoculable, supposing the temperature to be the obstacle. This inference he confirmed by experiment; having kept a fowl for some time in water of 75° Fahr., he succeeded in inoculating it with anthrax.

We have to record the demise of two European astronomers of note—namely, Prof. Wolfers, of Berlin, editor of the "Year-Book" of the observatory attached to the university of that place; and Rev. R. Main, F. R. S., director of the Radcliffe Observatory, England. The former died in the seventy-sixth year of his age and the latter in the seventieth.

Magnus Nyrén writes to the St. Petersburg Academy of Sciences that the great earthquake on the South American coast, in May, 1877, was perceptible at Pulkowa by a tremor of the instrument with which he was observing the passage of a star. He further states that the tremor continued sufficiently long to be satisfactorily verified, and that there was no disturbance in the neighborhood by which it could have been occasioned.

In Natal, South Africa, grass is kept in the moist state for months by being buried in pits, the process being known as "ensilage." A pit is dug in the ground in a dry situation, and filled with fresh-cut grass, which is packed closely down and then covered with a thick layer of soil, to exclude the air. Grass thus stored is apparently unchanged in its nutritive properties; cattle consume it with avidity, and thrive well upon it.

A statue commemorative of Giordano Bruno, the philosopher and martyr of science, will be dedicated at Rome on February 17, 1879. He was burned at the stake in that city on the same day of the year 1600, on the charge of being an "obstinate heretic."

Prof. O. C. MARSH.

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THE PLACE OF CONSCIENCE IN EVOLUTION.

By Rev. T. W. FOWLE.

OF all the objections and difficulties that sprang into life the moment that the doctrine of evolution was propounded for our acceptance, very few indeed (exclusive of the purely scientific ones) now give evidence of persistent vitality. Time, which, if age and experience can give wisdom, ought to be so much wiser than any of us, has consigned the greater part of them to oblivion, and evolution is taking its place, one might say, as part of the furniture of the human mind. Chief among these objections was the assertion that evolution could give no satisfactory account of the origin of morality and the genesis of conscience.

Many persons, religious thinkers especially, among whom Mr. Charles Kingsley may be cited as an instance, while willing to accept any reasonable conclusion of science as to the origin and constitution of man, appeared determined to reserve conscience as something inexplicable by any effort of human thinking, and therefore as a direct gift of God to his creatures; others, again, have gone so far as to assert that the idea of duty as of divine obligation must perish, if the nature and growth of conscience could be explained, as part of the evolution of the race, by natural causation. This feeling, natural and indeed honorable, was strengthened by the fact that the explanation given of the place of conscience in evolution seemed to unprejudiced minds—seemed also to that *communis sensus* which is, after all, the ultimate court of arbitration in these matters—on the whole inadequate to account for the phenomenon for which explanation was desired. These persistently averred that they were conscious of something within them which no considerations derived from utility or from social life, or from the transference of external sanctions to the inward individual consciousness, at all explained or enforced. To a certain extent this feeling was itself a justification of resistance to the claims of evolution to be regarded as a sufficient history of the creation of man. The evolutionists had claimed to be able to make clear to its possessors the mystery of conscience; and if reasonable men asserted that, so far as they were concerned, the sense of mystery remained, it was clear that the last word on the subject was not yet spoken.

I am certainly very far from thinking that the last word will be spoken for some time to come, but I make bold to believe that it is possible to throw further light upon the subject without at all departing from the general principle of evolution to which I have for long given such intellectual adherence as was in my power. Let us, then, begin by endeavoring to understand what were the precise features in the power called conscience, which seemed to intuitional thinkers to baffle and defy the explanations of the evolutionists.

Their general point of view may be fairly expressed by the statement that the conscience must have had an existence prior to the conditions out of which it was supposed to have been evolved. Drawn out in detail, this statement contains the three following propositions:

1. Conscience is instantaneous—that is, innate—in its origin, and therefore not to be accounted for by the supposition that by degrees it was impressed upon the mind from without. It bears so strong a resemblance to the other faculties, the senses and emotions, that, like them, it must have formed part of the original constitution of man. When examined it seems to testify that it is in no sense a composition, not made up of long and varied experiences, but the result of a single creative act, or at any rate the instantaneous product of certain conditions brought for the first time into relation with each other. In other words, the length of time postulated by evolutionists for the development of man is not granted them in the case of conscience. We shall see presently whether they really require it.

2. Conscience is instantaneous—that is, intuitional—in its operations, and therefore not to be accounted for by the action and reaction of social relationships. Had there been but one man, that one man would have been able to say, "I must do this;" and, again, there must have been a sense that it was right to combine for social purposes of mutual help and comfort before men could have conceived the idea of doing so. The notion that I ought to act in a certain way toward my neighbor is, if not a primary, at least a very easy one, whereas the notion that I ought to act in a certain way, because it is for his or our advantage, seems *prima facie* a much later one. There is, in short, a correlation between the conscience and an external rightness, which is just as natural, as rapid, as unaffected by later relationships, as is the correlation between the eye and light. In primeval man the conscience detects, however dimly and imperfectly, morality in actions just as the eye detects shape and color in objects. Social and civilized life may

enable him to see more clearly and explain more completely, but it cannot give him either the eye or the conscience.

3. Conscience is also instantaneous—that is, imperative—in its commands. It never stops to argue when once the right is, or is thought to be, ascertained. But if mankind had reached the lofty heights of duty by the ladder of utility or the gradually-growing influence of external sanctions, it might have been expected that some fragments of the ladder, some traces of the process, some memory of the time when "ought" was a word of dubious meaning and uncertain cogency, would have been preserved. The evidence derivable from the histories of savage existence seems plainly to indicate that this imperativeness of conscience is inseparable from the most rudimentary stage of moral and social life. In short, to put the matter as briefly as possible, those who object to the theory of evolution maintain that it is impossible to conceive of any creature entitled to the name of a human being who was not as much furnished with a conscience as any of his successors. True, the primeval conscience had not begun to construct moral rules any more than the primeval eye had formed theories of light and form; but the existence of both was equally indisputable and essential to the idea of man.

Now, if it can be shown that there is a place in evolution for the formation of a conscience fulfilling all these conditions—if, that is, the theory of evolution can be proved to account precisely for those phenomena that seem *prima facie* to militate most strongly against it—if this feature, which I have called instantaneousness, and have exhibited in three of its leading characteristics, is exactly what one might expect to find in the evolution of the human race—then I submit we have obtained a confirmation of the truth of the said theory of that nature which appeals most forcibly to the common-sense and practical judgment of mankind. Let this, then, be the judge as to whether all that is instantaneous in conscience is not fully accounted for by the considerations I am about to urge.

In seeking to account for the origin of man by evolution we are frequently obliged to confess that the entire absence of contemporary evidence compels us, at any rate for the present, to say of many phenomena, that if we knew more we should be able to answer difficulties and clear up perplexities which seem at this present moment wellnigh insuperable. The gaps are such that they cannot be filled up even by the imagination. Science has done but little yet to enable the intellect to form an idea to itself of the way in which organic life and reasoning man began to exist upon the earth. Impenetrable darkness hangs over vast epochs, nor is it possible in the present absence of materials to fill in the picture of that critical time when man (slowly or suddenly, who can tell?) rose up from among the beasts and said, or rather felt without being able to say, "I am." But then by our hypothesis this is also the time when he also said, "I must." We may feel assured that at this time, by orderly development and natural process of causation, all that is most vital and precious to humanity, all the seeds of man's present and eternal future, came into existence; but none the less is the darkness so great that even the imagination refuses to move from its place. The surrounding objects are there if the light would but dawn so as to enable us to see them. It is very necessary to remind ourselves of this, lest we seem to be expressing ourselves with too much certainty in doubtful matters. But however necessary this may be when we are dealing with many other questions respecting the origin of man, it is, I firmly believe, by no means so necessary in our present investigation. That phenomenon, called conscience, which seemed at first sight the most likely to resist analysis by way of evolution, proves upon experiment to yield most readily to it.

As usual in questions of this description, philosophy has been made the slave, the victim, and finally the accomplice of language. The word conscience has come to suggest a kind of special faculty, not exactly thought and not exactly feeling, which presides over a specific department of man's being, namely, his moral conduct. Whereas, reduced to its simplest elements, conscience is merely the power which the mind possesses of discerning rightness. Just as we discern something called beautiful which we must admire, or something called pleasurable which we must seek, so do we perceive something right which we must do. And so our specific question comes to this, "How did the idea or the fact of rightness enter into the world?"

There can, I think, be no doubt that the general tendency of the teaching of evolution has been to reintroduce into philosophy the idea that such things as virtue, goodness, happiness, right, are absolute and fixed quantities, formed for man and not by him, existing independently of him, and therefore the same to all men in all circumstances. They are realized by the complete and harmonious adjustment of the self-conscious ego to the circumstances out of which it came and by which it is surrounded. Can, then, evolution help us to perceive how the idea of there being such a thing as absolute fixed rightness came into the world?

Let us transfer ourselves in thought as far back as the time when the origin of man took place, and let us imagine a being slowly or suddenly arriving at the stage of self-conscious existence. For our present purpose it matters little whether we attribute this to a gradual progress, or (what is surely possible) to a sudden but natural leap in evolution, or to a special act of creation adapting itself to materials already at its disposal. (I mention this last alternative merely to show that this theory of the origin of conscience does not conflict with any reasonable hypothesis as to the origin of man.) Now this Being owed his origin to the law or process of natural selection. He had been cradled, so to speak, under conditions which prescribed a continual struggle for existence, and which permitted only the strongest and fittest to survive and multiply. His "conduct" up to the moment or epoch when it became self-conscious was confined to these two spheres of action, flying (by combination and otherwise) for life and killing for life. There were creatures whom it was natural for him to kill, and others who, it was equally natural, should kill him. This was the state of things in which he found himself a living, thinking being; this was the law which he found not only confronting him on every side of his exterior life, but also deep rooted in his inmost nature as an indubitable, unanswerable fact.

Having arrived at this point, let us as our next step remind ourselves that it is impossible to imagine a rational human being in whom there is not present the assurance that he has a right to himself, to be allowed to live in the first place, afterward (as the result maybe of long years of evolution) to be allowed to live happily. That no one has a right to take my life from me is a thought inseparable from myself, it is at any rate the first piece of knowledge of which I become possessed. The infant's cry for nourishment and warmth contains this much meaning to those who can discern how moral feelings grew out of physical conditions. But then this thought remains a mere mystery, and therefore quite unsuitable for affording a basis on which to explain the origin of conscience, until we set it in the light of evolution. So regarded, the mystery vanishes in an instant. For this thought is merely the necessary result of the correlation of the first self-conscious being with his environment, and conscience is the *struggle for existence become aware of itself in the mind of a thinking person.* The first man, in however dumb, inarticulate a fashion, did nevertheless practically contrive to claim of the universe, of Nature, of creatures like himself, nay, ultimately of the unknown Author of all things, that they should not destroy the life which they had originated. He made his appeal (makes it in truth now) to all the tremendous forces amid which he moved, and in the balance and play of which he endeavored to maintain an independent personal existence, that they should minister to *him*, the one thinking creature among them, and therefore (for the first man was also the first philosopher) their centre and final cause. It seemed to him, in short, right, could not indeed seem otherwise, the past being what it had been, that his environment should be such as would make life possible to him at once, and in due time useful and enjoyable.

Observe that the condition essential to all knowledge, namely, contrast or the perception of dissimilarities, is here present. As light is meaningless without darkness, or heat without cold, so is right without its contrast of force or wrong. No doubt primeval man may have for long perceived by sensation the contrast of heat and cold, day and night, before he so far separated the ideas as to give them abstract names. So, too, the same man may have for long felt the indescribable contrast between the external force that was everywhere threatening his existence and the internal force that was resolutely bent on continuing to be, before he called the two by the names right and wrong. But as the mere fact that the contrast was there, and always had been there, at the very root of things, produced at once the appropriate feeling in the first mind, so did the feeling produce in due time the words in which it is expressed. Take the first and commonest action in the struggle for existence. The meanest creature that lives seeks instinctively to escape from its enemy by flight. But man alone can think, as he flies from his pursuer, with an energy quickened by his knowledge of what death is and means: "All this is unutterably wrong. I have a right to save my life, this thing or creature has no right to take it from me." Such, or something like this, were the first thoughts of the first conscience, the first expression of the conviction that there was a rightness in the world.

Whatever else may be urged against this account of the origin of conscience, it seems to me certain that those phenomena, upon which intuitionalists have particularly relied as being beyond the reach of analysis, and therefore of discovery, are fully and precisely accounted for. Take, for instance, the word creation, which men have used because of their feeling that there were things in the world of instantaneous, and therefore of specially divine, origin—a feeling which gave rise to the most sublime utterance of antiquity: "God said, Let there be light, and there was light." Now the poetical beauty and religious truth of such phrases are surely not in the least degree prejudiced by the scientific statement that these "creations" correspond to those critical epochs in the progress of evolution when, by the union or marriage of one set of conditions with another, a third is instantaneously, and for the first time, called into being. Such an epoch, resulting in the origin of conscience, was that in which a being conscious of himself said, or thought, or felt, "I am," and then, confronted with a world of opposing and destructive forces, added, "and I have a right to be."

So, too, the truth contained in the assertion that conscience is innate, intuitional, and imperative, is seen to be in harmony with the foregoing account of its origin. It is innate in the sense that, though undoubtedly impressed from without during long periods upon man in his *animal state*, it was *not* gradually impressed upon him in his intelligent state, but was, from the first, part of the mental furniture with which as a rational being he commenced his life upon earth. It is, in short, not a composition, i. e., the result of various tendencies such as pleasure, utility, and the like, but, in the sense explained above, a creation, coeval with man himself, the inheritance of the first human being no less than of the last.

Again, it is intuitional in the sense that it has a direct necessary and immediate perception of an external something, named rightness, with which it is correlated. Man, by virtue of his conscience, is obliged to believe that there is right and wrong, just as by virtue of his eye he is obliged to believe there is light and darkness. And this belief exists and must exist independently of all theories as to what in the abstract constitutes right and wrong, and in spite of mistakes in particular cases.

Lastly, conscience is imperative, because the inwrought consciousness in human nature that man has a right to himself makes every other consideration whatsoever subordinate to itself. This is the right which must be at every cost pursued by myself and conceded to me by others, which dominates every action, lies at the root of all human progress, shapes every institution of our devising, and presides over the destiny of mankind to its remotest end. For, travel as far as we please, we can never escape from the conditions under which we were called into being.

So far, then, the task we set before us of ascertaining how the sense of rightness came into the world has been in some degree accomplished. The process by which from this prolific germ the vast fabric of human morality, together with the exquisitely delicate machinery of the individual conscience, as we now see it, has by slow degrees grown up, can be indicated in a sentence. Morality consists in transferring to other beings like ourselves those rights which we feel that we ourselves possess, in learning that what is due to us from them is also due to them from us, in ascertaining in what those mutual rights consist, in adjusting the rights of individuals within the limits of one society, lastly, in forming to ourselves notions of abstract right and wrong by the methods of philosophical inquiry. Manifestly, therefore, this account of the origin of conscience does not conflict with any one proposition that has ever been formulated by any of the great masters of experimental philosophy; it does but claim to add to them that undefinable something which seemed to the common-sense of mankind deficient in their account of conscience. The true method of inquiry is surely not to ask what such words as "conscience," "ought," "duty," "happiness," mean in the mind of a modern thinker, but to discover, if we can, what they meant, or rather to what instinctive impressions they corresponded, in the minds of the forefathers of our race. For the question is *not* "How did I come by my conscience?" but "How did those remote ancestors of mine, the first man and after him the first society of men, come by theirs?"

The history of the process by which, under the influence of social life, its wants, obligations, utilities, arrangements, and sanctions, the sense of a right due to ourselves was elaborated into the voice of conscience prescribing what is due to others, would be a valuable and interesting contribution to moral science. But though quite beyond our present limits it is, I think, possible to sketch in mere outline the stages through which conscience passed till it reached its full growth. I disclaim any pedantic desire to show that these stages are chronologically successive; on the contrary, they act and react upon each other, and may be immensely varied in their operations among different races or at different times. But with this proviso the seven ages of conscience may be briefly indicated as follows:

1. The Animal Stage. Mr. Darwin's book has familiarized us with the idea that the moral and mental elements in man's nature, no less than the physical and material, were derived from irrational creatures by the process of evolution. How far this is capable of being proved in other respects it is not for me to say (whatever I may believe), but I am sure that it is true of that element which seems at first sight most opposed to it—the conscience. Making all allowance for the temptation and tendency to read our own thoughts into the minds of animals, and also for the effect upon the animals themselves of man's moral control, it yet remains certain that the materials out of which conscience has been constructed are everywhere discernible, like the rough unhewed stones of a quarry, in animal life and in Nature itself. The mere fact that animals can be taught and made to feel what they ought to do (how can we avoid using the word "ought?") settles the question. But, without relying upon this, is it not evident that the contrast between the external force that *would* destroy and the internal power that *will* live existed long before it became an object of perception and reflection in the brain of a reasoning creature? And this contrast produced such actions as the following—flight, combination for defense, appealing looks, cries of remonstrance, self-defense to the last moment of existence. For instance, the sight of an object accustomed to prey upon a weaker animal then and there stimulated that animal to immediate flight by putting into motion the appropriate muscles and limbs. But the animals with which man is in closest alliance were those whose weakness must certainly have made the necessity of escape a large part of their experience. With this would come a great number of painful and also pleasant emotions. The need of horrible exertions, the terror of anticipation, the sense of unavailing wrath, sometimes the ecstasy of deliverance, which must have been so strong in the heart of every hunted animal that turned to bay at last, are seen to border closely upon that instinct of rightness which so evidently belongs to our individual inherited experience. It needed but the touch of self-consciousness to make the instinctive feeling pass by a bound into an instinctive thought in the mind of a being that "could look before and after." And whatever difficulty there may be in accounting for the evolution of man lies not in his moral but in his mental growth. How he became conscious of himself we may possibly never be able even to imagine, but that being conscious of himself he was by mere force of circumstances possessed of the germ of conscience, is a statement that presents no difficulty at all.

2. The Intermediate Stage. What was the moral condition of the "ape-like man?" He was a creature who had a vivid and intense conception of his own right to exist, and no conception whatever as to the rights of other creatures to the same existence. He was the inheritor of conditions and tendencies which wrought in him such thoughts as these: "You shall die before I will;" "I will use you to please my-

self;" "I am born to pursue my own happiness;" "The whole world is mine to occupy, plunder, and rule over, so far as I find a power within me to do it and to prevent others." He was, in short, the incarnation of perfect selfishness. No one, of course, supposes that these "thoughts" amounted to anything more than vague impressions in the minds of the first men, till they grew into positive convictions under the fostering power of progressive and multiplied experiences. All that seems certain is, that there was an era in the history of man when there was added to his nascent conscience that sense of physical or necessary obligation expressed in our word "must." If he was to avoid destruction, it was borne in upon his mind that he "must" act in such and such a way; his perception of right, that is, of his claim to existence, demanded of him a certain course of action (hardly yet perhaps of conduct), and demanded it in the most brief and imperative fashion. In this stage of human life, before men entered into social relations, we can plainly discern that aspect of conscience which we have described by the word "instantaneous," and which has seemed to so many minds independent of, and prior to, any social experiences. We do but reproduce this ancient fashion of our race when, putting aside all opposing considerations, and refusing to listen to arguments based upon expediency or advantage, we say peremptorily and decisively, "I owe it to myself to do this at once."

3. The Family Stage. The phenomena of primeval family life are so obscure, so varied, and so complicated by institutions like polygamy and polyandry, that in making even the most general and apparently common-sense observations we are obliged to express ourselves with caution and reserve. One indubitable fact, however, stands out impressively amid all the chaos, and affords us a sufficient standpoint for indicating the precise growth of conscience at this stage of its existence. I mean, of course, the maternal care of offspring. It was from this deeply-rooted instinct that men first learned to transfer to the beings whom they loved, and whose helpless weakness appealed to them for protection, the same rights which they claimed for themselves. But however important and indeed enormous is the step thus made in the evolution of conscience, we must beware of making too much of it at this stage of its growth. For the first parents, even when preserving and protecting their children, could only regard their children's rights as part of their own, which they were entitled to defend against all opposing forces; nor could they possibly have imagined that their children had any rights as against themselves. Still, when every deduction has been made, the fact remains that the sense of an obligation due to others besides ourselves, and perhaps too from ourselves, became part of the human consciousness, and men learned that if they wished to do well unto themselves they must make efforts of care and protection for the life and for the welfare of others. All the earlier annals of our race seem to show that this consideration for others, even those dearest to

us, was at first but a very flickering and transitory feeling as opposed to our inherited selfishness; but, for all that, it was the bridge by which men first began to cross from self-love to benevolence, and to become social beings. An interesting survival of this primeval state of things may perhaps be traced in Roman law, under which the father's control over his children seems to point back to the time when men did their duty to their children only as part of themselves, and exercised to the fullest extent the right to do what they pleased with their own. A less pleasing reminiscence of the primitive conscience is to be found in the plea of the slaveholders, that they do not ill-treat their slaves because it is for their own interests to keep them alive, healthy, and happy.

4. The Social Stage. At a certain period of his mental growth primeval man must have begun to form conceptions or ideas of the various objects that came within his experience, so as to be able to say, "This is a flower, and this a stone, and this a man." Now his idea of man must of necessity have been framed upon his knowledge of himself. Whatever qualities or properties he recognized as belonging to himself, these he would transfer to all other beings of whose likeness to himself in all essential conditions he had become aware. Hence it would follow that as he had a distinct and vivid impression of his own right to existence, he would have the same impression, in a faint and dubious form, of other men as possessing the same right. It seems probable that to this rudimentary perception of mutual likeness may be traced all that part of our social feelings which owes its origin to an intellectual as opposed to physical sources. Anyhow this recognition of likeness selects for man the kind of beings with whom he is willing to enter into those social relations to which he finds himself impelled in part by inherited instincts, and in part by the necessity of living together with other creatures in the same territory, and upon the same means of subsistence which they must procure in common. Thus the important fact emerges that man brought (in germ) the idea of right and wrong with him to the formation of society, and did *not* obtain it as a result of social intercourse acting through the agency of pains and pleasures. From the moment that A, B, and C, recognizing a likeness of nature, and therefore a possibility of intercommunion, resolved upon trying the experiment of living together, they must have perceived that they could only do so by acknowledging each other's independent claims to be allowed to live. In respect of all that pertains to life and death they must, in short, have acted up to what Mr. Mill called the "golden ethics" of doing to others as we would they should do unto us. Let us note, in passing, that this "golden" saying, when seen in the light of evolution, becomes not merely a moral rule but also a statement of a scientific fact, for it was only by acting in accordance with it that "neighborhood" became possible. "Who is my neighbor but he to whom I assign the same right to exist that I claim for myself from him?"

We are now in a position to describe how man came by that social *modus vivendi* which we call utility, and define as all that makes for the continued existence and progressive welfare of the community. Utility is scientifically "*the result of the conflict of individual rights, with survival of the fittest.*" The first right that passed away was the right to kill my neighbor ; the first that survived was the right that my neighbor should not kill me. And to these rights conscience paid an intuitive deference (rendered perhaps all the more striking by the contrast presented by men's habitual practice) from the moment that the mind conceived the possibility of social relations. Things being as they were, it could not do otherwise. But then this right to one's self soon passes, under the fostering nurture of social life, to mean not merely bare animal existence, but all that conduces to make life happy, free, good, and useful. During the long course of advancing ages, rights are being conceded to the individual or being abandoned by him according as experience shows what is possible and best for human life and happiness. And all the while the conscience plays its part in this upward progress by transferring to any recognized reasonable rightness (alas! also to a thousand wrongs, which, yet true to its innate origin, the universal conscience persists in regarding as doomed to pass away) the same intuitive deference that it could not help but pay to the first moral inference evolved by the needs and the instincts of social life, "If you have no right to kill me, then have I no right to kill you."

5. The Political Stage. The earliest and (in a certain sense) most authentic records of the human race represent the murder of a brother as the first crime, the murderer's fear of vengeance as the first idea of punishment, and "Whoso sheddeth man's blood by man shall his blood be shed" as the first effort of criminal law to curb the murderous instincts. We have in this a very impressive representation of the next stage in the history of conscience. At first the faint and shadowy idea of my neighbor's right to existence must have been a poor and frail defense indeed against the storms of innate passion, the cruel, selfish lusts, the reckless and savage assaults of men just emerged from the animals and beginning a social life, which, unlike theirs, involved a conscious sacrifice of the individual's will to the community. But no society could have lasted for long without there growing up a distinct and profound conviction that the indiscriminate taking of life cut at the root of its own existence. There are many interesting (in a scientific sense) survivals (blood-feuds, for instance, or the cheapness of human life, which invariably accompanies the dissolution of society at revolutionary epochs) of this primeval state of man, during which some of the strongest sentiments we possess were engraved upon our mental and moral constitution by the external action of laws and customs. It was now that the voice of the community began to proclaim in no hesitating tones to the individual conscience "Thou shalt not kill," and to take

very decisive steps indeed to make its decrees heard and obeyed. And so the word duty began to be in the air.

Now, I hold it to be quite impossible that any such external command could create in the mind the sense that it is a matter of duty to obey it; nay, all law must have presented itself to the individual merely as part of that very external force which was originally, and is still liable at any moment to become, the natural enemy of his personal rights. And if I (that is to say, my ancestor of thousands of years ago) am merely forced by laws acting upon my fear of punishment to surrender my desire to slay another man, I may of course yield to superior force, but I cannot possibly thereby acquire the sense of duty, which may be defined as *the pleasure resulting from intelligent acquiescence in self-sacrifice that makes self-sacrifice possible.* But when the law appeals to a sense of right and wrong already existing, when the command "Thou shalt not kill" is met by a response in the conscience, "I know that this is true, for I had the thought before, or rather at the moment when, I became a social being," then there results the joyful sense of duty which makes obedience pleasant. "Wherefore," the conscience cries, "the law is holy, and the commandment holy, and just, and good." It is welcomed as the interpreter of conscience, as that which explains a man to himself. And so through countless avenues of utility, and through as many sanctions of social opinion embodied in law, custom, or tradition, the conscience advances toward the perception of the rights of men and of a corresponding internal sense of duty toward them. And thus, as I think, we get an explanation of the pleasurable element in duty. For while the law is becoming more and more imperative, and sacrifice of self more and more exacting, and our personal rights more and more circumscribed, there goes along with us the sense that we are but finding our true selves and expressing our own convictions and obeying our own highest wills, and are thus enabled to experience the greatest possible delight in doing our duty. For what is this, after all, but the satisfaction of finding our life when we were willing to lose it?

6. The Ideal or Moral Stage. The next step in the history of conscience carries us a long way forward in the course of man's mental evolution, because it brings us to the time when he became capable of forming abstract notions. But it must be borne in mind that long before these notions were formed, the tendencies and impressions in which they culminated were busily, if silently, at work; hence it is possible to trace the line of advance along which the conscience passed from the primitive sense of rightness to the complete ideal state.

It is natural for men, under the pressure of social obligations, to fall back upon their personal rights and innate egoism, and to question the authority to which they have submitted more from a gregarious instinct than from any exercise of their reasoning powers. Questions like the following lie deep down in the nature and necessity of things, and exercise powerful effect upon the mental and moral modes of thought long before they become articulate in language: "Why am I restricted from doing what I please? Why does law or custom pronounce it wrong to kill one man, right to kill another? Why would my fellow-men think it right to kill me under certain circumstances? Why is the law on this and other points so unfair, so irregular, so incomplete, that were I to fashion my conduct by it alone, I should be always doing something of which I did not approve? Above all, am not I, the unit of which society is composed and for whose benefit it exists, in danger of losing my right to myself and becoming merged in a mere aggregate mass of my fellow-units? Is right and wrong to be determined for me without effort or remonstrance, or even coöperation of my own?"[1]

Now the answer which man has made for himself to such questions is, by common confession, the discovery and the assertion that there is an absolute rightness belonging to society as such, with which individual rights may be harmonized, but which they can never supersede. How did he come to make this discovery and assert it with so unhesitating a conviction? Of justice in the abstract (for this is what we call the social rightness) it is true that primitive man could have no conception; that idea has been generalized from experience. Now we have seen that the first man was dominated by the consciousness of a primitive rightness due to himself. We have seen also that, compelled by the instincts of forming a social life, he extended the same rightness to individual men like himself. We are now to see that, under the stress of questions such as the above, and strengthened by the growing power of forming general ideas, the mind transferred to society, to Nature, nay, to inanimate matter, the same idea of absolute rightness which it claimed for itself. Man perceived right everywhere and in all things just as he had done at first—*then* in the simple concrete form of the right to his own existence, *now* in the highly-abstract form of everything having its own right and wrong. At first all Nature is indebted to him, now he is indebted to all Nature. Utility prescribed in what right and wrong consisted, but did not give the idea of it; or, to speak more accurately, if we are willing to define utility as that which makes for the existence of anything, then just as utility or the needs of his own existence had suggested to man the idea of primitive rightness, so did it impress upon him the idea of rightness as inherent in the constitu-

[1] The relation between the power of law in enforcing rights and the power of conscience in detecting rightness is well illustrated by a sentence of Sir Henry Maine's, describing the action of English law upon Indian modes of thought: "Unfortunately for us, we have created the sense of legal right before we have created a proportionate power of distinguishing good from evil in the law upon which the legal right depends" ("Village Communities," lect. iii.). I may add that the history of village communities presents a curious illustration of the way in which the conflicting rights of egoism and society were preserved in early times, i. e., by what would now be considered an exaggerated expression of them side by side. *See* his remarks on the isolation of households and the secrecy of family life, in the fourth lecture.

tion of things, and especially of society, if it were to continue to exist. Men come to think that they have no business wantonly to destroy anything, not even an insect or an inanimate object. Yet if they do it at all, they answer that it was because it was "useless." It is thus by tracing ideas apparently dissimilar to the same root that we obtain the strongest possible confirmation of the truth of our contention.

It was thus, then, that men began to form to themselves moral ideas, having an absolute and universal existence as opposed to the mere passing dicta of laws and opinions. In the special case before us the inference ran thus: "If it is not right for me to kill, then all killing is naturally wrong, necessary exceptions notwithstanding." And thus the ideal was formed of the sanctity of human life, and society was regarded only as a means for this end, all its arrangements and institutions being of necessity submitted to the moral judgment of the individual mind, and approved only so far as they came up to the ideal. It must, indeed, be confessed that there are survivals from earlier stages of moral growth which cast a strange and ironical reflection upon man's claim to wisdom and advancement, and cause his practice to fall lamentably short of even so early and obvious an ideal as the sanctity of life. How else are we to account for the fact that while all England will thrill at the news of some specially savage murder, or while we ourselves would be saddened to the end of our days by the result of some homicidal carelessness, we yet contrive to read morning after morning without a sigh or even a passing remark of battles in which thousands of human beings have perished for a cause in which they had no more real concern than they had for the politics of the planet Jupiter?

It was thus, then, that men embarked upon that process of forming ideals which led them from the primitive thought, "Self-preservation is the first (and only) law in Nature," up to the highest abstract expression of moral duty, "Fiat justitia, ruat cœlum." But now observe the immensely important influence which the formation of ideals exercised upon the moral constitution. It was this which enabled men, amid the pressure and conflicts of life, to vindicate their primeval claims to themselves, and to establish an independent moral existence in the midst of society, as they had at first established an independent physical existence in the midst of the universe. The immediate effect was that they became a law unto themselves. For instance, under the influence of such an ideal as the sanctity of human life, they refuse to kill even when authority commands them; nay, they prefer themselves to die. That is to say, the original claim to bodily life reappears in the form of a claim to moral life, to which we insist that the same deference shall be paid as our forefathers claimed for their natural existence, and which, thanks to the innate law of our being, we refuse to surrender upon any conditions whatever. And thus we have come to understand what is meant by the significant phrase, "rights of conscience." Can it be said that this has been satisfactorily explained up to the present time?

Mr. Herbert Spencer finds the origin of the sense of justice to self in the egoistic sentiment known as the love or instinct of personal freedom. Carry the analysis one step further back, to the innate demand for personal existence, and, like finding a diamond in a coal-mine, we come upon just that element of absolute, all-pervading, essential rightness for which we might otherwise search in vain.

No wonder, then, that men have almost deified the power they possess of discerning right and wrong, to which they owe in the last resort the possession of themselves. But, unhappily, egoism is easily overdone, and egoism, identifying itself with liberty and duty, is liable to all kinds of mischievous exaggerations and delusions. Conscience comes to be regarded as a special faculty instead of being an ordinary operation of thought directed to special objects. It is ascribed to a divine origin and erected into a test of religion and truth. The chief stress of practical exhortation is laid not upon finding out the right, but upon doing what we believe to be right, very often irrespective of advice, common-sense, and obvious consequences. Nay, men go so far as to assign to conscience a sort of lordship or supremacy over themselves, and so, by a roundabout way, only end at last in doing what they please. Like Arthur, they "reverence their conscience as their king," and, like that excellent but unprosperous monarch, they contrive, with the best intentions in the world, to make a bad business of life. In short, they glorify not the sun which gives the light, but the eye which perceives it, and thus give rise to a reaction against the pretensions, nay, the very existence of conscience, which causes whole volumes of philosophy to be written with barely so much as the mention of its name. To redress the balance, recourse must be had to the good genius of philosophy—evolution.

7. The Religious Stage. I have placed this stage last because the association, much more the identification, of religion with morality comes so late in the history of man, that religion has but little to do with the conscience in its elementary state. Among savages, religion can hardly be called moral at all, although the gods might, on the whole, be believed to be on the side of what the tribe thought to be right—subject, however, to the very important qualification that the gods of another tribe held different views. Still, so far as primitive man believed that the gods would visit him with rewards and punishments by an exercise of superhuman power, to that extent there was added to the conscience a feeling of responsibility and solemnity together with an awful imperativeness which must have considerably modified his moral constitution. Moreover, by calling attention to a will external to our own, something was done to counteract the egoistic tendency which I have just described. And so it was that morality did not take final refuge in stoicism until religious belief had died away.

The truth, of course, is that religion can and does become definitely moral when the human mind rises to a belief in one Almighty God with whose will righteousness is of necessity identified. How the Hebrew branch of the Semitic family came by this belief (along with other peoples who, however, did not retain it) cannot at present be positively affirmed, but it is of exceeding interest to observe that the earliest idea of the moral will of God is connected with the instinct of self-preservation, to which we have traced the genesis of conscience. What in other races is the voice of tribal opinion condemning murder, is, among the Hebrews, regarded as the voice of God, "who at the hand of every man's brother will require the life of man." In this we see how records, old in themselves, and pointing back to tendencies and traditions lost in the mists of antiquity, identify the primitive rightness with the will of God, by whom first Nature, then man, then the family, then the society, had been established. And thus the will of the Creator has been by degrees definitely set up as the standard of right and wrong to which men must conform, so that the supreme effort of human morality is breathed in the prayer, "Thy will be done." And this accounts for the remarkable fact that the idea of conscience had little or no hold upon the Jewish mind. Modern theology bases religious belief mainly upon a supernatural origin of the conscience and a supernatural revelation as to the conditions of the future life. The Bible, for all practical purposes, has nothing to say about either of them.

To sum up, then, the result of our investigation, the conscience which we now possess is the primitive sense of a rightness due to one's self, resulting from the struggle for existence; extended to others as men entering into the social state perceived a likeness to themselves in their fellows; intensified and sanctioned by the urgent pressure of external law in the political state; becoming a law to itself as men became capable of forming abstract notions; and saved from egoism by the Christian development of the Hebrew monotheism.

Now the truth and adequacy of this statemant may be tested in two ways: Is it conformable to what we know to be true of evolution generally? and is it in harmony with the phenomena presented by the conscience now? It has been impossible to do more than here and there indicate an answer to the second question; but if opportunity offered it would be, I believe, easy to answer it at length by an examination of the operations of conscience in actual practice, and by surveying the conflicting forces, the curious survivals, the metaphysical theories, with which the word conscience is associated. Anyhow, the history of the conscience from an evolutionist point of view remains yet to be written.

But is this theory of its origin in harmony with evolution itself? How far, for instance, are we justified in using such words as "think," "say," "feel," or "law," "idea," and "consciousness," in describing the moral condition of primitive man? To this we must reply that the inchoate tendencies and slowly-deepening impressions which finally culminated in the phenomena described by words like the above, present an inward and personal aspect of the nature and progress of evolution which ought not to be overlooked. For the very method and circumstances of man's creation by evolution planted within him a consciousness from which, when acted upon by myriads of slowly-widening experiences, were evolved all the fundamental powers of his moral nature. Let us illustrate this position by the cognate example of the genesis of religious beliefs. These were developed, let us say, either from the worship of ancestors, or (according to the mythological theory) by personifying the operations of Nature. But it seems to me totally impossible that any merely external cause could have produced a belief so primitive, so powerful, so universal, so permanent, and above all so strongly marked by certain original and undeviating characteristics, unless they had been correlated with the consciousness of a creature in whom by the very law of his origin the Spirit of Evolution was always suggesting an unanswerable question: "Where wast thou when I laid the foundations of the earth? declare, if thou hast understanding." Primitive man had enough of philosophy to ask this question, and enough of science to attempt to answer it out of such materials as lay ready to hand; hence it is that speculations as to their own origin are common, if not universal, among savage races. As in religion so in morality. All the external impressions arising out of society, law, utility, and the like, were related to and conditioned by an innate sense of rightness in the individual, wrought in him by the power of evolution itself by which he was created. And thus we arrive at that inward and SPIRITUAL side of evolution to which I have endeavored to call attention, in the belief not only that justice remains yet to be done to it, but also that it contains a reconciling and adjusting element much needed amid the conflicts and misunderstandings of modern thought. But from the further pursuit of this thought I am obliged, however reluctantly, to turn away.—*Nineteenth Century.*

CIVILIZATION AND SCIENCE.[1]

BY PROFESSOR EMIL DU BOIS-REYMOND,
OF THE UNIVERSITY OF BERLIN.

PART III.

VIII.—PRUSSIAN GYMNASIUM EDUCATION IN THE STRUGGLE AGAINST THE PROGRESS OF AMERICANIZATION.

HOW are we to guard our youth against this debasing influence? The answer appears to be easy, and has often been given before. Let us set up the palladium of humanism against that natural science which would subject to dissection our ideals, which contemptuously re-

[1] An address delivered before the Scientific Lectures Association of Cologne. Translated from the German by J. Fitzgerald, A. M., and carefully revised by the author.

jects whatever it cannot bring into the cold light of reason, which would divest history of its profound interest, and would even tear away the veil which adds to the charms of Nature. As humanism rescued man from the prison-house of scholastic theology, so let it enter the lists once more to battle against the new enemy of harmonious culture. The gods and heroes of antiquity, with their immortal fascinations; the myths and stories of the Mediterranean nations, in which, as we might say, is enshrined all that is good and beautiful; the spectacle of a civilization which subsisted, it is true, without natural science, but out of which prominent men rose to a mental greatness hardly ever attained since—it is from the action of such influences as these upon the mind of youth that we can most confidently hope for victory in the struggle with the neo-barbarism which, though as yet its hold upon us is loose, is, from day to day, tightening its iron grasp. It is Hellenism that must ward off from our intellectual frontier the onset of Americanism.

But is it, then, possible to bring our youth into more intimate and more stable contact with classic antiquity than heretofore? In our old and tried gymnasia have we not most careful provision made for this very thing? What other country can boast of imparting so thorough and so learned a classical education, and that to so large a proportion of its youth, even of the less wealthy classes? Other enlightened countries of Europe have their eminent university professors, but the profoundly-erudite, unassuming, and hard-working *Oberlehrer* is a German type, of which the nation may well be proud. Thus not only do we hold the foremost rank in gymnasial education, but we even, in all probability, have reached the limits of the possible; and were there no other means of staying the decline of German idealism, save by increased study of Latin and Greek in the gymnasia, we could have but little hopes of checking the downward tendency.

It will now seem paradoxical for me to assert that more Latin and Greek certainly will not, but that perhaps a little less of them might, insure this result. In fact, if our gymnasia are not to promote Americanization, instead of counteracting it, I hold that certain reforms of the plan of study are imperatively necessary.

The gymnasial education of the youth of Germany, like the constitution of the army, exerts an enormous influence on German life. The gymnasium has gradually come to possess a simply despotic power over the family. For every educated citizen, therefore, who has himself made the gymnasium course, or who has sons in the gymnasium, it becomes a right and a duty to concern himself about the organization of those schools. Doubly is it his right to do this if, belonging to a learned profession, he has had opportunities of observing the results of gymnasium education. This is the case with myself. As a professor in the university, not only am I in constant relations with students in the early semesters, and frequently, through my public lectures, with those who are not studying medicine, but also, for upward of twenty-five years, as examiner for the state and for the Faculty, I have learned more or less accurately the educational standing of some 3,000 young men who had left the first class of the gymnasium from two to four years previously.

But there is a special reason why I should express my views about the organization of gymnasia. In 1869 the rectors and senates of the Prussian universities were invited by the Government to report on the question "whether and to what extent the pupils of the Realschulen[1] could be admitted, as well as those of the gymnasia, to the faculty courses of the universities." As being at that time Rector of the Berlin University, it fell to my lot to draw up the report of its senate. Not merely as reporter of the senate, but also with the warmth of personal conviction, I pronounced against the admission of the realschulen pupils, and took all pains to inculcate the importance of classical studies, for which nothing else could be substituted. In harmony with the senate, however, I even then insisted that, in taking sides with the gymnasia against the realschulen, one is not bound to look on the former as perfect—i. e., as not susceptible of, or not requiring, reformation in one point or another.

If I had now again to make a report in the same sense, I should find myself embarrassed. My opinion as to the advantages imparted by classical training is unchanged. My objections to making the pupils of the realschulen the peers of those of the gymnasia are as strong as ever. But the conviction has ever been growing in me that our present gymnasium education is no sufficient preparation for the study of medicine, nay, that as viewed from a general standing-point, it does not quite perform the task which it has proposed to itself. Hence I could no longer justify the exclusion of the realschulen pupils, at least from the medical classes, unless certain reforms were granted in the gymnasial plan of studies. Inasmuch as formerly, when placed in prominent position, I maintained a different opinion, I consider myself under a sort of obligation publicly to state my change of views, and to give the reasons therefor. Should that report come up for discussion in the course of the debates upon the education act, which we suppose will soon be laid before the Parliament, I, for my part, do not wish to be held answerable for it any longer. For the rest, of course I abstain here from an exhaustive discussion of this subject, and purpose simply to indicate in brief the direction in which I should like to see our gymnasial plan of studies modified.

I regret that, in the first place, I have to state an impression which has been steadily growing on me, that the humanistic education of the average medical student is, with us, sadly defective. Such is their unfamiliarity with Latin etymology, such the poverty of their Latin and Greek vocabularies—for instance, many of our medical students, a few years after passing the maturity examination, are unable to trace to their source Greek technical terms—that we can only conclude that

[1] Industrial schools.

these evidences of defective scholarship were glossed over at the time of the examination by some mechanical contrivance. How far these young men were familiar with the personages, the thoughts, and the forms of the ancient world, whether they had any sense of our dependence on the ancients, and of our being their intellectual descendants —for that is the sum and substance of humanism—I of course have had no opportunity for determining. Nor did I get any systematic information of their historical knowledge. However, their indifference toward broad ideas and historic sequence makes it difficult for me to believe that they are permeated with the spirit of antiquity, or that they had received a sound historical training.

To all this I must add another deplorable fact. For the most part these young people wrote in ungrammatical and inelegant German. Owing to the unsettled state of our orthography, our word-formation, and our construction of sentences, instruction in the mother-tongue is more difficult among ourselves than among people who have a settled usage in language. But the young people, as a rule, did not even suspect that any one could care about purity of language and pronunciation, force of expression, brevity, or pointedness of style. One is ashamed, as a German, of such barbarism as this, knowing what care instruction in the mother-tongue receives from the French and English, in whose eyes an infraction of its rules appears to be, as it were, a sacrilege. The more closely this blemish in our educational practice is connected with a deep-lying national defect, the more is it to be wished that the gymnasia had been successful in removing it. This neglect of the mother-tongue is, in the youth of the present day, accompanied by a lack of acquaintance with the German classics that is oftentimes astounding. Time was when, in Germany, no one any longer quoted from the first part of "Faust," because quotation had been overdone. Is the time now coming when it can no longer be quoted, because no one would understand the allusion?

With respect to instruction in mathematics, I know that but few masters succeed in advancing all their pupils equally. Clearly there are minds highly gifted in other respects, but to which mathematics is a book with seven seals. I would only remark upon the mathematical programme prescribed by tradition and convention for the highest class in our gymnasia. In a semi-official plan of studies this programme is given as follows: "Geometry of solids, with mensuration of surfaces and volumes; geometrical and stereometrical problems; problems in algebra, particularly in its application to geometry; indetermined equations; continued fractions; the binomial theorem." Though under "problems in algebra, particularly in its application to geometry," analytical geometry might be included, that branch is omitted from the gymnasial plan of studies by a ministerial decision of ancient date, but still in full force, and the mathematical programme of the highest realschulen surpasses in this respect that of the gymnasia.

Now, this I hold to be a serious error. The influence of mathematics as an educating force is not fully exerted till the student passes from these elementary studies to analytical geometry. No doubt, even simple geometry and algebra accustom the mind to strict quantitative reasoning, and to assuming as true nothing but axioms or demonstrated propositions. But the representation of functions by curves or surfaces opens a new world of ideas, and teaches us the use of one of the most fruitful methods whereby the human mind has increased its own powers. What the invention of this method by Viète and Descartes was to mankind, that will initiation into it still be to every mind that has any turn for such studies—namely, an illumination marking an epoch in life. This method has its roots in the profoundest depths of the human intellect, and hence is of far higher importance than the most ingenious analytical processes which are applicable only to a particular case. True, trigonometry is analytical geometry; as taught in the gymnasia, trigonometry, like stereometry, as both these terms indicate, has to do rather with mensuration, and its use is restricted to a certain class of problems. On the other hand, between any two quantities whatsoever, of which the one can be regarded as dependent on the other, there never exists a relation so complicated but that it may be represented by a curve; of this fact Quetelet has furnished an instructive demonstration—as, for example, where he represents by curves criminal tendency, literary talent, etc. This mode of representing the mutual dependence of things is of as much advantage to the government functionary and the political economist as to the physicist and the meteorologist.

But in medicine it is indispensable. In the preface to my "Untersuchungen über thierische Elektricität," which bears the date of March, 1848, I spoke in commendation of it as a means of bringing mathematics to bear on physiology, even in cases where the complexity is so great as to preclude the possibility of measuring, of weighing, or of calculating time. I then first laid an absciss-axis in a nerve, while Ludwig made the blood-circulation itself trace in curves its variations of pressure, and Helmholtz made the muscle in like manner trace its own contractions. Nowadays, thanks mainly to the labors of Marey, there is scarcely any department of experimental physiology or pathology that does not yield, through the graphical method, results of high importance. But, as our students of medicine may have quit the gymnasium without ever having so much as heard of a system of coördinates, I am compelled, at the opening of my lectures on physiology, to make my hearers acquainted with the elements of analytical geometry.

From the reasons assigned for the above-quoted decision of the ministry, whereby conic sections are excluded from the gymnasium course of study, it is plain that its author was unacquainted with the general scope of the branch of science he put under ban, and that he considered it as too difficult for the *prima*.[1] This is a mistake. On the contrary, there are minds which, though highly gifted, and of a philosophical turn, yet lack the sort of subordinate attention that is necessary in order, for instance, to carry out a long trigonometrical calculation, and which find themselves much more at ease in analytical geometry. The fact that analytical geometry prepares the way through the differential and integral calculus to the last and highest aims of mathematics, and hence to their most difficult portion, should only form one reason more for beginning the study of it in the gymnasium. And, not to pass by unanswered an objection which might be raised, I would remark that, owing to the flourishing state of mathematical instruction in our universities for a long time past, the present masters of mathematics in the higher classes of our gymnasia are, almost without exception, qualified to teach analytical geometry, and would even be glad were they authorized to teach that branch. Many of the highest living authorities in this department share in the views which I have here expressed. Then, too, in several gymnasia of non-Prussian Germany, analytical geometry is already taught.

I will not now dwell on the fact that the freshmen in our medical classes, who, in the course of their studies, and later, in the practice of their art, have to depend largely on a right use of their senses, bring from the gymnasium only a very defective training in this respect. I omit the consideration of this, because we have not to do here with the medical student as such, but only in so far as he typifies the student in general ; and I take him as a type because my observations on the work of the gymnasium are based principally on the results seen in him. Here the question arises, whether the gymnasium attains its end better in the case of students belonging to the other faculties. To a certain extent it does. With those who later devote themselves to the intellectual sciences, natural disposition and home-surroundings will oftentimes be more favorable to humanistic studies than with those who are impelled by hereditary realism toward medicine and the investigation of Nature. Besides, students of theology and jurisprudence are more favorably situated for retaining their humanistic culture than are students of medicine, who from their first semester have to do with a world of things which have no connection, save through their terminology, with classical studies. Hence the average degree of humanistic culture among medical students is a very good test for determining how far the gymnasium is in a condition to oppose the encroachments of realism.

But even when we take into account all the youths who receive a gymnasium education, however diverse their tendencies as regards branches of study, we do not find in them so quick an interest in classical studies as would justify us in seriously expecting from it a reaction in the idealistic sense. Not reckoning philologists, who of course are not within the scope of our remarks just now, there are but few stu-

[1] Highest class in the gymnasium.

dents, indeed, who in later years ever open an ancient author. So far from having any warm love for the classics, most persons regard them with indifference ; not a few with aversion. They are remembered only as the instruments by means of which they were made familiar with the rules of grammar, just as the only conception they retain of universal history is that of learning by rote insignificant dates. Was it for this that these youths sat for thirty hours weekly on a school-bench till their eighteenth or twentieth year? Was it for this that they devoted most of their time to studying Greek, Latin, and history? Is this the result for the attainment of which the gymnasium remorselessly englooms the life of the German boy?

In view of this state of things, we ask whether everything is going on aright ; whether it is not time, and whether it is not worth our while, to make an effort at reform? Here as elsewhere it is easier, especially for outsiders, to find fault than to determine how to repair the defect. Here, as is so often the case in complicated questions of administration and of human life in general, there are many causes in operation. We take into consideration one, while ten others of no less importance escape unnoticed. Still, though I expose myself to this danger, I will not refrain from expressing my views.

Without meaning any offense to the distinguished men who have taken an active part in organizing our gymnasia, or who are still so engaged, I cannot conceal my conviction that the spirit of the gymnasium does not sufficiently keep pace with the development of the human mind in modern times. As is evident from what has already been said, I am fully alive to the perils with which our intellectual culture is threatened by an excess of realism. At the same time, we cannot shut our eyes to the fact that natural science has given a new aspect to human existence. We should be imitating the ostrich in burying its head in the sand were we to deny the mighty revolution described above, and it were a vain and perilous thing to try to stop the rolling wheel of such a process of development. But hitherto the gymnasium has not taken this development sufficiently into account. Despite a few concessions, which are apparent rather than real, it is still what the Reformation made it, when as yet there was no natural science—namely, a learned school essentially designed as a means of preparing for the study of the intellectual sciences.

In this backwardness of the gymnasium and its refusal to comply with the demands of the time lies the strength of the realschule. I do not propose to enter here on the intricate question of the competencies proper to each of these two kinds of institutions. For the rest, I agree with the views of those who desire only one species of higher schools, which should fit their pupils equally for the university, the industrial or architectural academy, the army, etc. Plainly, this would be simply the humanistic gymnasium transformed so as to meet these new requirements. Apart from measures of administration, all that is needed to put an end to the rivalry of the realschule is, that the gymnasium should sacrifice to the needs of the time some of its time-honored but antiquated claims, and conform itself somewhat more to the tendencies of the modern world. So soon as the gymnasium becomes imbued *bona fide* with a new spirit, and insures fitting preparation even to those who devote themselves to other than intellectual sciences, this rivalry will cease of its own accord. The much-mooted question of the admission of realschulen pupils to faculty classes would thus be settled, for then the realschule would revert to its original intent, and be an industrial school—an institution of great importance in its proper sphere.

What, then, do I demand of the gymnasium so that it shall appear to meet the requirements of the time? Essentially, very little, indeed. First, I demand more mathematics. The mathematical course must include the discussion of equations of the second degree, and a few other plane curves, and must also give an introduction to differential calculus through the theory of tangents. To this end, a greater number of hours must of course be given to mathematics—six or eight, instead of four. In the examinations for advancement and graduation, mathematics must really stand on an equality with the ancient languages and history. The equality of the teacher of mathematics with the teachers of the other branches would in this way be made an actual fact.

It will now, perhaps, be expected that I will further demand a large increase in scientific instruction. But I do not at all purpose to convert the gymnasium into a school for science-teaching. All that I ask is that as much shall be done to meet the wants of the future physician, architect, or military officer, as those of the future judge, or preacher, or teacher of classical languages. Thus, I ask for only so much natural history in the lower classes of the school as will awaken the faculty of observing, and that facilities be given for familiarizing the lads with the method of classification, which is rooted in the depths of the understanding, and whose educational force is so eloquently described by Cuvier. Let Darwinism, of which I am myself an adherent, be excluded from the gymnasium. In the higher classes, for the reasons assigned in my report, I should like to have taught, not physics and chemistry with experiments, but mechanics, the elements of astronomy, also of mathematical and physical geography—to which studies one hour more than heretofore could be devoted without injury.

But how are we to find time for these innovations? In the *prima* two hours might be gained by doing away with the religious instruction. We cannot understand the use of such instruction in a class whose Protestant pupils have all been confirmed; and yet, in the semi-official plan of studies already quoted, more than half a page of fine print is expended in setting forth the subject-matter of this instruction, while five lines suffice to dispatch the mathematical programme. On reading this half-page and the corresponding half-page for the upper second class, one imagines he has before him the programme of a theological seminary. Even with the best intentions, it is not easy to see how "the reading of the Augustan Confession in connection with instructing in the differences between various symbols of faith" can form part of the general culture which it is the object of the gymnasium to impart to its pupils.

My second scheme for giving more room to mathematics and natural science will probably seem more objectionable, at least to a larger circle of people, than the first. I dare hardly express it, but I would restrict the study of Greek grammatical forms. My enthusiasm for the beauties of Grecian literature is assuredly not less than that of any German schoolman. But, unless I am greatly mistaken, the proper aim of studying Greek—namely, acquaintance with Grecian myth, history, and art, and being imbued with Greek ideas and Greek ideals—can be attained without the unspeakable labor—mostly labor in vain—which it costs to acquire the power of putting together a couple of Greek phrases. Surely neither Goethe when he wrote his "Iphigenie," nor Thorwaldsen when he modeled "The Triumph of Alexander," could write a Greek composition such as is written by the pupils in the lower second class of our gymnasia. If there is one Greek author whom all pupils read understandingly, and even with enthusiasm, and whom many of them hold dear and commit to memory, it is old Homer. And yet Homer's dialect is so different from that in which the *extemporalia*[1] are written that the practice gained by such exercises is of no account as far as his works are concerned. Hence without written exercises one can acquire such mastery of a dead language as is needed in order to read the authors who have written in it; and, as Homer, so, too, might the great Attic masters of style be read, the written exercises being restricted to preparation and translation. On a former occasion I gave utterance to the heretical opinion that our German style has been impaired by too extensive a study of the Greek. For exercising the intellectual faculties, and for awakening and developing a sense of the fundamental properties of a good style—namely, correctness, precision, and brevity of expression—there is no doubt that Latin with its limpid clearness, its rigorous precision, and its absolute definiteness of meaning, is a better object of study than Greek with its multitudinous forms and particles, the import of which is matter rather of skilled conjecture and artistic feeling than of logical analysis. Since the time when our system of gymnasium education assumed its present shape, our knowledge of the ancient world has undergone an almost entire transformation: barren philology has become the living science of that defunct world, and even daily our store of pictures of ancient life is enlarged by successful excavations. To one not versed in the study of pedagogy it would appear as though wonderful results might be attained here, just as in natural science, by the *demonstratio ad oculos*. Such a one is inclined to think the pupil would, by studying copies of antique

[1] Off-hand compositions.

works of art, in a few hours imbibe more of the true Hellenic spirit than he could by listening ever so long to dissertations on the aorist tense, the subjunctive and optative modes, and the particle ἄν.

In the teaching of history, the course of instruction which often loses itself in unimportant details—as, for instance, the party struggles of ancient Rome, or the rivalries of emperors and popes in the middle ages—I should like to see more fully illustrated than is usually the case, with general views of the state of civilization, exhibiting the heroes of science, literature, and art. The mass of very unprofitable dates which the young are required to commit to memory seems all the more pitiable when we remember that these pupils are suffered to remain ignorant even of the existence of the most important constants of Nature. Can it be that a knowledge of the date of an agrarian law, or of the accession of a Salico-Frankish emperor, is of more importance for a liberal education than is a knowledge of the combustion-heat of carbon or the mechanical equivalent of heat?

I have not time to enter on the question of the modern languages in the gymnasium. Besides, to me it appears to be a matter of greater moment to find out how we can secure for pupils in the gymnasia more thorough instruction in the mother-tongue. As I have already remarked, we have here to do with overcoming a national defect. But to discuss this point more fully here would carry us too far away; besides, I have already discussed it elsewhere.

So far I have spoken only of my own wishes. But I do not stand alone. I know of a large number of eminent men who share my views. Under the banner with the motto "Conic sections! No more Greek compositions!" I am sure I could assemble a meeting for gymnasium reform which would be formidable for the amount of intellect which would be there represented. I am very glad to find myself, as regards every topic of importance, in accord with my colleague, Prof. Adolph Fick, of Würzburg, who quite recently has written a paper entitled "Considerations on Gymnasium Education."

It were rash to attempt to penetrate the future in so complex a matter as this. But, in conclusion, to come back to the train of thought which led us up to this practical question, it appears to me that in such a reform of the gymnasium as I have here indicated is to be found the best security against the inroads of realism on our intellectual culture. The transformed gymnasium, again harmonized with the requirements of the period, will for the first time be fully equipped for the struggle with realism. Instead of burdening its pupils with classical studies till they turn from them in disgust, rendering them insensible to the charms of the Hellenic spirit, and giving them an aversion to humanism by the torturing drill in pedantic forms; instead of violently giving to their ideas a direction which sets them at variance with the world around, the gymnasium will insure to them an harmonious education in accordance with modern ideas. While based on an historic foundation, this education will at the same time embrace the elements of modern civilization in due measure. By itself giving free play, within certain limits, to realism, it will be all the better enabled to resist its encroachments. By yielding a little of its own, it will insure the safety of all the rest; and thus perhaps it will defend—if it is not already too late—the nation's treasure which has been intrusted to it, German idealism.

ARTIFICIAL PRECIOUS STONES.[1]

By CARUS STERNE.

ONE day, not long ago, the jewelers of Paris were in a high state of excitement, and justly so, for the news had reached them from the Academy of Sciences that two chemists, MM. E. Frémy and Feil, had discovered a process for the manufacture by the pound of certain kinds of precious stones ranking in value next to the diamond, and frequently commanding still larger prices than the latter—namely, the ruby, the sapphire, and the most precious of all, the Oriental emerald. At first the Parisian jewelers consoled themselves with the thought that the genuine stones would always be preferred to the artificial ones, but the excitement increased when it became known that MM. Frémy and Feil did not propose to imitate precious stones, but that their productions would be perfectly equal to the natural ones, and that a watch would run on their artificial rubies as well as on natural ones, because both of them were equally hard. Now the dealers in precious stones asserted that it was sinful to imitate Nature's work in that manner, and that the Government ought to prohibit it. On the other hand, a few enthusiastic *feuilletonistes* proclaimed that the discovery in question foreshadowed a still more important one—that of making gold and diamonds; that the dreams of the alchemists were about to be realized, and that poverty and wretchedness would be no more.

Of the prospect of poverty and wretchedness coming to an end we say nothing here. As for the transformation of lead and other base metals into gold and silver, we have to declare that this branch of alchemy is something altogether different from the manufacture of precious stones. Most of our modern chemists hold metals to be simple, immutable elements, which have always been what they are now, and which may change their form, but never their peculiar nature. Not so with precious stones, most of which, and especially those that are most highly prized, are of very lowly origin indeed. In the eyes of the chemist the ruby, the sapphire, the topaz, etc., are simply modifications of one substance (alumina), which, as *clay*, forms the greater portion of the earth's

[1] Translated from the *Gartenlaube*.

crust; and the diamond, which is the prince of all precious stones, is simply pure crystallized carbon, and so allied to charcoal, lampblack, etc. Other highly-esteemed precious stones, such as the emerald, the aqua-marina, and chrysoberyl, on the one hand, and the hyacinth, on the other, contain "earths" chemically related to argillaceous earth—namely, the former consist of beryl-earth, and the latter of zirconia; but these earths in themselves are neither rare nor precious, so that in some countries the streets are paved with the impurer brothers of the emerald. The same is true of all other precious stones, including pearls; in the main they are formed of substances of no value whatever, and to be found everywhere, such as argillaceous earth, silicic acid, fluor-spar, boracic acid, lime, magnesia, etc. Their only superiority consists in the fact that the common substance in them has reached an extraordinary degree of crystallization, for, aside from their beauty, their rarity enhances their value in the market.

Chemical combinations and simple substances of mineral as well as of organic nature assume their due crystal shapes, which are so well defined as frequently to bear a strong resemblance to those of cut stones, only when they pass from the liquid into the solid state, and they assume a large size only when this transition takes place very slowly. For instance, if we dissolve in hot water as much alum as can be dissolved therein, and suspend in the fluid, while allowing it to cool in a quiet place, a wire vessel—a basket, a rosette, or a crown, wrapped in wool—we shall find next morning that wire vessel covered with glass-like, transparent, more or less large, glittering octahedral crystals. Cold water is unable to hold in solution as large a quantity of the salt as warm water; and the surplus, as the temperature of the water decreases, has to separate slowly from it. In so doing, small crystals are formed. They grow constantly as the separation goes on, and, if we leave the solution exposed to the fresh air so that it slowly evaporates, we shall at last obtain very large crystals. If the alum contained an impure admixture of other salts, they would remain in the water. Crystallization, as a general thing, is also a purification of foreign admixtures.

In all probability, in Nature many precious stones have formed in the same manner; and most mineralogists concur in the opinion that rock-crystals, consisting of nothing but silicic acid, and frequently weighing hundreds of pounds, have originated thus. It is almost certain that this formation from liquids into solid bodies has taken place in a large class of half-precious stones, such as quartz and pyrites, consisting likewise of nothing but silica—namely, agate, jasper, opal, chalcedony, chrysoprase, carnelian, heliotrope, and others.

At the same meeting of the Parisian Academy where MM. Frémy and Feil described their process of manufacturing artificial rubies and sapphires, M. Monnier stated that he had obtained artificial opals by pouring a highly-diluted solution of oxalic acid cautiously upon a solution as thick as molasses of silicate of soda, which brings about a slow separation of the silicic acid. When, in so doing, he used a solution of the sulphate of nickel protoxide, he obtained apple-green stones, such as the chrysoprase. Thus we see that, as long as the process of separation lasts, we may talk of the growth of precious stones; and we perceive, from the laws of crystallization, how by the attraction of similar parts, and the exclusion of foreign ones, the formation of precious stones of perfectly "pure water" among the more impure ones, which are frequently found, becomes more intelligible.

Another process of crystallization is the slow cooling of molten substances. This can be explained very strikingly to students of chemistry if a kettle of sulphur or molten bismuth is cooled slowly, until it is covered with a crust of congealed matter, so to speak. Pierce that crust in the middle, and pour out a portion of the liquid, and there will form on the walls of the cavity thus created crystals of surpassing beauty, and the whole assumes the appearance of a so-called crystal druse, a form often assumed by amethysts and other half-precious stones. It has been thought that, to make artificial diamonds, it was necessary only to melt coal; but, unfortunately, the results thus far obtained are of no value.

Nature's most successful way of producing precious stones was not to dissolve minerals, but to put them into a fiery liquid condition, and to separate the new productions slowly from their former impure parts by chemical and electric influences, as we shall see directly. The earth, like the sun and most fixed stars at present, was undoubtedly formerly in a fiery, liquid condition. Then the elements were commingled; all substances met, and entered the strangest combinations; the whole globe was an immense chemical laboratory. The earthy substances with the light metals, at the last period of those gigantic processes, probably formed the "mother-liquor," from which, under various chemical agencies, there separated now valuable metals, now grains of gold, and still more frequently substances which were ennobled by crystallization. The "mother-liquor," cooled with its productions, we call primitive formations—granite, feldspar, porphyry, etc. It may here be stated that these primitive processes have recently been imitated in part, and that two principal components of feldspar, albite and orthoclase, have lately been obtained from a fiery, liquid mixture of minerals.

Precious stones so formed would be colorless if, in the terrible furnace of the primordial world, fire-proof metals had not taken upon themselves the task performed by aniline in our present dying-works. Long before there were colored plants and animals, metals played the part of pigments in Nature, and thus produced, in stones, colors almost surpassing in brilliancy those to be found in the animal kingdom. Rubies and emeralds are probably colored with chrome, sapphires with cobalt, lapis-lazulis with iron, and other precious stones with copper, nickel, manganese, etc. But we only have to refer our readers to the magnificent windows of Gothic cathedrals, with their gorgeous colors, produced by combinations of metals in the molten state. The false precious stones made in Paris with so much perfection from heavy strass-glass are colored with metallic oxides in as lasting a manner as the genuine stones.

The first precious stone reproduced, not only in its appearance, but its real nature, and in all its component parts, is the lapis-lazuli, the sapphire of the ancients, not to be confounded with the sapphire of our modern jewelers. This untransparent stone, of a magnificent azure-blue color, was most highly prized by the ancient Hindoos, Assyrians, Persians, Jews, Egyptians, Greeks, etc.; and this irrefragably refutes the erroneous theory of some archæologists that the ancients were unable to distinguish the blue color. When pulverized, this stone furnishes the surpassingly beautiful ultramarine color with which the artists of the middle ages delighted to paint the mantle or gown of the Virgin Mary, although they had to pay the most extravagant prices for the pigment, which they always charged in the bills of those who had ordered a sacred picture from them. Some fifty or sixty years ago, Gmelin, the German chemist, discovered that this most beautiful of blue colors could be artificially produced by heating argillaceous earth with soda, sulphur, and carbon; and now that Guimet, the French chemist, has practically introduced this process, Europe manufactures annually about 100,000,000 pounds of this pigment, most of which is produced in Germany.

At a very early period chemists devoted their attention to the artificial reproduction of rubies and sapphires, which, as we have said before, consist of nothing but crystallized argillaceous earth, colored by minute particles of metals. Several decades ago, the chemist Gaudin succeeded in obtaining small ruby pellets from pure argillaceous earth, precipitated from dissolved alum and moistened with chromate of potash. The color of these rubies, according to the quantity of chromate which they contained, was either that of a rose or bordering on purple. The pellets were so hard that they easily cut glass, garnets, and topazes; but they were not crystals, and their transparency was by no means perfect. Similar experiments were made by the chemists De Bray, Sainte-Claire Deville, Caron, Sénarmont, Ebelmann, and others. It was long acknowledged that a crystallization of argillaceous or beryl earth had to be obtained, and to that end it was necessary to reduce them with the requisite quantities of the coloring metallic combinations into a state of fiery liquefaction. Boric acid was selected for that purpose, because when heated it slowly evaporates. It appears as vapor in volcanic countries, and is especially obtained in Tuscany. The belief that this fiery means of reduction had played in Nature a part in the formation of precious stones was perfectly justifiable; and so boric acid was placed in comparatively large quantities with argillaceous or beryl earth in open platinum crucibles, which were subjected to a long-continued heat in porcelain furnaces. In fact, as soon as the larger portion of the boric acid has evaporated, there are evolved from the fiery, liquid mass small rubies, sapphires, or emeralds. This was discovered some twenty years ago, but the crystals were too small to make the process a remunerative one.

Far more satisfactory were the results of Frémy's recent experiments. They are based upon a different principle, namely, that of separating the argillaceous earth slowly from its usual combination with silicic acid, as it is found in Nature everywhere, by bringing to bear upon it a substance of stronger affinity for the acid. In consequence, small crystals of argillaceous earth are formed in the fiery, liquid "mother-liquor," which, in the course of further separation, grow slowly. In the glass-factories of M. Feil, quantities of this "mother-liquor" of precious stones, weighing from twenty-five to fifty pounds, were easily kept in a fiery, liquid state for two and three weeks, and in this way very favorable results were obtained. The most advantageous process turned out to be the separation of the argillaceous earth from the silicic acid by means of oxide of lead, for which purpose a mixture of equal parts of pure porcelain-clay and red-lead was placed in a large crucible of fire-proof clay and exposed for weeks to an intense red heat. Usually, the lead also extracts the silicic acid which the walls of the crucible contain, and eats holes through them. Hence, to avoid losses, the precious-stone crucible should be placed in another.

After several weeks of patient waiting, vividly recalling the expectant watching of the old alchemists at their crucibles in which the philosopher's stone was to be created, the crucible is taken out and cooled. After destroying the crucible, the contents are found to consist of two strata, above a glassy one, consisting principally of silicate of lead, and below a crystalline one, containing the most beautiful crystals of argillaceous earth in round clusters. If nothing but argillaceous earth and red-lead has been placed in the crucible, these crystals are as colorless as glass. They will cut glass and rock-crystal, nay, even the very hard topaz; in short, they are precious corundums or diamond-spar, so called because, next to the diamond and crystalline boron, it is the hardest of all stones.

Now rubies, sapphires, and Oriental emeralds, are nothing but colored corundums, and the former two can be easily obtained by the addition of the requisite quantities of the coloring metallic combinations. When there was added to the mixture of argillaceous earth and red-lead two or three per cent. of bichromate of potash, the crystals showed the beautiful rose-color of the ruby; when only a small quantity of that salt was used, and simultaneously a still smaller quantity of oxide of cobalt was added, sapphires were obtained. The precious stones thus produced, as a rule, are covered with a firm crust of silicate of lead, which is best removed chemically by melting it with oxide of lead or potash, or by means of hydrate of fluor-spar. Among a number of pounds of such crystals of argillaceous earth which the inventors submitted to the Academy, there were numerous pieces that could not be distinguished at all from natural rubies and sapphires. They possessed their crystalline shape, their weight, hardness, color, and adamantine lustre, although the latter was not altogether faultless.

How completely the imitation of Nature has succeeded, may be inferred from a peculiarity which the artificial rubies have in common with the natural ones: both, upon being heated, lose their rose-color, and do not recover it until they are cooled again. The diamond-cutters who were requested to grind these artificial rubies found them not only as hard as the natural ones, but in many instances even harder; they were not long in blunting their best tools made of the hardest steel. For the use of watch-makers they are, perhaps, better than the natural stones.

But jewelers, too, are certain, sooner or later, to derive a great deal of benefit from these discoveries. The rubies hitherto obtained, although very beautiful, did not equal the first-class natural stones; but they are only the first productions of a new process, and it is decidedly creditable to the inventors that they immediately divulged their method without trying to mystify the public. Now others, too, may follow up this new branch of a promising alchemy. Perhaps more time should be given to the crystals for their formation, for Nature had a great deal of time for such productions, and it was owing to this fact, perhaps, that it achieved such glorious triumphs. There can be no doubt but that, at some future time, these crystals of argillaceous earth will be colored also green, yellow, and purple, and that thus the precious stones, which were hitherto distinguished as Oriental emeralds, topazes, and amethysts, from inferior stones of the same name, will be produced. The addition "Oriental," in this connection, has no geographical meaning, and was applied by jewelers to the harder and better classes of emeralds, topazes, and amethysts. Perhaps these Oriental stones will be cheaper at an early day than the inferior ones, and the middle classes may wear as brilliant stones as princesses do now.

Diamonds, too, were the objects of similar processes, that is, by trying to bring about a slow separation of carbon from its combinations. However, Chemistry has to admit here that it cannot demonstrate, with any degree of accuracy, how Nature really produced the diamond. Some think that it could only have been formed at an enormously high temperature; others consider its very slow formation in a cold condition more probable; nay, there are scientists who regard it as the production of some organic agency, because there are frequently discerned in them green, cellular formations resembling certain algæ. In view of the rapid progress of synthetic chemistry, it might, perhaps, be as well for the diamond to maintain even in the eyes of chemists its time-honored name "adamas"—that is, *the indomitable one*. For what should the "fine lady" wear in the future if the prince of precious stones should follow the example of those standing closest to its throne, and allow itself to be reproduced for a few shillings?

THE TEREDO AND ITS DEPREDATIONS.[1]

By Dr. E. H. VON BAUMHAUER,

COMMISSIONER TO THE CENTENNIAL EXHIBITION FROM HOLLAND.

II.

CONTRARY to the opinion of Sellius, who regarded the teredos as hermaphrodites, Quatrefages has taught us that they are of both sexes and that the ratio of males to females is about one to twenty. The females are oviparous. The eggs are expelled by the branchial siphon: Quatrefages found them in that siphon and in the branchial canal itself. The mode of fecundation is, however, unknown; it is supposed that, in that act, two different teredos project their siphons and bring them in contact.

As regards the metamorphoses which the eggs undergo, either in the branchial tubes or in the water, nothing has been added to what was made known through the researches of Quatrefages in 1849. That naturalist has taught us that the eggs pass through the series of modifications, from the starting-point, which one meets with in the examination of all animals—i. e., the formation of the germinative area and of the vesicle of Purkinje, the disappearance of this and the breaking up of the vitellus. The eggs undergo their development in the branchial cavity of the mother; the embryos resemble very small, rounded animalcula of vesicular form, and are provided with vibratile cilia, by the aid of which they have regular movements, and probably are expelled from the branchial cavity into the siphon. In a third phase of development the bivalve shell is formed, the foot appears on the outside, the vibratile cilia form a sort of crown, and the embryo thus possesses the faculty of locomotion as well by creeping as by swimming. The development of the eggs takes place from time to time, and especially in the month of June, although even as late as the 29th of July Harting found eggs in all the teredos which he opened. The development of the eggs progresses very rapidly; in four days they pass out of the embryonic state, fully equipped for living in wood. Toward the end of June, Kater observed them in large numbers on the surface of wood, and by the 15th of July he found them in the interior in the form of perfectly-developed teredos. Even in the month of December, but no later, he saw young teredos enter into pieces of wood placed by

[1] Extract from the "Archives of Holland," vol. i., translated by Edward R. Andrews.

design in the water; at that time they were from eight to fourteen days old, and, although very small, they resembled in every respect older teredos.

Teredos penetrate wood naturally by very small openings in a direction perpendicular to the surface (Figs. 12 and 15, *C*); then they generally turn about in order to follow the direction of the woody fibres, usually upward, but sometimes downward. Although they do not enter into the earth or mud, one generally finds the first traces immediately above the line of the mud in which piles are driven; it is at this point that piles destroyed by the teredo generally break off.

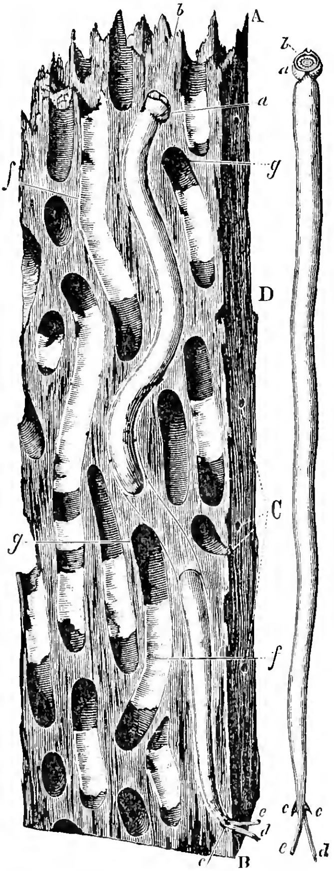


Fig. 12.—Wood exposed from November, 1874, to September, 1876, in crib at Pier No. 1, New York, North River, twenty-five feet below mean low tide.

When the teredos are lodged in a piece of wood, one recognizes them by very small holes on the surface, and the extremely delicate tubes which project from them (Fig. 12, *e*, *d*). These are the siphons, only one of which shows at first, the other appearing later. These siphons are generally kept outside the wood in the water, but the slightest touch causes the animal to retract them. One of them is shorter and larger than the other, but they both seem to serve for the expulsion of the fæces, which largely consist of particles of wood reduced to a very fine powder. It is known that the teredo does not perforate wood for nourishment, but only to procure a suitable abode; the woody substance, detached in the boring, passes through the intestinal canal, and then is expelled in the form of a very fine white substance by one of the siphons, generally, according to M. Vrolik, by the shorter, but sometimes by the longer. The long siphon appears to serve principally for the introduction of food, which consists of infusoria, diatoms, and other inferior animalcula, which the sea-water brings with it into the siphons. It is nevertheless still uncertain whether the matters expelled through the longer siphon come directly from the intestinal tube, or if they are first introduced from outside with the inflowing water to be expelled again after a short sojourn inside.

The teredo requires for respiration a clear, pure water. It has often been remarked that piles placed in dirty, muddy water, near drains, for example, are protected thereby. The water should have, moreover, a certain degree of saltness; the teredo cannot live in brackish water; that is a point to which we shall return later.

The teredo continues to grow in the wood; while the gallery which it forms presents near the surface a diameter of only one-quarter to half a millimetre, it enlarges little by little, until it reaches a diameter of five millimetres and more; as regards his length, and consequently that of the tube which incloses him, we have sometimes found it to be thirty to forty centimetres. He never goes upward more than half-way between the flow and ebb of the tide; although the teredo is thus, for a short time, partially above the water, yet it appears that the wood holds a sufficient amount of moisture to sustain his life temporarily.

The researches of Kater have still further shown, what had already been remarked by Sellius, that the teredo can hibernate in the wood, and that it is those individuals, thus preserved, which in the spring go through with all the phenomena of reproduction—i. e., the formation of eggs, fecundation, development, and expulsion of the young.

The part of the external integuments which constitutes the mantle deposits a calcareous matter, forming an interior lining to the gallery in the wood (Fig. 12, *f*); between this calcareous casing and the body of the animal there remains a space sufficient to prevent any inconvenience, at least during the act of respiration; for it is possible that when the teredo absorbs water, which serves for respiration, his body is distended, and fills exactly the calcareous tube. The form of this tube, secreted little by little, corresponds exactly with that of the gallery, which has been slowly perforated in the wood; it has the appearance, also, of a series of rings placed one against the other. As the animal progresses, a new ring is added to those which existed before, so that when the tube is closed at its extremity by a calcareous film, its length represents the total length of the animal (Fig. 12, *b* to *c*). Among the segments of the tube, those which are nearest the surface of the wood are the oldest and hardest; in the interior of the wood, where the gallery ends (Fig. 12, *g*), the calcareous ring, newly formed, is at first soft, flexible, and of slight consistency; later, it becomes solid, and closes up the tube, as has been remarked by Sellius. In the variety of teredo described by us, we have never observed the formation of two openings surrounded by calcareous matter, situated side by side, like an eight placed sidewise, ∞,[1] and serving as a passage for the siphons, as described by Deshayes.

The calcareous tube, once formed, constitutes for each teredo his own abode, where he isolates himself from his companions, and has nothing to fear from their close proximity. One never sees a teredo pierce the tube of another. The tubes make their way side by side,

[1] Some Oriental varieties have this form. I have seen them at the Boston Institute of Technology, with solid tubes one and a half inch in diameter.—TRANSLATOR.

and cross each other in every direction, but, be the wood ever so worm-eaten, there always remains a woody wall, often very thin, it is true, between two adjoining tubes.

The very existence of the adult teredos seems dependent upon the wood. Withdrawn from their galleries and placed in sea-water, they could be kept alive by Kater scarcely more than three or four days. Left in the wood, but taken out of sea-water, they would die within twenty-four hours. Deprived at the same time of contact with wood and sea-water, they perished at the end of one or two hours. In damp wood, that is, wood soaked with salt-water, their existence is prolonged somewhat. Wood and sea-water are, then, both necessary. If these two conditions of existence are furnished them, one can, Kater assures us, keep them alive during several months.

The teredo does not always remain in peaceable enjoyment of the home he has constructed, and the nourishment the water brings to him. He finds himself exposed to the attacks of an enemy, of an annelide to which the late M. W. de Haan has given the name of *Lycoris fucata* (Fig. 13). In our day, as well as at former epochs, this annelide is constantly found wherever the teredo exists. His eggs and embryos are met with in the midst of those of that mollusk.

Fig 13.

Kater has remarked that the adult annelide, leaving the muddy bottom, where he has hibernated, and in which the piles are driven, climbs along the surface of the wood toward the opening made by the teredo; there he sucks away the life and substance of his victim; then, slightly enlarging the aperture, he penetrates and lodges in place of the teredo. Later the annelide reappears and seeks for new prey. All the early writers on this subject state that they have found this annelide in wood at the same time with the teredo. It is remarkable that a similar annelide, and perhaps the same, has been found in the cavities hollowed out in stone by the *pholades*.

It is important that it should be generally understood that this annelide is not only harmless, but renders the greatest service in devouring the wood-destroyer. It is a narrow annelide, ten to fifteen centimetres long, provided on his sides with a great number of small feet terminated with a point and garnished with hairs and showing in front a pair of strong upper jaws, horny and sharp, and lower jaws bent backward in form of hooks and carried outside by the aid of the lower lip, which is developed somewhat like the finger of a glove turned backward. Behind the head are four pairs of tubular-formed gills. With these weapons the annelide pursues and devours the teredo. The observations of Kater teach us that he is generally found in the empty galleries with the remains of the teredo; sometimes even he is seen as if clothed with the integuments of the teredo, while he is occupied in ransacking his intestines. Once Kater had the rare chance (which, by-the-way, only secures such good fortune to very careful observers) to seize the moment when an annelide, coming out of one of the openings of wood, at once took possession of a teredo that he had placed on the bottom of the vessel which held the wood. He saw the annelide seize the teredo with his jaws, draw him into the canal which he occupied, and devour him so completely that there only remained the two valves of the shell.

It is in an entirely different manner that the cirripeds (*Balanus sulcatus*) aid in preserving wood. When these animals, to which sailors and the inhabitants of our coasts give the name of *Pustules of the Sea*, or *Sea-Thorns*, multiply to such an extent on the surface of wood that their disks touch, without leaving the least vacant space, the natural consequence is, that the young teredo cannot find any place where it can attach itself, and hence it is impossible for him to penetrate the wood. This preservative effect is produced even when the shells have fallen, provided the disks adhere to the wood.

III.

On the Circumstances which favor the Ravages of the Teredo.—The commission gave in its first report an historical epitome of the injuries done by the teredo at different epochs in Holland.

When the teredo was remarked for the first time, an idea prevailed that it was imported from abroad; vessels coming from the East Indies were accused of having brought that destructive guest. Two facts show the incorrectness of this idea. On the occasion of the deepening of the Dumbart Dock at Belfast, William Thompson[1] found, twelve feet below the surface of the earth, in a blue, argillaceous soil, the trunk of a tree entirely riddled by the teredo. Considering the depth at which this *débris* was found, and the fact that it lay beneath a series of strata of shells, it is certain that it was deposited there ages ago, long before a vessel, coming from the East or West, could touch the coast at Belfast.

Fossil wood, perforated by the teredo, has been found in different localities: for example, in the London clay, in the Eocene formations at Brussels, where Van Beneden discovered fossil wood, inclosing the remains of the teredo; and at considerable depth, also, near Ghent, at the time of the construction of the citadel.

The teredo existed in a geological period earlier than our own, and he appears to have been always an inhabitant of our coast. Why is it, then, that at certain epochs, as in the years 1730, 1770, 1827, 1858, and 1859, he multiplied so prodigiously as to destroy entire dikes in a very short space of time? Even as early as 1733, Massuet assigned as a cause an increase of the degree of saltness of the water, resulting

[1] W. Thompson, on "The *Teredo navalis* and *Limnoria terebrans*," in Edinburgh *New Philosophical Journal* for January, 1855.

from a diminution in the quantity of the rainfall; the same opinion is found expressed in the reports of many chief engineers of Waterstaat. To decide whether this opinion was well founded, careful analyses were made in 1859, which, compared with those made at other epochs, showed that the proportion of salts found in the water of the Y was just double what it was in 1855, and a third more than in 1825.

. . . .[1]

The three circumstances, under which this exceptional increase of the teredo was observed, were a moderate rainfall, and, as a direct or remote consequence, a falling of the level of the rivers, and an increase of the saltness of the water of our arms of the sea. As an additional favoring circumstance should also be noted an increase in the temperature.

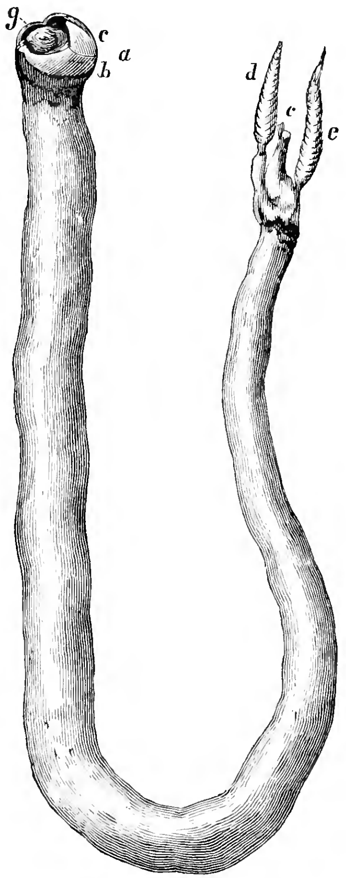


FIG. 14.—This cut was made from a *Teredo navalis*, taken from a pile exposed two seasons (1876 and 1877) at Horn Island, Gulf of Mexico. When first taken from the wood it was eighteen inches long.

IV.

EXPERIMENTS IN THE PRESERVATION OF WOOD FROM THE ATTACKS OF THE TEREDO.—To justly appreciate the experiments tried by the commission, it must be borne in mind that when it was discovered, in 1858 and 1859, that great injury was being done to our marine works by the teredo, very many methods of preservation were recommended on all sides to the Government, and that the nature of many of these remedies was kept secret by the persons extolling them. In order that its labors should offer every guarantee of impartiality, and although convinced in advance of the inefficacy of a large number of the means proposed, the commission decided not to lay aside any without a trial. Moreover, as far as possible, it had the pieces of wood to be experimented with prepared by the inventors or proposers of the processes, in order to protect itself from every accusation of unfairness.

The experiments were made the first year in the ports of Flessingue,

[1] Several pages omitted, of no especial interest to American readers, describing local observations of the state of the water and atmosphere, and analyses of the waters, to show their chemical character.

Harlingen, Stavoren, and Nieuwendam, and afterward in the ports of Nieuwe-Diep and Stavoren. The woods employed were oak, red fir, ordinary fir, and *Pinus sylvestris*, generally in pieces one metre long by two or even three decimetres square. These blocks were prepared in different ways, and care was taken to place by their side blocks of the same kinds of wood without any preparation as counter-proofs.

The trials made by the commission may be placed under three principal groups:

1. Coatings applied to the surface of wood, or modifications of the surface itself.

2. Impregnation of wood with different substances, which modify the interior as well as the surface of the wood.

3. Employment of exotic woods, other than ordinary woods of construction.

Coatings applied to the Surface of Wood.—The methods belonging to this group, which have been examined by the commission, are the following:

1. Method invented by M. Claasen, and kept secret by the inventor.

2. Metallic paint, invented by M. Claasen and likewise kept secret.

3. Method of M. Brinkerink, consisting of a mixture of Russian talc, coal-tar, resin, sulphur, and finely-powdered glass, applied hot on wood previously roughened by a toothed instrument; this application was two millemetres thick.

4. Method of M. Rijswijk, analogous to the preceding.

5. Paraffine varnish, obtained by the dry distillation of peat, from the factory of MM. Haages & Co., at Amsterdam.

6. Coal-tar, applied cold on the wood in several successive layers, or applied hot on wood whose surface had been previously carbonized. Some pieces were treated as follows: Holes were first bored in them and filled with tar, then plugs were fitted closely to the holes and driven in with sufficient force to make the tar penetrate the wood; other pieces still were painted over with a mixture of tar with sulphuric acid, or sal ammoniac, or turpentine, or linseed-oil.

7. Painting with colors mixed with turpentine and linseed-oil—among others with chrome-green or with verdigris.

8. Singeing or superficial carbonization of the wood.

The pieces of wood thus prepared were placed in the water at the end of May, 1859, and the first examination, made toward the end of September of the same year, showed that neither of these methods afforded any protection from destruction by the teredo. There was one partial exception, and that was the pieces of wood treated according to No. 6; these showed only traces of the teredo here and there. But, at a later examination, in the autumn of 1860, when the wood had been exposed a year and a half, these were also found to be equally severely attacked by the teredo.

The results of these experiments strongly convinced the commission that no exterior application of any nature whatever, or modification of the surface merely, would give any efficacious guarantee of protection against the teredo. Even supposing that one or another of these means would prevent the young teredos from attaching themselves to the wood, yet the constant friction of the water or ice, or any accident, might break the surface of the wood sufficiently to give access to the teredo.

This seems a proper place to mention a practice in general use in Holland for warding off the teredo: this consists in covering wood with a coat-of-mail made of nails. This operation is very costly; for, to really protect wood in this way, it is important that the square heads of the nails join exactly; for insuring the best results, the armored piles are exposed in the open air for some time before being placed in the water, that rust, forming on the surface of the iron, may close up the interstices inevitably remaining between the heads of the nails. But this precaution is not infallible, as the commission examined piles more than once, in the course of its investigation, which had been several years in the water, and whose surface was entirely incrusted with rust more than a centimetre thick, but which were, nevertheless, eaten in the interior by the teredo.

Sluice-gates are frequently covered by sheets of iron, copper, or zinc. It is evident that, so long as such covering remains intact, there is no cause for anxiety on the score of the teredo. Unfortunately, experience has taught us that this protection is not permanent, but is rendered ineffectual by being broken by the force of the water or blocks of ice.

Nature affords sometimes, as we have seen above, a more efficacious protection in covering wood with barnacles or other shell-fish, with the condition that this covering be made before the young teredo attaches itself to the wood. Facts of this sort have led Lehmann to propose the planting on wood of the common mussel (*Mytilus edulis*).

IMPREGNATION OF WOOD WITH DIFFERENT SUBSTANCES. — The commission examined in this category the following methods:

1. *Sulphate of Copper.*—The impregnation of the blocks with this salt was performed at the factory of MM. Van der Elst and Smit, at Amsterdam. Experience proved, even in the first summer (of 1859), that this preparation had absolutely no power against the teredo. Nevertheless, to make sure that the failure of this experiment was not due to insufficient preparation, the commission procured from the establishment of M. Boucherie, at Paris, two pieces of beech-wood covered with its bark, two pieces of beech without bark, and two pieces of pine, all prepared with sulphate of copper. These blocks, when exposed, did not resist the teredo any better than those prepared at Amsterdam. These trials completely confirmed the results obtained by the engineer Noyon ("On the Inefficacy of the Boucherie Process in Sea-Water," *Annals of Bridges and Roads*, April, 1859).

2. *Sulphate of Protoxide of Iron* (*Green Vitriol*).—The blocks were

impregnated with this salt at the establishment of MM. Van der Elst and Smit. The first summer proved that this method would not in the least prevent the wood from being destroyed by the teredo. And the same was true of the following method :

3. *Acetate of Lead.*—The blocks impregnated with this salt were prepared at the same establishment.

Surprise may be expressed that the commission did not try experiments with corrosive sublimate. It felt that it could dispense with them, as its inefficacy had already been sufficiently established by previous experiments on a large scale at the marine dock-yards at Rotterdam. Experiments with mercurial and arsenical salts were tried, in 1730 and later, but without satisfactory results.

4. *Soluble Glass and Chloride of Calcium.*—Pieces of oak and red fir were impregnated at the same establishment at Amsterdam, first with a solution of soluble glass (silicate of soda), and afterward with a solution of chloride of calcium; the object of this double impregnation was to produce in the pores of the wood a silicate of lime. The pieces thus prepared were left in the open air during six months before being placed in the water, in order that the chemical combination might be as complete as possible. These pieces were exposed in the water at Nieuwe-Diep, in March, 1862, and

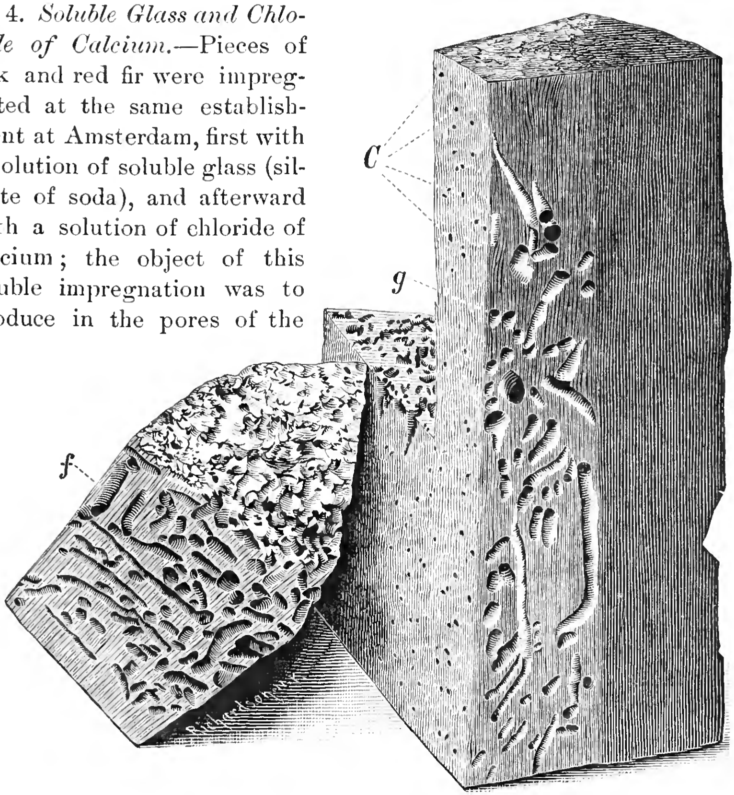


FIG. 15.—This cut was made from a piece of pine-slab, partially creosoted and exposed one season (1877) in the Gulf of Mexico. Only the dark-colored portion on the right side of the block was creosoted for this experiment. The rest of the block, *untreated*, was entirely riddled by the *Teredo navalis*, up to the edge of the creosoted portion, but that the destructive marine worm carefully avoided.

when withdrawn, in October of the same year, the preparation was found to be powerless as a protection against the teredo.

5. *Oil of Paraffine.*—The firm of Haages & Co., at Amsterdam, delivered to the commission some pieces of oak and red fir injected with a substance produced by the dry distillation of peat, to which they gave the name of *oil of paraffine.* In the month of July, 1860, the commission placed at Stavoren and Nieuwe-Diep ten pieces thus prepared. They were examined in the course of the same year, after they had passed one summer in the water, and it was found that they had resisted the attacks of the teredo.

The commission conducted all its experiments thus: They placed in the water ten pieces of each variety of wood, treated according to the prescribed method, so that they could withdraw each year, during ten consecutive years, one of the pieces to be submitted to examination. In making the examination, they removed with an adze the outside of the wood to a depth of some millimetres, which was sufficient to show the galleries of the teredos, if there were any. The pieces found intact were replaced in the water, and the following year their condition was tested in the same way, by removing the shavings as before. By this plan the commission felt certain that, if the blocks were not injured by the teredo during several successive years, they did not owe that protection to a superficial covering, but that the wood itself resisted the destructive efforts of the teredo, and that there would be no reason for fearing that piles, prepared in a similar manner, would, at any time, lose their power of resistance, when injured on their surface by water or ice, or by slow dissolution of the active principle of the preservative substance.

When the pieces of wood treated with oil of paraffine were taken from the water in 1862, after a sojourn of more than two years, or rather during three summers, traces of the teredo were found in the pieces of oak, but not on those of red fir; but when examined in November, 1863, fully-developed teredos were found everywhere, in the fir as well as in the oak, in the pieces whose surfaces had been removed by the adze, but not more than in those which had not been submitted to any examination.

6. *Oil of Creosote.*—This is, as is very well known, a product of the dry distillation of coal-tar, separated by distillation from the more volatile parts, which serve for the preparation of benzole and naphtha, the residuum being pitch. Experiments had already been tried abroad, as well as in Holland, with this substance, and from the beginning of their experiments the commission paid especial attention to this very important method of preparation.

Wood of various kinds, prepared with creosote-oil at the works of the Society for the Preparation and Preservation of Wood, at Amsterdam, was placed in the sea in the month of May, 1859, at Flessingue, Harlingen, and Stavoren. In the month of September following, at

Flessingue, the pieces of oak, pine, and red fir, were found intact, while those unprepared were perforated. In the month of October, of the same year, the pieces of creosoted pine and fir at Harlingen showed a perfect state of preservation. At Harlingen the treated and untreated pieces were fastened together; the teredo penetrated the latter, but had not touched the creosoted wood. The same was true of the creosoted wood exposed at Stavoren, when visited in 1859.

At Nieuwendam, in March, 1859, three pieces each of oak, pine, and red fir, all creosoted at Amsterdam, were exposed in the sea. They were examined in September of the same year. They had been fastened together by cross-pieces of unprepared wood: it was found that the teredo had penetrated, at the juncture of these cross-pieces, even into the creosoted wood, and that sometimes he stopped immediately beneath the surface, at others he penetrated to a depth of several millimetres; in the oak, he worked his way into the interior through those parts of the surface which were not in contact with the unprepared wood.

Experiments with creosote-oil were recommenced in July, 1860, with ten pieces each of oak and red fir, following the plan indicated in paragraph 5; the localities chosen were Nieuwe-Diep and Stavoren; in the latter place the pieces which remained intact the previous year were again placed in the water after their surface had been removed by the adze. Still later, in August, 1861, a further trial was made at these same places with pieces of pine, beech, and poplar, sent to the commission by Mr. Boulton, and prepared at his works in London.

All these pieces were examined toward autumn in 1862, 1863, and 1864; while the unprepared pieces, placed near the others as counterproofs, were found each year filled with teredos, one could not discover any traces of the teredo in the creosoted pieces except in the oak creosoted at Amsterdam; in cutting these, it was found that the creosote had penetrated them very imperfectly.

A third examination, in 1864, showed that all the pieces prepared by Mr. Boulton, and which had been exposed in the sea since August, 1861, were entirely intact; the most careful examination could not show the slightest trace of the worm, even in the pieces withdrawn from the water in 1862 and 1863, and each time scraped to a depth of several millimetres and again placed in the water. They resisted the attacks of the teredo perfectly.

An equally favorable and decisive result was obtained from the pieces of fir creosoted at Amsterdam. Notwithstanding they had been exposed in the sea since July, 1860, during five consecutive summers, nothing could be discovered which resembled the galleries of the teredo: one of the pieces, at a point where the color of the wood indicated an insufficient penetration of the creosote-oil, showed a very slight worm-eaten appearance; but the absence of the calcareous deposit, and the whole character of the opening, indicated clearly that it should be attributed to some other animal than a teredo.

As to the unprepared pieces, there only remained small ends, which reached above the water. All the rest was converted into a spongy mass, which broke at the slightest effort.

The experiment with the creosoted oak was less satisfactory. In all the pieces were found, here and there, galleries of the teredo, but always in small numbers; in sawing the wood, it was found that the injuries were invariably in those parts where the color showed that the oil had not been able to penetrate. Although, as far as is known, no effort has been made elsewhere to preserve oak from the teredo, the commission places great value upon experiments with this wood. In fact, for many marine works, oak cannot be replaced by any soft wood which absorbs creosote-oil easily. Hence, the commission has had creosoted at Amsterdam, by a newly-perfected process, some pieces of oak, which were exposed in 1864 at Nieuwe-Diep; these will not be examined until tested during three summers.[1]

Petroleum has also been recommended to the commission, but it was not deemed worth while to experiment with it, especially on account of its high price; even although petroleum should prove to be as efficacious as creosote-oil for protecting wood against the teredo, its price would prevent its use for that purpose.

Experiments with Exotic Woods, other than Ordinary Woods of Construction.—The commission has not been able to make many experiments in this direction. It acquired a certainty that the greenhart of Surinam, the bulletrie, the American oaks, and wood as hard as *mamberklak*, are not spared by the teredo. The commission received a large piece of the wood of guaiacum, which had been five or six years in the water at Curaçoa, and was found to be entirely eaten by the teredo—an evident proof that even the hardest woods are not safe from the attacks of that mollusk.

The commission has received, it is true, many communications relative to different kinds of woods known to be poisonous to fish, but it has not had an opportunity to experiment with them. We await some light on this point, from researches which the Government has ordered to be made at our possessions in both the East and West Indies.

Conclusions.—By way of recapitulation, the results of the experiments, tried by the commission during six consecutive years, were as follows:

1. The different coatings applied to the surface of wood, with the design of covering it with an envelope on which the young teredo cannot attach itself, offer only an insufficient protection; these coverings are likely to be injured either by mechanical means, such as the action of the water, or by being dissolved by the water. Just so soon as

[1] American oaks of coarse, open fibre are easily impregnated.—Translator.

a point of surface of the wood is uncovered, be it ever so small, the teredo, still microscopic, penetrates into the interior. Covering wood with sheets of copper or zinc, or with nails, is a too expensive process, and only protects the wood so long as they form an unbroken surface.

2. Impregnation with inorganic, soluble salts, generally considered poisonous to fish and animals, does not protect wood from the attacks of the teredo. This want of efficacy must be attributed in part to the fact that the salts absorbed by the wood are extracted by the dissolving action of sea-water, and in part, also, because those salts do not appear to have a poisonous effect upon the teredo.

3. Although we do not know with any certainty if, among exotic woods, there may not be found those which will resist the teredo, we can affirm that hardness is not an obstacle which prevents that mollusk from perforating his galleries; the ravages observed in the wood of guaiacum and *mamberklak* prove this.

4. The only means which can be regarded with great certainty as a true preservative against the injury to which wood is exposed from the teredo, is the oil of creosote ; nevertheless, in employing this means, care is necessary that the oil be of good quality, that the impregnation be thorough, and that such woods be used as will absorb oil readily.[1]

The conclusions arrived at by our commission are confirmed by the experience of a large number of engineers in the Netherlands, and also in England, France, and Belgium. M. Crepin, a celebrated Belgian engineer, expresses himself thus, in a report on experiments tried at Ostend, under date of February 5, 1864:

> "The result of our experiments now seems decisive, and we think we can draw from them this conclusion: that soft woods, well prepared with creosote, are protected from the attacks of the teredo, and are in a condition to assure a long duration. The whole matter, in our opinion, is reduced to a question of thorough impregnation with good creosote-oils, and the use of such woods as are adapted to the purpose. It has been found that resinous[2] woods are impregnated much better than other varieties."

M. Forestier, a French engineer at Napoléon-Vendée, in a report dated March 3, 1864, makes a *résumé* of experiments conducted by himself in the port of Sables-d'Olonne, in the following words:

> "These results fully confirm those established at Ostend, and it seems to us difficult to refuse to admit that the experiments at Ostend and Sables-d'Olonne are decisive, and prove in an incontestable manner that the teredo will not attack wood properly creosoted."

Under date of Haarlem, April 20, 1878, Prof. Von Baumhauer writes to Edward R. Andrews, of Boston:

> "I have deferred answering your favor of the 22d of February until I had

[1] The efficacy of creosote-oil in protecting wood from decay and marine worms is largely due to the fact that it is insoluble in water.—E. R. A.

[2] The yellow pine of the Southern States absorbs oil very readily.—E. R. A.

corresponded with the chief-engineers of the Waterstaat as to the results obtained in their experience in the use of cresoted timber in all our marine works, in large quantities and during some tens of years. They all unanimously agree that the teredo will not penetrate timber thoroughly impregnated with creosote; but that, to obtain the best results, the work must be thorough, as they had observed that the teredo had destroyed piles only superficially injected.

"Fir, if the sap be first withdrawn in a vacuum and then treated with hot oils under a heavy pressure, can be most thoroughly creosoted; but oak is more difficult. Still, I have often seen heavy oak-piles where the creosote had entered into the very heart.

"Creosoted wood is also used in our country for railway-sleepers and tramways, and everywhere with the best results. They last four or five times longer than when unprepared, while experience shows that wood treated with sulphate of copper or chloride of zinc (Burnettizing) is neither protected from the teredo nor the influences of humidity and of the atmosphere."

SCIENCE IN THE ENGLISH SCHOOLS.

THE rejection of Sir John Lubbock's motion for the addition of elementary science, or, rather, as the matter was more happily put by Dr. Lyon Playfair in the course of the debate, of elementary knowledge of common things, to the subjects for which grants are given under the education code, although an inevitable and foregone conclusion, is not on that account the less to be deplored. As happens in many similar cases, the argument was all on the side of the minority, and Lord G. Hamilton, in opposing the suggestion on the part of the Privy Council, was only able to say that its adoption would, perhaps, entail some temporary uncertainty about the subjects in which inspectors would be required to examine and children to pass. If schools existed for the convenience of inspectors, or oven in order that children might not be troubled by uncertainties, the objection would have been a valid one; but upon any other supposition it seems to tell against, rather than in favor of, the contention which it was intended to support. The nation is spending large and rapidly-increasing sums of money upon schools, and it will every year become a matter of greater urgency that these sums should not be misapplied, either by the omission from the code of subjects which would be useful or by the inclusion of others which have no apparent tendency to promote the attainment of the ends to which education is supposed to be directed. These ends, in the case of a peasant-child, are presumably to render him a more useful and a better conducted member of society than he would become by the unaided light of Nature; and it is obvious that the means to their attainment are twofold—first, to cultivate the intelligence in such a way as to facilitate the acquirement and the application of knowledge; and, secondly, to impart the knowledge which has to be applied. Until a comparatively recent time, however, the imparting of knowledge was considered to be the sole purpose of education, and to be in itself the best means of mental training; so that educationists occupied themselves more about the seed than about the soil, and were chiefly concerned to teach those things which they thought it most important that a child should know. The instruction given to the poor for many years was almost limited to reading, writing, arithmetic, and elementary religious instruction, while that imparted to the rich was laid upon the same foundation, and was only carried further because the pupils had more time at their disposal. In the employment of this time the instructors could only teach what they knew; the most famous public schools and the two great universities restricted themselves to giving their pupils some knowledge of classics and mathematics.

As soon as physiologists had discovered that all the faculties of the intellect, however originating or upon whatever exercised, were functions of a material organism of brain, absolutely dependent upon its integrity for their manifestation, and upon its growth and development for their improvement, it became apparent that the true office of the teacher of the future would be to seek to learn the conditions by which the growth and the operations of the brain were controlled, in order that he might be able to modify these conditions in a favorable manner. The abstraction of the "mind" was so far set aside as to make it certain that this mind could only act through a nervous structure, and that the structure was subject to various influences for good or evil. It became known that a brain cannot arrive at healthy maturity excepting by the assistance of a sufficient supply of healthy blood—that is to say, of good food and pure air. It also became known that the power of a brain will ultimately depend very much upon the way in which it is habitually exercised, and that the practice of schools in this respect left a great deal to be desired. A large amount of costly and pretentious teaching fails dismally for no other reason than because it is not directed to any knowledge of the mode of action of the organ to which the teacher endeavors to appeal; and mental growth in many instances occurs in spite of teaching rather than on account of it. Education, which might once have been defined as an endeavor to expand the intellect by the introduction of mechanically compressed facts, should now be defined as an endeavor favorably to influence a vital process; and, when so regarded, its direction should manifestly fall somewhat into the hands of those by whom the nature of vital processes has been most completely studied. In other words, it becomes neither more nor less than a branch of applied physiology; and physiologists tell us with regard to it that the common processes of teaching are open to the grave objection that they constantly appeal to the lower centres of nervous function, which govern the memory of and the reaction upon sensations, rather than to those higher ones which are the organs of ratiocination and of volition. Hence a great deal which passes for education is really a degradation of the human brain to efforts below its natural capacities. This applies especially to book-work, in which the memory of sounds in given sequences is often the sole demand of the teacher, and in which the pupil, instead of knowing the meaning of the sounds, often does not know what "meaning" means. As soon as the sequence of the sounds is forgotten nothing remains, and we are then confronted by a question which was once proposed in an inspectorial report: "To what purpose in after-life is a boy taught if the intervention of a school vacation is to be a sufficient excuse for entirely forgetting his instruction?"

In order to avoid such faulty teaching, few agencies are more valuable than what are technically called "object" lessons, in which the faculties of the pupils are exercised about things instead of about words; and the suggestion of Sir John Lubbock would lead to object lessons of a very useful character. To be taught something about gravitation, about atmospheric pressure, about the effects of temperature, and other simple matters of like kind, which would admit of experimental illustration, and which would call upon the learner to make statements in his own words instead of in those of somebody else, would be so many steps toward real mental development. At the end of a vacation, even if the facts of any particular occurrence had become somewhat mixed, the pupils would nevertheless preserve an increased capacity for acquiring new facts, and would probably retain these for a longer period; and such are precisely the changes which it should be the province of education to bring about. We would even go further than Sir John Lubbock, and in elementary schools would give an important place to the art of drawing, which teaches accurate observation of the forms of things. The efforts of a wise teacher should always be guided with reference to the position and surroundings of a child at home, and should seek to supplement the deficiencies of home training and example. Among the wealthier classes the floating information of the family circle often, though by no means always, both excites and gratifies a curiosity about natural phenomena; but among the poor this stimulus to mental growth is almost, if not entirely, wanting. An explanation of the physical causes of common events, such, for instance, as the rising of water in a pump, would usually be a revelation to the pupils of a board school, and would start them upon a track which could hardly fail to render them more skillful workers in any department of industry, and which might even lead some of them to fortune. A wise and benevolent squire set on foot many years ago a school for the children of his laborers, in which drawing and the elements of natural science were carefully taught; and the result was, that the children educated there, instead of remaining at the plough's tail, passed, in an astonishingly large number of cases, into positions of responsibility and profit. On every ground, therefore, we hope that Sir John Lubbock's proposal will at no distant time be adopted by Parliament; but in the mean while there is a still more important department of teaching which is wholly neglected, and concerning which the deficiencies of home instruction are at least equally manifest. We refer to a proper knowledge of the influence of conduct upon life. It should be the duty of every schoolmaster to try and make his pupils understand how production—that is to say, industry—leads to wealth; and how destruction—that is to say, idleness—leads to poverty. The reason why confidence in others is necessary to all enterprise, and the reason why honesty, in the largest sense of the word, is the only root of confidence, should in like manner be enforced by precept and illustrated by example; and such teaching, if it could only be made general, would do more to heal the breach between capital and labor than all the panaceas of all the politicians who have ever sought to figure as the "friends of the working-man."—*London Times.*

We print with pleasure on another page a remarkable article from the *Times* of Monday. In itself the article may present nothing remarkable to the readers of *Nature*, but, as the deliberate utterance of the leading organ of opinion in this country, it marks a distinct stage of progress toward a more enlightened conception of what constitutes education. We hope that it is significant of the near approach of a radical change of the conception in this country of what subjects should be included in elementary education. We need not be surprised at the fate of Sir John Lubbock's bill for the introduction of elementary science into schools, when such erroneous conceptions of what science is apparently exist in the mind of the Minister of Education in the House of Commons, Lord George Hamilton. The Vice-President of the Council has much to learn, when his idea of the Royal Society, one of the most venerable institutions in the country, is that of a kind of select Polytechnic, where "lectures" are delivered on "biology, chemistry, natural history, mechanics, astronomy, mathematics, and botany." But he is new to his work, and we must hope that the debate of Thursday last may lead him to obtain a more accurate conception of what is meant by elementary science.

Dr. Lyon Playfair, we believe, pointed out what is one of the great hinderances to the introduction of science into elementary schools; the mere name, "science," frightens ministers, inspectors, school boards, and teachers; perhaps if the simpler phrase, "elementary knowledge," were used, the simple-minded individuals in whose hands is the training of our future citizens might find that they themselves had been compelled to become acquainted with it to their cost after they left school, and that it would have been much better for them had they had some little training in it before entering into the thick of the fight.

The most notable feature in the *Times* article, as well as in Thursday's debate, is the fact that it has at last dawned upon the leaders of opinion and the makers of our laws that "education" and "instruction" are different things, and that a man may learn a great many "facts" at school, and have his education to begin when he leaves it. It is lamentable that we have to be continually reminded that we are the only one of the great European countries where this distinction is not recognized and practically carried out in education. Our whole system of education, hitherto, has been a mere cramming of the children's memories with words, words, words, to the weariness of children and teachers, and with results unsatisfactory to all concerned. As the *Times* puts it, "To be taught something about gravitation, about atmospheric pressure, about the effects of temperature, and other simple matters of like kind, which would admit of experimental illustration, and which would call upon the learner to make statements in his own words instead of in those of somebody else, would be so many steps toward real mental development." Sir John Lubbock gave a most conclusive refutation of the idea that the teaching of science must be attended with hitherto unexperienced difficulties, and at the same time proved what a relief science-teaching would be to the ordinary dull routine of instruction, when he told the House that in the Scotch schools the authorities began to take alarm because science-teaching was found so comparatively easy and pleasant by the children. As to the argument that children who have been taught to know something about the object and forces with which they come every day into contact contract a distaste for manual labor, we should have thought it had been long ago played out; it has almost as much force as the story told by another speaker of the boy who had been impudent to his master because the latter could not read his newspaper.

It is unnecessary for us to go again into the merits of the question which has been so often and so thoroughly discussed in these pages, especially as the *Times* has put it quite as forcibly as there is occasion for doing at present. It certainly seems sad, nationally suicidal, indeed, that a few more millions of those who will have the destinies of this country in their hands are likely to be launched into active life, with all their education to acquire, ere legislation steps in to give us the advantages which nearly every other civilized nation gives to its children. Every day we hear of the ignorance of the working-classes, every other month "congresses" are held to devise means to remedy the consequences of this ignorance—ignorance of the laws of health, ignorance of household economy, ignorance of the implements and objects of labor, ignorance of the laws of labor and production, ignorance of the nature of the commonest objects with which they come into contact every day, ignorance of almost everything which it would be useful and nationally beneficial for them to know—an ignorance, alas! more or less shared by the "curled darlings" of the nation. Yet while every day's paper shows how keen is the industrial competition with other nations, and how in one department after another we are being outstripped by the results of better—i. e., more scientific—knowledge, the poor pittance of "elementary knowledge" asked for in Sir John Lubbock's bill is refused by a minister whose own "education" leaves much to be desired. This state of things cannot long continue, and with such advocates for the children as the *Times* and Mr. Forster, we may hope that next time Sir John Lubbock brings forward his bill it will meet with a happier fate.—*Nature.*

MONERA, AND THE PROBLEM OF LIFE.

By EDMUND MONTGOMERY, M. D.

II.—THE PHYSICAL PHASE OF THE PROBLEM.

LET us suppose that we have before us a living spherule of the uniform viscid material of so-called protoplasm. It is seen slowly to push forth, at some part of its circumference, a conical process; and, after a while, it is seen still more slowly to retract the same. We are here brought face to face with the initial and fundamental manifestation of one of the chief properties of life. For, what we are observing is living motion, incipient motility. How is it accomplished? What changes in the protoplasm have given rise to this duplex movement, first of protrusion, and then of recoil, on the part of a peculiar portion of the living material?

When the phenomenon is closely watched in different kinds of monera, it becomes evident that the conical projections are formed by a portion of the protoplasm, in which the bonds of cohesion are in some way being loosened; for the matter flows out into space with a certain pushing force—it liquefies and expands. This view is quickly corroborated by the unmistakable recontraction and resolidification of the material forming the projections, when retrogression is taking place. It is plain, then, that alternate expansion and contraction are the visible elements of motility.

Strange to say, biologists have as yet only realized the importance of the latter, less fundamental part of this twofold process. They have been so struck with the peculiar contractile power, with the seemingly sensitive shrinking exhibited by the living substance, that they have deemed it the most salient and characteristic manifestation of life. To convey this notion, they generally give to the protoplasm the name of contractile substance.

Now, "contractility" may be a very expressive term for the property by which the protoplasm is enabled to accomplish the second part, the retrograde half of motility; but, even thus restricted, it includes too much vitalism to suit our present purpose, which is to link the organic to the inorganic world.

We, therefore, cannot allow our scientific inquisitiveness to be arrested by the interposition of a mere name, or *qualitas occulta*. We do not wish to make known to others that contraction actually occurs in the living substance, for that is notorious. We wish to ascertain for ourselves how this contraction is effected—whether it is the work of entirely new forces exclusively appertaining to life, or whether it is the mechanical expression of molecular forces, with which we are already familiar in the domain of inorganic activities. Is it a specifically vital force which executes the contraction of motility? Or is it a molecular activity of a known kind which gives rise to vital motion?

This simple question may appear to some very unexciting; yet, upon its answer turns, nevertheless, the entire problem of life; for it is just at this point that the doom of vitalism has to be sealed. Vitalism or evolution: these two conceptions of Nature are incompatible. Vitalism means essentially the era of metaphysical agencies, the sway of extraneous powers coercing a resisting world of stubborn matter. Evolution means the era of inherent efficiency, the interaction of intrinsic powers ever elevating the constant realm of transient existences. It is of great importance, then, not to be deceived with regard to the exact manner in which this decisive vital act, the contraction of motility, is at all times being performed in Nature.

Fortunately, our monera give us plain information upon this point. It can be proved that it is *chemical decomposition* by which the liquefied and expanded material of the conical projection is caused to assume its former condition and place in space. The living substance contracts because it suffers decomposition, as can be directly witnessed. On the strength of this observation it would be quite legitimate to infer that it must have been *chemical composition* which also caused the reverse activity—which made a portion of the protoplasm start out from its globular limitation, and form a projection measuring in length in some cases more than three times the diameter of the main body. But we are not reduced to mere inference in this instance, so important to the understanding of vitality. By means of various accompanying appearances we can visibly ascertain that it is really a process of chemical composition which underlies the liquefaction and expansion of motility. This leading property of vitality is brought into actual play by the expansion of a certain substance in course of composition, and by the contraction of the same substance in course of decomposition, expansion and contraction being merely the physical concomitants of a definite chemical occurrence. This is shown on the one hand by the products of decomposition being separated and eliminated under our view, and on the other hand by the combining substances being brought together, and effecting their union during inspection. We have no occasion, then, to appeal to the intervention of any specific force in order to understand motility; that is, to understand it in the same manner as we understand other natural processes not belonging to vitality. We have here evidently only a display of specific chemistry. But, then, chemistry is specific all through down to H_2O, CO_2, and NH_3, and who knows how much further?

Expansion and contraction are, as is well known, no uncommon physical concomitants of mere chemical activity, even without addition or subtraction of masses; and it is of fundamental importance clearly to comprehend that vital expansion and contraction are of the same chemical kind, being due to the intrinsic nature of the compound, not to the mere addition or subtraction of mass.

A part of the protoplasm of a moner expands. Chemical composition of a specific kind has taken place, and now it is the physical property of this peculiar compound to occupy more space than before; then the same part of the moner contracts in consequence of chemical decomposition. It is the physical property of the less complicated organic molecule to occupy so much less space. The mass of the added or separated material fills but a very small part of the entire space of expansion or contraction. The expansion as well as the contraction forms part of the specific nature of those different kinds of protoplasm. The organic substance of the moner, plus the separating molecule, is the expanded material. The organic substance of the moner, minus the separating molecule, is the contracted material. The activities of expansion and contraction are merely the physical expression of the gradual process of composition or decomposition occurring within the living substance; they are marks of the shifting of the special relation existing between the protoplasm and its medium during the transitional stages from one state of equilibrium to another.

The great truth which I wish to make quite evident is, that the specific nature of the acting substance constitutes the real power in motility, and not, as is usually believed, the addition of something from outside.

Vital processes will never become intelligible until it is clearly perceived that all vital efficacy resides in the living substance itself, forms an integral part of its specific nature. Many serious misconceptions are afloat with regard to the source of vital power. Science has as yet scarcely penetrated into the outermost precincts of the laboratory of life. The so-called vital dynamics of the present day are beggarly conceptions when measured against the actual wealth of vital manifestations. All we know is, that if so much pressure, so much heat, etc., will effect a new molecular equilibrium in a certain substance, that substance will return to the medium what it has received from it in reassuming its former state.

Will any one pretend to compute the value of the influences which the living substance in the course of ages has absorbed from its medium, in order to become what it at present is? Yet it is these assimilated, equilibrated influences which constitute its real wealth, its source of power, its store of potential energy, whence all its performances emanate.

In the execution of vital motion matter is to some extent "consumed." During expansion it is consumed—taken up by the expanding substance at the cost of the medium. During contraction it is consumed—taken up by the medium at the cost of the contracting substance.

Now, in conformity with the prevailing one-sided view of motility, which attributes the entire phenomenon to so-called contractility, it is generally supposed that the force displayed during living motion is derived exclusively from the consumption of matter on the part of the medium; and it is also generally supposed that this consumption consists in a process of oxidation. Oxidation, it is said, generates a certain amount of heat; this heat is the real motor power in the case.

It does not much affect the bearings of this view whether the oxidizing material be derived, as some maintain, from the contracting substance itself, or whether, as others think, it be derived from food-ingredients. The combustion of matter, with accompanying evolution of heat, is deemed to be the true source of power; and the contracting substance—the muscular fibres in higher animals—are stated to be playing merely the part of machinery.

Thus viewed, the problem of life may be considered altogether hopeless. The organism then represents nothing but a force-directing engine, in which the combustion of compounds previously put together in vegetables constitutes the actual driving force. Vital manifestations, accordingly, can be only due to the action of the force liberated from vegetable compounds and applied to the organic machinery. Poor Science, of all-powerful vitality, thou art very young yet, and amazingly unconscious withal!

The moving substance, the protoplasm, plays just so much or just so little the part of machinery as the steam does in the steam-engine. The substance H_2O in a calorific medium from about 32° to 212° Fahr., under ordinary atmospheric pressure, occupies a certain space. In a calorific medium above 212°, under the same pressure, it occupies an enormously larger space. This specific property of filling such different spaces, under these different thermal conditions, is the very source of its power—of that motor power which sets the engine going. Whoever wishes to become fully convinced of the fact that it is not the heat of combustion, but the specific expansibility and contractility of H_2O, by which the engine is driven, may just throw, instead of so much H_2O, a proportionate weight of Au into the boiler.

If this remark should happen to appear far too commonplace for the purposes of scientific illustration, I can merely state in defense of it that, perhaps, in pondering over its meaning, the reader will find himself initiated into a deeper view of force than is usually accepted.

It is for the sake of a somewhat commensurate appreciation of vitality, of high-wrought molecular organization, that it is necessary, again and again, to point out the might of potentiality intrinsic to matter, the vast and specific stores of force locked up in the peculiar molecular entanglements which constitute our different substances. All forms of matter are essentially magazines of equilibrated energies: inert against such other energies as have no power to disturb their equilibrium, but seething with incalculable commotion against such other energies as have power to disturb their equilibrium.

What H_2O is to the steam-engine, the moving substance, the protoplasm, is to the living engine. Machinery is fastened on to both these motor powers exactly in the same manner. The expansion and contraction of H_2O give motion to the prearranged and molecularly unyielding levers of the steam-engine. The expansion and contraction of the protoplasm give motion to the prearranged and molecularly unyielding levers of the animal engine. We see the correspondence between an engine and a higher organism is even more complete than is generally conceived by philosophers of the purely mechanical school.

Only, the specific power of the slightly complicated molecule H_2O cannot possibly afford any standard for the estimation of the specific power of the immensely more complicated molecule constituting protoplasm. Protoplasm differs from water in proportion to its synthetical wealth. Whatever synthetical wealth may be the symbol of, in its gradations is to be sought the source of all difference in Nature. This is the gist of what chemistry teaches: the work of Nature consists in molecular synthesis. It has required the ceaseless toil of endless ages to build up the molecule of living matter. Let us then value it accordingly, and nevermore view it under the degrading aspect of stolid machinery.

Motility, then, consists in the alternate expansion and contraction of protoplasm, which expansion and contraction are incited by a process of chemical composition and decomposition occurring within the protoplasm. The property of occupying so much more or so much less space, under these different conditions, belongs entirely to the respective organic substances, which alternately fill the larger and the smaller space. The forces which are brought into activity during the process are forces of a known kind, but essentially inherent in the living substance. They are stimulated, not transferred. They are a display of intrinsic power, not an application of extrinsic power. They are not the heat of combustion pushing together or dragging asunder the molecules of the organic substance; they are part of the expression, i. e., of the influence on the medium, of those most specific chemical affinities which synthetical elaboration has ingrained into the constitution of the protoplasm.

If, in contemplating this truth, so positively disclosed by the study of living matter, it should become evident that the display of all other force is exactly of the same stimulated and not transferred nature, then, surely, a great advantage will have been thus gained toward a correct understanding of natural phenomena and their relation to each other.

It would then be clearly perceived that Nature does not consist of so many particles of inert matter, held together or pushed about by a set of mysterious agents; but that it rather consists in the disturbance, the overthrow, and the new formation, of equilibrated states of energies.

I have found myself reluctantly compelled to advance this general statement, in order to fulfill the obligations undertaken in this section. For, how am I to establish the gradual, unbroken development of the organic world from inorganic beginnings, when already in the domain of inorganic activity there are believed to exist so many different modes of force, so many kinds of self-sustained and transferable agents? It is true, the so-called forces, the specific motive activities, by diving into certain substances, are said to be in some unknown way "transformed" or "converted" into each other: so much friction into so much heat, or so much electricity. In this conception the identity of a supposed agent or force is evidently sustained in thought. Struck by the definite proportionality found to obtain between the changes occurring simultaneously in the substratum from which the force is thought to have been transferred, and the substratum to which it is thought to have been transferred, the mind is induced by means of a fictitious entity substantially to connect the changes as such, losing sight of the true substances, of which the changes are in reality mere affections. However much the notion may be formally repudiated, the forces are nevertheless in science still conceived as specific entities; to which the current expressions "correlation of forces, "equivalence of forces," "transmutation of forces," etc., bear sufficient witness.

If friction can become electric force, why cannot heat become vital force? And this is exactly what is generally maintained. If it be the rubbing that is or makes the electricity in the sealing-wax, then, surely, it must be the heat that is or makes the vitality in the hen's-egg. This also, but somewhat more reservedly, is at times advanced. So much mechanical force converted into so much electric force, in the former instance, whereby—as easily perceived—the preëstablished specific molecular constitution of the sealing-wax is counted for nothing: so much heat converted into so much vital force, in the latter instance, whereby the preëstablished most specific molecular affinities within the egg-substance are counted for nothing. Is not even the proportionality between the changes entirely limited and quantitatively determined by the nature and state of the manifesting substances?

Whether the forces be conceived as specific entities, as definite modes of motion, or as different affections of matter, the idea of their equivalence and convertibility is just as unwarranted, though not so palpably incongruous, as the idea of the equivalence and convertibility of air-vibrations and sound-perception, of ether-vibrations and light-perception. A certain, even quantitatively definite relation obtains between the intensity of stimulation and the stimulated effect, but that relation is neither one of equivalence nor of convertibility. This fact is universal in Nature, but becomes the more obvious the less the mutually affecting substances resemble each other. It is just as impossible that one kind of force can be converted into another kind of force, as it is impossible for any kind of force to originate out of nothing, or to exist without substratum.

A "force-directing" machine or apparatus corresponds to a well-known intelligible fact. A "force-transforming" machine or apparatus corresponds to something altogether unintelligible. If substances had really any such transforming effect on forces, even then they would themselves constitute specifically intervening powers. But this also is hyperbolical, for it does not adequately express the part which substances actually play in the manifestation of forces.

The now so famous notion of the equivalence and convertibility of forces indicates certainly a desirable attempt to bring under the grasp of Science the subtile balance of energies constituting our phenomenal world, but it partakes still too much of the old metaphysical weakness, under which we are wont to seize the shadow and lose the substance. By admitting molecular affections into the vicious circle of mechanical equivalence, it has, however, imported into it an insuppressibly qualitative element, that sooner or later, by its intense expansiveness, will break the narrowing spell, and open to scientific knowledge new fields of unexpected wealth.

The whole mechanical view of Nature rests chiefly on the supposition that effects are equal to their causes, that they are indeed the causes themselves, metamorphosed in appearance. This notion is radically erroneous, and can never lead to an understanding of reality. *Causa non æquat effectum.* In Nature there exists nothing corresponding to the so-called efficient causes of science, whether single or plural. The scientific conception of cause is a dynamical fiction, made to suit a realm of phantasmal inertia, in which molecularly imperturbable masses pursue forever an unopposed course in a resistless medium. How can we gain an insight into reality by always mathematizing it away?

In Nature all manifestations are the work of opposition and perturbation; agitation of preëxisting states, and subversion of the same. It is in this intrinsic potentiality and mutual affectibility of so-called masses that Nature has its being, its subsistence, and its perfectibility. The substrata of reality are not merely ponderable or imponderable vehicles of locomotion; but concentrations of actual and potential energies, thrilling through and through with consonant sensitiveness, reverberating with an accent of their own every commotion from the centre of the skies to the centre of the earth.

The entire result of development is preserved in the synthetical intricacies of matter and ether, the sensible and the supersensible substratum. All developmental achievement is embodied in what we chemically call complexity of composition. The more complex a substance, the greater its intrinsic value, the more specific its inherent power, and the less congruous in consequence its response to outside influences.

We cannot make any considerable progress in the philosophy of reality, of which the understanding of our own life is the consummation, before we have first formally reënthroned into their actual seat of power the sovereign energies, so strangely slighted during the long reign of visionary potentates—the eras of anthropomorphism and metaphysics.

Now that we are avowedly appealing to Nature for knowledge, it behooves us to become natural in our mode of thinking. To fix our attention merely on changes and their relation to each other is to grasp at the shadow of reality. That which changes is in every respect the substance, the potentiality and actuality in the case; and it is essentially its specific molecular constitution which determines the nature of the change qualitatively and quantitatively. The scientifically ascertained, most specific behavior shown by the various substances, with regard to their manifestation of different modes of force, or even of one and the same mode of force, is in itself abundant proof that that which we call forces are merely specific modes of *reaction* on the part of the various substances.

This somewhat lengthy but indispensable discussion on the nature and seat of force will save us the far greater labor of attempting to account for life by computing the foot-pounds of mechanical energy of which it is supposed to be the transformation; or of seeking a standard for the valuation of brain-power, or any other vital activity, by accurately determining the units of heat obtainable from the substances which exhibit these activities.

"But," it will be asked, "if combustion is in no way essential to the manifestation and production of motility, what part is actually played by the oxygen, which is known to permeate all protoplasm, and which is inhaled in such vast quantities by higher organisms?"

Oxygen is the mighty scavenger in the vital economy, the general purifier and clearer. Everywhere among the crevices and interstices of the vital *nexus* it lies in wait, seizing upon all stray stuff—waste products of function and unassimilable matter of all kinds—and converting the same forthwith into harmless and eliminable compounds. Besides, the heat evolved during this entirely depurative process helps essentially to compose the calorific medium of the organism. But oxidation is in no manner directly conducive to vitality. Within the organism combustion merely hides away death; does not kindle the flame of life; belongs to the domain of destruction, not to that of construction.

Having thus to some extent prepared the way for a more strictly chemical and physical appreciation of vital phenomena, we will proceed, in the next paper, to inquire by what agencies the chemical composition and decomposition of the living substance are effected.

[*To be continued.*]

THE ASTRONOMICAL HISTORY OF WORLDS.

By Professor DANIEL VAUGHAN.

THE information which geologists derive from the evidences of organic remains does not wholly satisfy the keen appetite of educated minds for a knowledge of the mysteries of Nature and the revolutions of past times. The relics disentombed from our globe give no clew to its origin; and they throw but little light on the great physical events which transpired before life appeared on its surface. There are, however, reasonable hopes that the records which are wanting on this earth may be supplied from the heavens; and that some general cause, to which the numerous orbs of celestial space are indebted for their existence, may be revealed from the peculiar character of their movements, or from some of the mysterious phenomena which they occasionally exhibit. In associating his researches with those of the geologist, and in taking cognizance of the great events in the course of time, the astronomer may enhance the value of the inquiries which more commonly fall to his lot. A knowledge of the condition of the earth in past ages is calculated to give much insight into the state of similar orbs in remote space; and opinions of the habitability of other planets must be more valuable in proportion as geology and terrestrial physics show more definitely how our globe acquired and how long it can retain the conditions necessary for the maintenance of life.

The tendency to widen the range of its inquiries and to speculate on the origin of the celestial bodies cannot be considered as a new feature of astronomy. The sudden appearance of the new stars, in 1572 and 1604, led Tycho Brahe and Kepler to the belief that the cosmical vapor or exceedingly rarefied matter of space was occasionally condensed to form great stellar orbs. These crude notions of the quick growth and ephemeral life of great suns were gradually replaced by views less repugnant to reason and experience. In the succeeding age the faintly luminous spots which the telescope revealed in the heavens were regarded as primitive chaotic matter exceedingly rarefied by intense heat, and they were supposed to be undergoing a slow cooling and a gradual condensation which would ultimately convert them into suns or into planetary systems. This opinion, however, though held by many astronomers, was controverted by others who maintained that the light, supposed to come from primitive fire-mist or nebulous matter, was in reality emitted by extensive sidereal groups, or vast universes too distant to show their individual stars. But, after some time, the round and the oval forms of many of these faint objects were looked upon as marks of a concentration around a centre, and the rare matter seemed to be emerging from its original chaotic state. It was thus that Kant, guided chiefly by the observations of Maupertuis, obtained a basis for his nebular hypothesis, which he published in 1755, and which, in essential features, differs little from that which has been held during the present century. Yet the subject excited little attention until many years afterward, when Sir William Herschel made his extensive and careful observations on planetary nebulæ, and pronounced them incipient solar systems, while he looked on irregular nebulosity as indicative of the presence of distant collections of stars.

As the doctrine founded on these observations was generalized by Laplace and supported by him with additional evidence, it obtained for a while much currency in astronomical circles; but it was seriously shaken in 1845, when many of the supposed embryonic systems of Herschel were resolved into stars by the powerful telescope of Lord Rosse. Yet, after a decline for a few years, the nebular hypothesis was revived on this side of the Atlantic by the announcement of Kirkwood's analogy; and some time afterward it obtained more decided support from the authority of Kirchhoff, as, on the discovery of spectrum analysis, it seemed to furnish a good explanation of solar phenomena. When Huggins obtained positive proof of the gaseous constitution of many of the irresolvable nebulæ, the tide of scientific opinion set more strongly in favor of the views of Herschel and Laplace; but it was soon checked when it was found that all the true nebulous objects had a uniformity of composition, and consisted entirely of hydrogen, nitrogen, and an unknown gas. It seems impossible that the vast diversity of material objects in future families of worlds could be afforded by the agency of three elements, one of which is noted for its reluctance to take part in chemical combinations. In addition to this difficulty, the periodical and the permanent changes, detected in certain nebulous objects by Hind and Holden, differ widely from a slow transition into a planetary system; and they are fatal to the idea that these cosmical clouds were in past ages impassive to physical influences and departed little from their primitive condition. But facts still more difficult of explanation, in regard to these celestial objects, have been made known by the recent observations on Nova Cygni; and the apparent metamorphosis which was witnessed, of a temporary star into a nebula, was so little expected that theory seems much at fault; and it is evident that many of the views on this obscure department of astronomy must be either considerably modified or entirely abandoned.

According to the crude opinions prevailing during the infancy of modern science, matter and motion were all required for calling a world into existence; but it was soon found that, unless, in the beginning, the materials which formed the solar system moved with a certain order and regularity, they could never have risen from the chaotic to the cosmical condition. As all the planets move around the sun in the same direction, Laplace was led to believe that in remote times all must have been connected together; and such a primitive connection might be afforded if the sun and his attendants were originally a vast fire-mist, their matter being so much attenuated by heat that it extended far beyond its boundaries of the solar domain. He supposed that such an immense rarefied mass, on being set in motion by some cause which he does not specify, would ultimately be compelled by its own friction and by gravity to rotate with a uniform angular velocity in all its parts and around a common centre. In accordance with the principles of physical astronomy, he concluded that this rotation would become rapid as the immense solar nebula cooled and contracted, until at last the centrifugal force became great enough to overpower gravity and to throw off matter from the equator of the whirling mass. Laplace considered that, under the most probable circumstances, the nebulous matter thus thrown off, or abandoned by the shrinking spheroid, would all collect together to form a planet; but that, in some unusual cases, it would assume the expanded figure of a vast solar ring; and that, under certain conditions, it might break up into a number of asteroids. The singular group of bodies revolving between Mars and Jupiter is supposed to have come into existence in consequence of some rare accident, which made the great solar ring a prey to many centres of aggregation, instead of allowing it to coalesce around a single one. In all other cases, the cooling and contraction are said to have been successful in giving birth to a great planet, whenever the centrifugal force became sufficient to separate the equatorial portions of the rotating solar nebula. According to the views of Laplace, Neptune must be regarded as the first-born world of those already known; while Uranus is next in age, and the other planets were launched into being in a succession depending on their distances from the sun; so that Mercury is the youngest member of the solar family. It has been also concluded that from the condition of its birth each planet must have commenced its career as a rotating nebula; and that many of the larger ones, by subsequent cooling and contraction, were at certain periods enabled to throw off their equatorial matter, which in all but two instances was converted into a satellite. Of these minor worlds or moons, Saturn has succeeded in obtaining eight, in addition to the double ring, which in the eyes of Laplace appeared as two embryonic satellites, and which has been so often appealed to for proof of the world-making doctrine under consideration.

Yet, when examined with care and impartiality, the evidence derived from the condition of the Saturnian girdle will be found unfavorable, if not fatal, to the views which it has been so frequently adduced to sustain. The superficial character of the examination which Laplace has given to this subject is betrayed by two statements which he makes in regard to it in two different parts of his writings. In setting forth the nebular hypothesis in his "Système du Monde," he asserts that the matter separated from a contracting nebula would take and maintain an annular figure, if there were a complete uniformity in its entire circuit and in its rate of cooling; but in the "Mécanique Céleste," in treating on Saturn's rings, he concludes that their preservation would be impossible without some decided irregularities in their structure. It is scarcely necessary to say that the annular appendage could not be of long duration if the conditions necessary for its existence or security in one age were fatal to it at another. On examining the alleged history of its birth, also, we feel at a loss for some cause of intermission in the work of detaching matter from the cooling nebula. It is difficult to imagine why, after the outer ring was completed, the separation of matter from Saturn, after a long continuance, should have ceased for a while; and why, after the completion of the inner ring, the centrifugal force again became weak, and that it has declined steadily until the present time, when, at the planet's equator, it is scarcely one-sixth of the force of gravity. Since the period when Saturn is supposed to have launched forth the zone of matter circulating nearest to him, his movements could be but little retarded by tidal action; and there seems to be no cause which could reduce his angular velocity of rotation during a contraction from the loss of primitive heat.

Kant, who regarded the rings as composed of aëriform matter separated from Saturn, was led to the natural inference that the time in which the planet turns once on his axis must be equal to that which the nearest annular zone requires to make a circuit around him. From such considerations, the eminent *savant* was induced to assign for the rotation of the planet the period of six hours, twenty-three minutes, and fifty-three seconds. But this theoretical or predicted length of Saturn's day is only about three-fifths of the actual value which was first revealed by the observations of Sir William Herschel, and lately determined with more precision by Prof. A. Hall. From the difficulties which the facts present in this case, Laplace endeavors to extricate his doctrine of planetary evolution by maintaining that it requires only that Saturn's day should be shorter than the period of revolution due to the inner ring, supposed to be one unbroken solid mass. But the basis on which this conclusion is founded has been exploded by modern researches, which show the impossibility of the existence of such vast solid annular structures; and Prof. Kirkwood, though long a supporter of the views of the great French astronomer, has lately pronounced the evidence obtained from the Saturnian system and from the inner moon of Mars as adverse to the nebular hypothesis.

While all scientific researches are exposed to uncertainty in proportion as they aim to penetrate very far into space and time, the ordinary means for avoiding error are wanting, and mathematical investigation is unavailable, in dealing with the supposed primitive fire-mist to which the birth of worlds has been ascribed. It would be hazardous to attempt to calculate or to trace the precise effects of gravity, motion, and friction, on matter more than 100,000,000 times more rarefied than the air we breathe, and diffused over a spheroidal space more than 6,000,000,000 miles in extent. It may seem easy to suppose all its parts rotating with regularity in the same direction around a common axis; but it would be very difficult to determine how many millions of years or centuries must elapse before such a regular rotation of the entire mass would be produced by an impulse at any locality. Inquiries respecting the arrangement of matter in the primitive solar nebula may seem to come within the scope of physical science; yet they have been hitherto unproductive of the evidence expected from them. Reasoning from the principles of hydrostatics, Kant regarded the great density of the planets near the sun and the rarity of Saturn as a proof of their nebulous origin; and he ventured to predict that, on future discoveries, the most remote members of the solar system would be found to resemble comets, in being composed of very light matter and deviating widely from circular paths in their revolutions. Yet time has shown the fallacy of his predictions, and of the proof on which he placed so much reliance. The evidence which late writers have endeavored to deduce from the large size of Jupiter and Saturn is equally weak and unsatisfactory; for the most distant planets are not the largest, and there is no definite law calling for an increased size of worlds in proportion as they are distant from the solar orb. According to the most generally received theory of its variability, the star Algol presents the case of a remote sun with a planet nearly as large as himself, yet confined to so small an orbit that the period of revolution is less than three days. But the defects and the utter inadequacy of the hypothesis are rendered most apparent when it is called on to furnish an account of the origin of binary systems, and to show the cause of the great eccentricities of the ellipses which pairs of distant suns describe around a common centre of gravity.

In modern times the doctrine of the nebular origin of worlds has been much modified by new speculations and inquiries; and it has been extended far beyond the state in which it was left by Herschel and Laplace. More than twenty years ago Helmholtz advanced the hypothesis that the sun's heat and light are produced by the contraction of his mass; and that, in concentrating from primitive nebulous diffusion and shrinking to its present dimensions, the solar orb has derived from the same cause the calorific energy which enlivened the ancient world. When the views of Mayer, who regarded falling meteors as the solar fuel, were exploded, chiefly through the discoveries by the spectroscope, the contraction theory of Helmholtz gained many votaries; and it became more attractive as it held out the hopes of giving a means of definitely measuring vast periods of time. It was calculated that the concentration from a widely-diffused nebula to its present size would produce as much heat as the sun would lose in 20,000,000 years, according to the present rate of radiation. This period was accordingly fixed as the age of the sun and the duration of solar light. Another step was soon taken in this direction by fixing a limit to the age of worlds. It was concluded, with much confidence, that less than 20,000,000 years have elapsed since the earth became a planet, and that previously it must have formed a part of the solar atmosphere. In Prof. Tait's "Recent Advances in Science," the estimate obtained in this way for the age of our globe is placed between 15,000,000 and 20,000,000 years; and geologists are given to understand that they must recognize the infallibility of mathematical authority and abstain from their usual extravagance in making exceedingly large drafts on the limited fund of time.

But the conditions on which this surrender of geological belief has been demanded are far more liberal than any which the eminent mathematician is legitimately authorized to offer. The estimate on which he relies has been made for an homogeneous nebula supposed to be equally dense at its borders and in its central regions, whereas there must be a preponderating density near the centre, according to the necessary inferences from the doctrines of Laplace. This early central condensation must be adopted to account for the great mass of the sun compared with that of the planets. In an able investigation on the subject, in this point of view, published in *Silliman's Journal* in 1864, Prof. Trowbridge concludes that, even in the earliest stage of planetary development, there must have been a very great concentration of matter around the central nucleus of our solar nebula. If we adopt the law which he deduces for the rapid increase of density toward the centre, it may be found that the amount of heat due to contraction since the supposed birth of our world would not be enough to compensate for the calorific waste which the sun sustains in 1,000,000 years.

To obtain information of the age of the earth's crust from the increase of subterranean temperature with the depth, according to the method devised by Fourier, is an object to which much labor has been devoted, and from which valuable fruits may be expected. On this principle, the time since the permanent solidification of the surface of our globe has been estimated by Sir William Thomson at about 100,000,000 years. But this estimate, which is obtained by taking 7,000° Fahr. as the highest limit of internal temperature, will appear too low when we consider the vast amount of heat arising from the primitive concentration of terrestrial materials, and the obstacles which central density or igneous fusion may present to its escape. Instead, however, of controverting the peculiar views of the eminent scientist on physical geology, I will only trace the consequences to which they lead. He maintains that, in a molten globe, the rocks which became solid should sink into the fiery menstruum; that permanent solidification must have accordingly commenced at the centre and ended at the surface, leaving some internal lakes or pockets of lava to keep up volcanic action. Now, such reservoirs of molten rock should have a small size in order to receive a roof in opposition to the laws of hydrostatics; and, if much of the original fluidity of their contents is still preserved, notwithstanding their immense losses of heat, especially during volcanic eruptions, we are compelled to make a very high estimate of the time required for the solidification of a fused globe 8,000 miles in diameter; and we must conclude that the time since the earth was covered by a permanent crust is but a very small part of that which has elapsed since terrestrial matter began its career in a gaseous or in a molten condition.

Though deprived by recent investigations of much of the support first claimed for it by Hopkins, the doctrine of the almost total solidity of the internal earth is still held by many ; and, in the hands of Thomson and Tait, it is made to contribute to the evidences of the youth of our planet. They consider that, with such a solid and inflexible constitution, the terrestrial structure must have retained almost immutably, to the present day, the exact shape impressed on it in the beginning. As the figure which it now bears differs little from that of equilibrium, and as the polar compression is nearly the same as that which the present diurnal movement would occasion in a molten world, it has been concluded that, during geological history, the length of our day has changed little, though it would be increased by tidal friction one per cent. in the course of 20,000,000 years. From such considerations, the period since our earth assumed its terraqueous character has been estimated at not more than 10,000,000 years. Yet, in the vague use of this round number for marking the career of our globe, there is shown a wish rather to fix a limit to geological time than to adhere to strict mathematical precision. So little does the earth deviate from a figure of equilibrium, and so imperfect are the means for ascertaining the exact amount of the deviation, that it would be hazardous to say whether the age obtained by this course for the terrestrial crust is nearer to 1,000,000 or to 10,000,000 years.

Far more satisfactory would be the issue in dealing with a case like the hypothetical one which Prof. Tait introduces for illustration. Alluding to the ancient world he says: "Suppose, for instance, that it had not consolidated at less than 1,000,000,000 years ago. Calculation shows that at that time, at a moderate computation, it must have been rotating twice as fast as it now rotates; that is to say, the day must have been twelve hours instead of twenty-four. Now, if that had been the case, and the earth still fluid throughout or even pasty, the double rate of rotation would have produced four times as great centrifugal force; and the flattening of the earth's poles and the bulging out of the equator would have been much greater than we find them to be."

There is, indeed, no doubt that, under such circumstances, the flattening would be about four times as great as it is now, so that the difference between the equatorial and polar diameters would be about a hundred miles; and then the age of our world might be found as accurately as its distance from the sun. Now, the neighboring zone of the solar system presents an actual case very similar to the extreme one under consideration. The difference between the equatorial and polar diameters of Mars is at least three times as great as that which could be expected from his present rotation if he were in a fluid condition. On taking even the lowest values which observers give for his compression, it must be concluded that, since changing his primitive fluid state and becoming solid and inflexible, the planet must have lost about forty per cent. of its diurnal motion. It evidently follows, according to Prof. Tait's rule, that about 800,000,000 years elapsed since the solidification took place, supposing the length of the day of Mars increased at the same rate as that of our globe. But the same great number will seem scarcely adequate to express the centuries since the event, when we consider that the rotation of our planetary neighbor is checked, not by strong tidal friction, but by the more feeble impediment from the resisting medium of space.

In two publications, during 1856 and 1858, I discussed the geological consequences of the slow reduction in the earth's diurnal motion; and many reasons led me to the conclusion that the long-continued decline of centrifugal force would make our planet undergo a change of form, by the gradual retirement of water to the poles, and, after long ages, by the upheaval of the bottoms of the polar oceans. I also maintained that such upheavals of circumpolar lands would be prevented by the strength of the crust of a small planet, and that Mars would be able to preserve for an exceedingly long period the form impressed on him in the very early term of his existence. The earth's internal fluidity, which I regarded as playing a very important part in such rare paroxysmal events, has been long a favorite doctrine with geologists, and has been often invoked as a means of accounting for the oft-repeated cases of elevation and submergence in the ancient world. But, on a globe entirely solid and inflexible, there would seem to be no scope or even possibility of the vast changes recorded in geological history; and speculative astronomy, in curtailing the time and restricting the means of great physical revolutions, makes the information from organic remains difficult to be understood and deficient in value. Since the authority of Hopkins gave currency to the doctrine of the internal solidity of our globe, much scientific talent has been expended in attempting to account for the great geological changes; but the causes which have been appealed to would require millions of centuries to produce the results ascribed to them. It seems very difficult to set aside the opinion which has been formed of the high antiquity of the physical world, not only from the marks in the terrestrial crust of repeated elevations and depressions, but also from a knowledge of the insignificant alterations in the outline of continents during the last 3,000 years.

In the imaginary systems of celestial architecture which Aristotle and Ptolemy gave to mankind, there was a very narrow limit assigned to the extent of the heavens; the entire stellar host was supposed to be confined to a very scanty domain, and the human mind was prevented by these erroneous dogmas from rising to a knowledge of the magnitude or the riches of the universe. If science, in former ages, had been crippled by being restricted to too narrow a region of space, it cannot avoid suffering, at the present day, from being subjected to similar restrictions with respect to the range of time which its researches should embrace. On grounds as uncertain as those which sustained many of the exploded doctrines of antiquity, it has been too hastily concluded that the past career of the earth and the duration of solar light must have been comprised within the course of a few millions of years. It is even supposed that, within a like circumscribed period of change and activity, the myriads of solar systems in the wide domains of space around us came into existence from chaotic fire-mist which filled the entire universe. The transitory character which modern speculation would thus assign to many important cosmical arrangements will appear more surprising if contrasted with the long endurance of others, as revealed by the older and the ripe fruits of physical astronomy. From the planetary theories of Lagrange and Laplace it would appear that the future life of the solar family, if not absolutely eternal, must be many thousand or even a few million times as long as the period into which certain modern scientific writers are endeavoring to squeeze geological history. According to Proctor, 20,000,000,000,000 years must elapse before even Mercury can meet a natural death by incorporating with the sun; and this estimate, which I believe to be somewhat too high, is introduced here to give an idea of the opinions prevailing on the subject in astronomical circles. It may, however, be safely asserted that the future age of the earth cannot be much less than a million times as long as the period during which the sun's contraction could supply heat and light, at the equable rate which the purposes of life require; and there is no reason to admire a course of creation which makes worlds outlive so long their term of utility, and condemns solar systems in coming time to endure an interminable reign of darkness.

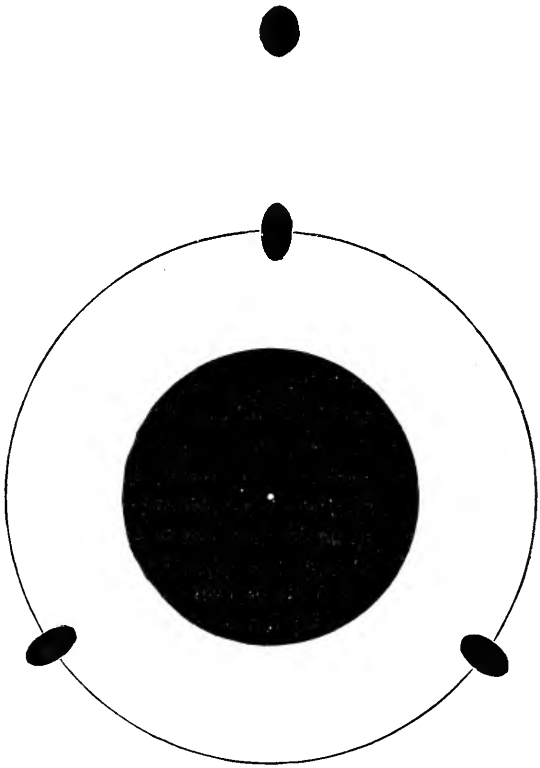
In proceeding to trace the course of the great cosmical events throughout the universe, it seems necessary to begin with a careful study of the permanent alteration in the movements of the earth and many of the celestial bodies. During the prevalence of the ancient doctrine of the immutability of the heavens, the occurrence of such unperiodical changes was denied. Even in modern times they were long ignored, as they proceed so slowly that it is only in a few cases that they can be revealed by the most refined methods of theory and observation. During the last century the doctrine of the uniformity of Nature held such a sway over scientific opinion that even slight accession of foreign matter to the earth by falling meteors would not be admitted. As, even at the present day, the origin of meteoric stones and shooting-stars cannot be said to be entirely free from doubt, I shall not introduce them for evidence in this stage of my inquiry, as items of the greatest certainty must claim the first attention. There is, indeed, no doubt that, if the mass of the sun were increased by falling meteors, his greater attractive power would make the planets describe smaller ellipses and occupy less time in their revolutions. Were the large worlds also to have their attraction increased by similar accessions of meteoric matter, they would reduce the orbits and quicken the speed of their satellites. Analogous results should be indirectly occasioned to both classes of planets by the resistance of the medium supposed to pervade space. But tidal friction is the best known impediment to planetary motion, and the changes which it slowly occasions in the condition and the career of the celestial bodies come more decidedly within the range of the investigations of modern science.

This retarding influence has been studied much in modern times, in so far as it affects the rotation of the earth, and even the movements of the moon. More than a hundred years ago Kant maintained that the tide-wave, in rolling from east to west, would reduce the earth's diurnal motion; but no positive proof of this conclusion could be given for a long time, in consequence of the peculiar difficulties of the inquiry and the imperfect condition of the tidal theory. Laplace, in dealing with the problem, concluded that within the last 2,000 years the length of the day has not been perceptibly affected by the alternate rise and fall of our oceans. But about thirty years ago, when science was enriched by the development of the doctrines respecting the conservation and the transformation of energy, the question of the effects of tidal friction was again opened for discussion, and Mayer was able to reproduce and to maintain on new grounds the almost forgotten doctrine of Kant. The evidence on which Mayer based his convictions was subsequently strengthened by a discovery which Prof. Adams made, of an error in the investigations of Laplace; and soon afterward Delaunay, in taking up the inquiry and repeating the previous operations with great care, found that the earth's diurnal motion is reduced on a scale corresponding to the waste of power involved in tidal movements. Although the amount of energy thus wasted has been estimated as over two thousand times greater than that of the united labor of the entire human population, yet so great is the stock of working force embodied in terrestrial rotation that 20,000,000 years must elapse before the length of our day is increased one per cent. by tidal friction.

The alteration which the moon occasions in terrestrial gravity is too small to be detected by the most delicate experiment; and it might remain forever unknown if our watery domain were not so sensitive to extraneous disturbance. A tidal force more than a thousand times greater prevails on the majority of the known secondary planets. If our globe, while keeping its present rotation, could exchange orbits with Jupiter's first satellite, our oceans would feel a periodical disturbance more than 20,000 times as powerful as that which now affects them; and perhaps few mountains would be high enough to escape being covered by the daily swelling of the waters. But by such a violent oceanic movement the earth's rotation should rapidly change until it kept pace with the revolution · and then the destructive tides would come to a close, as our planet, having the same hemisphere ever turned to Jupiter, would ever elongate in the same direction, and our oceans would be elevated in the same localities. Now, all the secondary planets, so far as observation has been able to decide, have their movements so adjusted as to keep the same ever turned to the primary. This arrangement, so necessary for security against excessive tides in a terraqueous satellite, would be the inevitable result of tidal friction during past ages. Even in the absence of a liquid envelope, the same result would be produced by the deformation which a solid satellite would experience from the enormous tidal force, if it turned at such a rate as to present its different sides alternately to the primary.

Yet, notwithstanding this arrangement, a satellite would experience tidal oscillation, though on a lower scale, if its path deviated much from a true circle. If a watery envelope had been given to the moon in the same proportion as it has been to our globe, there would be tides occasioned by the periodical change of distance between the two bodies, the lunar waters pressing during nearly fourteen days to the points nearest and most distant from the earth, and then retiring to other localities. The friction in such tidal movements would have the effect of making the moon describe an ellipse somewhat smaller and nearer to a circle in form, but the alterations which it could produce in the lunar distance could not exceed two or three miles in the course of a million years. Yet the agency of permanent changes, so feeble in the supposed case, may in the vicinity of great central orbs, and in the absence of great periodical disturbances, become potent enough to impress peculiar features on the paths of secondary planets. To the tides which rose on their surfaces in past times, as well as to oscillations in their solid matter, the first and second satellites of Jupiter seem mainly indebted for their peculiarity in revolving in true circles; while in the orbit of the third moon there is a slight and in that of the fourth a considerable deviation from a circular figure.

I shall now proceed to the examination of cases in which the cause under consideration becomes far more potent, and under the required conditions makes its effects recognizable by observation, and admitting of no doubt. The powerful tidal action which a great central orb is capable of exerting in its immediate vicinity would render it impossible for satellites to hold their parts together if revolving close to its surface. In a somewhat wider zone, the planetary structure could be only preserved under the form of an ellipsoid, which would deviate widely from a sphere, not so much on account of its rotation as from the effects of the unequal attraction which its different parts receive from the primary. The accompanying diagram shows the equilibrium form of a satellite moving in a circle around a large sphere, both bodies



being equally dense and separated by small distances. In a somewhat greater proximity to the primary, the satellite would be reduced to a state of instability ; and its matter, if not kept together by a great cohesive power, would scatter into independent orbits, and ultimately form a ring. There are, perhaps, in our solar domain too few cases to show how excessive tidal action can produce its definite results in its various degrees of power. If the nearest satellite of Mars bore to its primary such relations of size and density as subsist between the earth and the moon, it would, no doubt, surpass all known planets in deviating from a true sphere, even though its materials were not of the most yielding character. If similar relations existed between Saturn and his closest secondary, the latter would show a greater deviation than the primary does from a spherical form.

In the limited number of cases which one system is capable of affording, we cannot expect to see the last struggles of a satellite to maintain its planetary structure when moving in a very close proximity to its primary. But the wonderful annular girdle around Saturn shows evidence not only of a great conflict for planetary existence in past times, but even of lesser ones, on an extensive scale, at the present day. From the investigations which I have published on the subject in the *Philosophical Magazine*, it appears that in the zone of the outer ring a satellite as dense as Saturn could not hold its parts together, and that one twice as dense could not move in safety in the central zone of the inner ring. If, in treating on stability in small orbits, I have generally supposed the satellite fluid in my papers on the subject, it was because they were chiefly intended to decide whether or not it was possible for the matter of the rings to unite and form two secondary planets.

The long-cherished idea that the rings are two integral solid masses is now generally abandoned. For such a constitution the nearer ring would require to be composed of materials over 200 times as strong as wrought-iron, in order to escape rupture; but even this condition could not avert destruction from other dangers to which it is exposed. From the estimates and observations of Bond, as well as from the theoretical researches of Pierce and Maxwell, it appears certain that the innumerable parts of Saturn's ring cannot be all connected together, in a rigid or permanent manner, but must move independently around the great planet. But, while affording much valuable negative information on the subject, the investigations of these eminent mathematicians do not show how the floating matter eternally circulating in these extensive zones is kept from concentrating into two satellites by the impulse of gravity. The cause which prevents this aggregation is to be found in the *proximity of Saturn*, whose tidal action either annuls gravity or reduces it so much in two directions as to render a planetary structure unstable; and though an incipient satellite may constantly grow by appropriating the floating matter around it, yet it must fall to pieces before it has attained any considerable magnitude. The state of the rings thus depends not on accidental but on inevitable circumstances; and, with this basis for our inquiries on the subject, we may arrive at very important information in regard to the past and the future condition of worlds.

GENEALOGY.

By JOHN AMPHLETT.

THERE can be no doubt that, as each person now living has had a father and mother, grandfathers and grandmothers, and so on, every one really comes of as old a family as every one else. Moreover, every living eldest son is the heir male of either the senior or a junior branch, not only of the family of the man who first bore his name, but of progenitors hidden still deeper in the mists of antiquity. We so often hear of families either dying out altogether or ending in females, that we come to think that such a fate is the eventual end of all families; but this is far from being the case. Every man living could, if he only knew where to find the data, count up from son to father, from father to grandfather, from generation to generation, until he came to Adam himself. And this is the great difference between good families and families of all other kinds: the members of a good family can tell who their forefathers were, where they lived, and whom they married; while those who belong to no families in particular are classed in a body as those who don't know their own grandfathers, or who perhaps never had any to know. The goodness of a family depends much more on the number of its known generations than on any other condition. Given two families in which the numbers of recorded generations are equal, doubtless the family whose members have been the more illustrious would be reckoned the better of the two; but a family of only two or three generations, however illustrious their members might have been, would certainly not constitute what is known as a good family. As in the case of many popular ideas, there is some little substratum of reason in this belief. If to be educated and cultivated is an object of ambition, and if there is anything in the doctrine of heredity, it may be supposed that the members of a family who have been of importance enough to leave their names scattered on the bank of the river of time have had a better chance of being polished, and of handing down their good qualities to their posterity, than those who were swept away by the tide without leaving any mark.

It is not much to be wondered at that there is such a general mistiness as to the ancestors of any particular person. I wonder how many readers of this page can tell straight off the Christian names of their two grandmothers—very few, I suspect—and yet these are facts very close at home in any one's genealogy. I am sure no one who has not especially looked up the point could tell the Christian names of his great-grandmothers, though they also stand at the threshold of a pedigree. Unless recorded in the family Bible or otherwise committed to writing, such names soon fade from the memory. People are anxious enough that they themselves shall not be forgotten. Such a feeling is the root of all ambition; and there is a difference in degree only, not in kind, between writing one's name on the page of the history of one's country and carving one's initials on a wooden bench, or scribbling them with pencil on the walls of some famous and frequented house. But people are not so desirous to perpetuate their father's memory, or to hand down to future ages their grandfather's name, and they take no steps to that end; and the consequence is that of the mass of the people below the class immortalized in such books as Burke's "Landed Gentry," but few know whence they come, or anything at all about their antecedents. And yet among all ranks of people, from the highest to the lowest, there is some curiosity upon the subject, which, though usually languid, is always ready, should circumstances so direct, to burst into a flame.

It is a pity, however, that this flame should be fed with improper fuel to the extent that it is. When a new man rises up above the mean to such a degree that he thinks it necessary to inquire into his ancestry, his first conclusion is that he must necessarily be related to the best-known family of the name he happens to bear. Should that name be Howard, he considers himself related to the house of Norfolk; should his patronymic be Percy, he deems himself sprung from the same ancestry as the Duke of Northumberland; and if his name be Herbert, he claims affinity with the ennobled family of that name. While his ardor is fresh upon him, in his ignorance he probably applies to some professed pedigree-monger, who at once furnishes him with the missing links between himself and the great family he considers himself to belong to, and affixes to the sophisticated article the trade-mark, the coat-of-arms and crest, which belongs to the real thing; thereby confirming the *parvenu* in his ideas, and satisfying him that his views are correct. Of course it may be that the Howard in question is really sprung from the same ancestry as the Duke of Norfolk; and, indeed, the longer back a family can be traced to have existed, the more likely it is that some of its collateral branches will have sunk down to a lower level of society and have lost all knowledge of their origin. In fact, in the neighborhood of the seat of an old family are usually to be found persons bearing the same name, in all ranks of life, from the yeoman to the laborer. Perhaps they are not all related, for before surnames became fixed in the lower ranks of life the name of a leading family might have been assumed by persons whose connection with it was not that of blood, but of servitude or tenancy, or of some similar nature. In the fourteenth and fifteenth centuries a practice existed of alienating coats-of-arms from one person to another by deed, and grants by barons to their tenants of their own bearings more or less modified were not uncommon. If this occurred with matters so important as coats-of-arms were in those times, we may be sure that the same thing went on with regard to surnames; and in the rush to secure a name which must have taken place in the twelfth and thirteenth centuries, and which worked from above downward, the name of a neighboring family which was already provided with that desirable appendage must frequently, either with or without permission, have been assumed or obtained; sometimes, perhaps, without any connection at all with the original owners, but merely because such a name was already in existence.

The earliest documents in which names occur in any plenty, and from which we can judge of their distribution, are parish registers. In these we find that in each parish there is usually a marked preponderance of one name, which is probably peculiar to the parish, or to a group of parishes, of which the one in question forms a component part. We find names localized in groups, each group having a centre of density, thinning off, so to speak, toward the edges, and overlapping the groups of other names. In those times locomotion was difficult, and country-people were content to remain where they were born, and intermarry with their near neighbors; but nowadays people are more gad-about, and we should expect to find that such centres of names were broken up. Let us look at a book which deals with names on a large scale—I mean the new "Doomsday-Book." This is not a very good source for information on the subject, for the area, the county, is too large, and the standard of admission for a name, the ownership of land, too high for our purpose; but it is easily consulted, and can give us some idea of the localization of names. It will be seen that many names are nearly confined to, or greatly preponderate in, certain counties. For instance, Goddard is a south-country name, numerous in Hampshire and Wiltshire, occurring but seldom in the midland counties, and not met with in the north, not one person of that name appearing in the list of landowners for Yorkshire. Charlton occurs plentifully in Northumberland, and seldom in the southern half of England. Booth, Ibbotson, and several other names, have their headquarters in the West Riding of Yorkshire, while even such common names as Taylor, Robinson, and such like, occur much more frequently in some counties than in others. Five Shakespears hold land in Warwickshire, and one in the adjoining county of Worcester, but in no other county does the name appear. If names occur thus in groups in modern times, we can easily understand that they were still more localized three or four hundred years ago; and if they are thus localized in a return of landowners, we should find the localization still more apparent if we were to take into account the whole population of the various neighborhoods.

Of the importance of keeping a record of the genealogy of a family it is needless to speak. It is to appeal to a very low standard of usefulness to point to the numbers of advertisements for next of kin, and notices of unclaimed money. Since the establishment of a national system of registration of births, marriages, and deaths, there is not so much chance of the relationships of families being lost as there was in the days of the more careless registration which preceded its institution. But this only dates from 1837; and, moreover, the all-embracing nature of the system causes so many names to be brought together, that an extended search among them is a long and tiring process. It is a useful auxiliary to private registration, but cannot wholly supersede it. The date and place of either of the three occurrences in the life of a person with which genealogy especially concerns itself being known, it is easy to get an official record of the fact from the registrar-general; but to start with only a name, and to have to look through index after index to find the date of the birth or death of the particular person in question, is a very different matter.

And no one should say that he is too humble in station to make care about such things necessary. Fortune's wheel has many surprising turns, and sometimes carries those round with it who least expect to be raised from their station underneath it. To those higher in rank also the due recording of such things is equally important, for many facts concerning their families can be jotted down which must be interesting and may be useful to those who come after them, and which their posterity can learn in no other manner. In fact, it seems to me that the higher the state of culture of society becomes, the more care will be demanded in matters which so closely concern the family and the race; the more society will ask what it is and whence it springs, and in an increased degree will it be true that "the glory of children are their fathers."—*Gentleman's Magazine.*

AN INFANT'S PROGRESS IN LANGUAGE.

BY FREDERICK POLLOCK.

THE following notes were made in humble following of Mr. Darwin's and M. Taine's example, at first for my own amusement and without any distinct purpose of letting them go further. I found, however, that they grew under my hands, and that the editor of *Mind* thought further contributions on the subject of children's mental growth would be desirable. Here I have kept in the main to the one point of language, and, though I have probably omitted much, I think I have set down nothing as fact which has not been actually and distinctly observed. Exact dates I have not attempted to give, conceiving that they would be of no use unless for the comparison of a very large number of observations. Children differ so much in forwardness that the time of particular acquisitions seems of little importance as compared with their order. Though I have no pretensions to skill in phonetics, I thought it at least desirable to use some consistent notation for the sounds actually produced. For this purpose I have taken the Indian Government system, with a few additional signs which will speak for themselves. I may explain that in this notation, while *á*, *í*, are the long Continental *a* and *i*, unaccented *a* is not the short Continental *a*, but the obscure or neutral vowel (*Urvocal*) heard in English "at," "that," "but," when not emphatic; when strongly given, it becomes the full sound of *u* in emphasized "but." Thus the Punjaub, Lucknow, Kurrachee, of popular use, become in the official spelling *Panjáb*, *Lakhnau*, *Karachi*. "Governor and Company" would be written *Gavarnar* *and Kampani.* The vowel-sound in "bank," which does not occur in Indian languages, could be expressed only by some special symbol. I use *â* for the broad sound of *a* in "fall." Words in italics are in the Indian Government spelling. Words between inverted commas are in ordinary English spelling.

Age, twelve months. *M-m* often repeated; *Bá bá* repeated an indefinite number of times.

M-m generally indicated a want of something. *Bá bá* was: 1. A sort of general demonstrative, standing for the child herself, other people, or the cat (I do not think she applied it to inanimate objects); 2. An interjection expressing satisfaction. Both sounds, however, seemed often to be made without distinct intention, as mere exercise of the vocal organs.

Thirteen months. *Dá dá; Wa wa* (water, drink); *Wah wah*, with a guttural sound distinct from the foregoing (dog, cat); *Ná ná* (nurse—of course as proper, not generic name).

Dá dá was at first a vague demonstrative. I noted, however, with a query, man as a second and specialized meaning. About six weeks later it became a distinct proper name for the child's father, and has been consistently so used ever since. By this time the significance ot pictures was in a general way understood. The child said *wah wah* to figures of animals, and attempted to smell at trees in the illustrations of the *Graphic.* (Six months later she pretends to feed the dogs in a picture.) The fact is curious, having regard to the inability of adult savages, as reported by many travelers, to make anything of even the simplest representations of objects. About this time the ticking of a watch gave great pleasure, and for some months afterward the child constantly begged to have one put to her ear, or, still better, to have it in her hand and put it there for herself. Five or six months later she had left off asking for it.

Fifteen months. *M-m* discontinued. Sometimes *bá bá* used instead; sometimes she simply cried for a desired object.

Imitative sounds to represent dog, cat, sheep, ticking of clock. *Wah wah*, *miau*, soon became generic names of dog and cat (*wah wah*, which at first included cat, becoming appropriated to dog). I think, however, *wah wah* would include any middling-sized quadruped other than a cat or a sheep. As to cat, her name for it became, a few months later, *aya-m* or *ayá-m*, which, so far as I know, she invented for herself. The conventional "gee-gee" for horse was very soon understood by her, though she could not form the *j* sound. She recognized a zebra in a picture-alphabet as "gee-gee," and showed marked dissent when told it was a zebra.

These imitative sounds were all learned on the suggestion of adults, but studied from the real sounds; for as made by the child they are decidedly nearer to the real sounds than the *baa baa*, etc., used by adult voices.

"Baby" (or rather *bè bi*). This word was now formed with fair success, but soon dropped for a time. About a month afterward it was resumed, and became the child's name for herself. This was long before she attempted any other dissyllable. It was pronounced, however, rather as a reduplicated monosyllable.

Sixteen months. *Bâ* (ball), sometimes *ba*. *Tá* (1, thanks; 2, take, when offering something): this was deliberately taught her.

Playing with a ball became a favorite amusement at this time. She would throw a ball out of the window and expect it to be returned. When we tried a regular game of ball she seemed to think the point of the game was to get possession of the ball and keep it. A certain capacity for dramatic play was now first observed. The child knew the various animals in a toy menagerie by name, and would make believe to feed them with a spoon. About a month later she was taught a piece of rudimentary drama. The picture of the "little boy that cries in the lane" and gets no wool had fixed her attention in a book of nursery-rhymes, by this time constantly in hand, and now, on being asked, "What does the little boy that cries in the lane do?" she puts up her hands to her eyes and whimpers. She laughs afterward, which I think is fair evidence that she understands the performance and considers it a good joke.

Seventeen months. *Ní* (knee). This is a real word, used in a special and at the same time extended meaning. It signifies, *Take me on your knee and show me pictures;* and also expresses in a general way the idea of something (generally the cat) being on a person's lap, so that *ní* not unfrequently means, *I want to see the cat on your lap*. She also puts a toy dog on her knee and repeats *ní* several times with great satisfaction. About this time "baby" came to be freely used as an imperative or desiderative, combined with movements or gestures indicating an object—the sense being, *I* want that.

Seventeen to eighteen months. *Má má*, mother. I have no note of when this word began to be used (probably it was some months before this), but it was well established by this time at latest.

Ná ni or *ñá ni* (granny).

Pí (please). On learning to say "please" in this fashion the child left off putting her hands together to ask for things, which she had been taught to do before she could speak.

Pé pé, pencil (only once heard).

Pá pá. This was taught her as a synonym for *dá dá*, but she would not use it. Both "paper" and "pepper" (as common objects at the breakfast-table) became in her mouth something not easily distinguished from *pá pá*. This may perhaps account for her unwillingness to take up the new name.

Ba or *bö*, book.

"More," or rather *mâ*, often prolonged to *mâ-a* or *mo-a*—to ask for more of some food, etc., or to ask for any action that pleased her to be repeated. This word enabled her to form an approach to a sentence: thus, *mâ . . . má má* ("more, mama").

Tá tá (taught her as the usual baby word for good-by, but extended by herself); always distinguished from the single *tá* noted above. *Tá tá* not only is used to say good-by, but expresses the general idea of going out-of-doors. Thus she says *tá tá* to her perambulator, and on seeing one take up a hat or overcoat.

A final nasal sound is now produced: she tries to say "down," what she does say being roughly *dáõ*—take me down from my chair—a very frequent request, as she can by this time walk easily, and is fond of running about the room.

The vocabulary is now increasing fast, and almost any word proposed to the child is imitated with some real effort at correctness. The range of articulate sounds is still very limited: *a*, *á*, *i* (short and long) are the only vowels fully under command; *â* occurs in a few words, and is the usual result of attempts to form *o*: thus, *nâ*—nose. The long sound of English *i* (*ai*) cannot be pronounced; when she tries to imitate it she says *iá* or *ī-a*. No approach is yet made to the peculiar English short sound of *a* in such words as hat, bat. Of consonants *g*, *l*, *r* (the true consonant initial sound; the final semi-vowel, as in more, poor, is easy enough to her), and sibilants, aspirates, and palatals, are not yet mastered. "Guy" (a younger cousin's name) is called *dá*, or perhaps rather *ḍá*, the *ḍ* or *d* produced far back and apparently with effort; *k* is also produced far back in the mouth, with an approach to *t*. Final consonants are seldom or never given, and the vocabulary is essentially monosyllabic, the only exceptions being in the nature of proper names ("baby," *bá-ni*, *ná-ná*), and even these are reduplicated monosyllables rather than dissyllables proper. She once said "lady" pretty well, but did not take it into use. No construction is yet attempted; the first approach to a sentence above noted has not been repeated. Even with these resources the child already contrives to express a good deal, filling up the meaning of her syllables with a great variety of tone, and also with inarticulate interjections. Impatience, satisfaction, disappointment, amusement, are all very well marked; and perhaps even intellectual dissent (in the case of "zebra" and "gee-gee," see above).

After this time (viz., her eighteenth birthday, reckoning birthdays by calendar months, as for this purpose is convenient) the child's progress became much more rapid, and it would not have been possible to take down all her new words without giving much more and more continuous attention than I had at my disposal. I also doubt if anything would have been gained by it. The subsequent notes must be taken as being rather selections than a full record.

Eighteen to nineteen months. "Poor" (should perhaps have been set down earlier): no appreciable difference from ordinary adult pronunciation. *Dam* (gum), a word of large significance; see next paragraph.

"Poor" was taught as an expression of pity, but extended to mean any kind of loss, damage, or imperfection in an object, real or supposed. Some of her reasons for assuming imperfection were curious. She said "poor" to the mustard pot and spoon, taking, as we suppose, the movable spoon for a broken part. "Gum," on the other hand, with which toys are often mended, is conceived as a universal remedy for things broken or disabled. Later (at twenty-two and a half months) she says "poor" to a crooked pin, and on my beginning to straighten it, "dada mend."

The sound of *g* is now coming, and a final nasal is developed. "Down" is pretty well pronounced. *Ding*=dinner—not the meal or meal-time, but a toy dinner-service.

Bé bé=biscuit, with desiderative-imperative tone and meaning.

Nineteen months. *O* sound now distinctly made, and *g* distinct by the end of the month. "Guy" is now *gá* instead of *dá*. A final *l* once or twice observed: *t'âl*=shawl. Final *t* distinctly made: *hat* or *höt* (hot). Soon afterward *p* (in "top," pronounced *tap* or *töp*); *pu*=foot; after mastering final *t* she said *fat*. The monosyllabic form (one consonant and one vowel) still prevails. *K* is a favorite sound, and she has several words formed with it, which are carefully kept distinct. *Ku*=stool. *Kah* (later *kad*)=cod [liver oil], which she considers a treat. *Ko*="cozy" (on teapot); later *ka-zi* or *ka-zhi*. *Kâ*=cold. *Ká ká*=chocolate. *Khi-en* or *kli-en*=clean; her first real dissyllable, for so she pronounced it. *Bé* for biscuit has now become *bek*. *Sh'ad* (thread). She has now observed the process of sewing, and tries to imitate it. Things broken, etc., are now divided into those which are to be mended with *dam* and those which are to be mended with *sh'ad*. Approach to *chu* (sugar) and *shu* (shoe, also sugar) sometimes quite distinct. I also note "jar" as well said, but *s*, *sh*, *ch*, *j*, are on the whole indistinct, and attempts to form them give curious palatal and sibilant sounds which I cannot write down. *W*, *v*, *f*, are now formed, but not well distinguished. *Vák* or *wák*=walk, *fák*=fork. Here also we get intermediate sounds. The *w* is often more German than English, though she cannot have heard the German *w* spoken.

The fork is a toy fork in the set of things generally called *ding* or *din*. But *fák* has another unexpected meaning. The child likes to look at an old illustrated edition of Dr. Watts's poems, and she has turned "Watts" also into *fák*. It is possible, as M. Taine suggests, that to her there is some shade of difference in the sounds which escapes adult ears. At twenty months twenty-five days she said *vats* or *váts*. "Walk" has its proper sense as a mode of motion, opposed to riding, in perambulator for herself, or in carriage for others. She is much interested in watching callers going away, and says to them *dyi dyi* or *zhi zhi* (gee-gee) . . . *wák*, as if to ask how they mean to go; or, perhaps, merely to show her knowledge. Sometimes she begins to say *tá tá* to a visitor, not that she is tired of his or her presence, but that she wants the amusement of seeing the departure.

She has learned to repeat *no no* after she has been told not to do something, as an act of assent to the prohibition, and she seems to take pleasure in saying *no no* to the cat.

Twenty months. *Dash* or *dásh*=dust. *Ta'sh* or *tá'sh*, learned, I think, from "touch," one day repeated several times without assignable meaning, and then dropped. *Túsh*, however, is adopted for [mus]tache. N. B.—Final sibilants are more under command than initial. Final *g* now produced: *geg*=fizgig (toy so called).

At this time a sudden advance was made to dissyllables. Several words were produced with success on or about the same day: "Fanny, honey, money" (these two learned from the rhyme of "Sing a song of sixpence"), very distinct. "Money," however, seems to be confused with "moon:" when told to say moon she says money. Others are attempted with more or less success: as *fá-wá*, flower; *la-ta*, letter; *ha-pi*, happy (taught her as opposite of "poor," but I doubt if she sees the meaning. She has taken up *ha-pi* to stand for "empty," which we tried to teach her, and in that sense uses it without prompting). *Bá-ta*, butter. The child's own name, Alice, is given as *A-si*, or perhaps *A-śi* (later *á-si*). As to sound, she is now acquiring the English long sound of *i* (*ai*). *R* is still impracticable, and attempts to form it sometimes give *d* (but this was very transient, and *l* soon became the common substitute): compare the converse Bengalese treatment of Sanskrit *d*, which, I believe, is in Bengal regularly pronounced as *r*. "P'ram," for perambulator, becomes *thlam:* the *th*, with an extra aspiration, almost $\chi\theta$. A few weeks later this was simplified into *khlam*. There seems to be a difficulty about initial vowels: "egg" becomes *lleg* (or perhaps *yleg* would be nearer), which I can only write symbolically: the sound marked as *ll* or *yl* is something like the Spanish *ll* with an aspiration. A few days later the initial sound was more sibilant and less vocal, say (symbolically) *zhy*.

Early in March (at twenty months) we noted the first attempt at sustained conversation. The child was looking, or pretending to look, for a lost object on the floor. We told her she would get her hands dirty. On this she exclaimed, in a tone of dissenting interrogation, "Dirty!" (*da-ti*), and then, after looking at her hands, holding them out to us, and with triumphant affirmation, "Clean!" (*kle'n*). Here we have not merely vocal signs, but intercourse by speech—one may say an elementary form of repartee and argument. She can now say "yes" (*es*, or *is*, sometimes *as*) and "no" in answer to questions with fair intelligence, though she sometimes answers at random, and sometimes gives the wrong answer on purpose for a joke. One of her new words is *fa-ni* (funny), which she uses in a wider sense than adults, for anything that pleases and surprises her. The imitative name for the cat is dropped, and she now says (for "pussy") *pü-si* (*ü* as in South-German, coming very near to *i*). "Funny" is also used to disguise fear, e. g., on being introduced to a strange dog. When left to play alone she talks to herself constantly. The staple of one of these monologues (March 10th) was *á-diá* (formed on "O dear"). I half suspect a dramatic intention in her proceedings.

The peculiar short sound of English *a* (represented by *æ* in Mr. Ellis's general notation) is now forming. She can say "bag" nearly like an adult. But, as a rule, she still substitutes (Indian) *a* or *á*, saying, e. g., "cub," or "kahb," for "cab."

Twenty-one months. Progress is now less marked and rapid. New words continue to be acquired, but the power of putting them together does not seem to increase much. The child is, however, now more or less able to answer direct as distinguished from leading questions. Thus, when she had been paying a visit to some relations and cried to go home, she gave afterward (March 17th) a pretty connected account of it in monosyllabic answers. *Q.* What did you do to-day at ——? *A. Klai* ("cry"). *Q.* And what did you cry for? *A. Ham* ("home," i. e., I cried to go home). Also, when told not to handle a forbidden object, such as a knife, she will say, in a tone of intelligent acquiescence: *No—dá dá* (i. e., I may not have that, but *dá dá* may). One trisyllable is in common use: *Tenisi*=Tennyson, an illustrated edition, which divides her attention with *Vats* (Watts).

As to sounds, *r* is generally replaced by *l* or *ll*, or (approximately) *hl: hlan* or *llan*="run." The prosthetic initial sound for words beginning with vowels is now *zh*, or an aspirated *y*.

She begins, too, to put now and then a substantive and adjective together: "clever baby," "happy man" (in picture); the meaning of which she now seems to understand well enough.

Twenty-one and a half months. There is now a distinct advance in constructive power. Substantives and adjectives are freely put together (e. g., "dirty boots"), and I have noted one instance of the use of a real predicate, so as to form a complete proposition. The child had been told, half in joke, that cabs were dirty as compared with her perambulator. For some days she had been accustomed to say "dirty" on the mention of cab, "clean" on the mention of perambulator. Now she made the whole statement for herself: *Kábz dati klam*[1] *klín* ("cabs dirty, peram' clean"). She still talks constantly to herself, and with a continuity giving more or less evidence of continuous trains of thought. I am informed of dramatic conversations with her doll, such as pretending to make it look at things, and describing them to it.

The doll furnishes an illustration of the process of making generic names. A doll was named "Bessie," in honor of the donor; some time afterward another doll was given by another person. The child insisted on calling this "Bessie," too. She does not seem to feel the want of a specific distinction between the two dolls; when she does wish to speak of one as distinct from the other, she says "other Bessie." In like manner, *bet* (bacon) is used with a generalized meaning, nearly = ὄψον, to denote any dish that appears at breakfast.

Twenty-two months. Vocabulary and power of expression are gradually and steadily extending. A certain number of the words called symbolic by some recent philologists have been mastered: "now," "there," "other," or "'nother," are in constant use; the child often says "there it is" (in the compendious form, *zhátis*), and almost always adds "now" to the statement of anything she wants (e. g., "Bring—cake—now"). "Again" is also in use, though not quite so much. The following approach to a complex sentence is reported: "Out—pull—baby—pecs" (spectacles). Simpler combinations are freely used: subject and verb, as "run away man;" or, subject, verb, and *régime*, as "mama get Bessie." The sense is generally optative or imperative, but sometimes indicative. She often says *es es* (yes) to emphasize her demands, as: "Es es—baby's book there."

Articulation is firmer, and very distinct. She says "good-by" better than most adults, but making two separate words of it, and dwelling strongly on the "good." The vowel-range is increased, but *a*, *á*, are still favorite sounds. Of consonants *ch*, *j*, and *th* (both sounds), are still imperfect (*th* hard mostly becomes *s*, *th* soft, *z*), and consonantal *r* is not yet formed at all.

At twenty-two months one day, a real verbal inflection was used. She said of a younger child, "naughty baby;" and being asked why it was naughty answered without hesitation, *klaid* (cried). That she appreciates the general force of the inflection is shown about a week later by her using "comed" for the participle "come."

At twenty-two months ten days, a sentence is noted *ex relatione*, containing not only a direct but an indirect *régime*: "Annie—gave—baby—sugar;" and again, a day or two later, "Dada give *bátá* (butter, i. e., bread and butter) baby." Talk to the doll is now very common, as, "Bessie look," "Bessie walk away:" sometimes the child repeats to the doll what has been said to her by elders. She also puts the doll

[1] Simple *k* is now substituted for the initial *kh* in this word; which again, as noted above, had replaced a more complicated aspirate sound.

to bed, takes it out for a walk and brings it home, etc. On one occasion she scolded it for two or three minutes, saying "naughty Bessie" with much gravity. We could not discover what the supposed offense was. I may observe on this that I have no reason to doubt that all the play with her doll is purely and consciously dramatic, not animistic; in other words, I have seen nothing to indicate a belief that the doll is really alive, nor is there, so far as I can observe, any tendency to attribute life to other inanimate objects. I think the child is perfectly aware of the difference between animals and things, though I am unable to give specific reasons for this impression. "Again" is now used to strengthen "more:" when she wants anything repeated she says "more 'gain." The following is an actual short conversation, on seeing an ivory ring spun teetotum-wise: "Baby do't . . . [after failure to make it spin herself] more 'gain . . . ma-ma 'gain . . . ma-ma do't . . . [then turning to another object of interest] . . . baby's *báts* (basket) . . . ma-ma, take off cover." Command of general and symbolic language continues to make almost daily progress. *Zát sing* (that thing) is now used to call attention to any desired object, the name of which has not been mastered.

At twenty-two and a half months, besides the dramatic play with the doll, we have now some quasi-dramatic imitation of grown-up people's action. For some time the child has been accustomed to bring the newspaper to the breakfast-table, and she always pretends to read it herself before handing it over. To-day, seeing her mother writing, she scratched the paper with a dry pen, saying, "Baby *lait* (write) ma-ma's letter."

Twenty-three months. Fluency and command of language increase. We note the first appearance of a *question*, viz.: "Where's pussy? baby look up-'tairs."

The palatals, dental aspirates, and the peculiar English short *a* (as in "hat") are still imperfect, and *r* is represented by *l*. When *s* comes before another consonant, one of the two is dropped. *K* is in some words confused with *p* or *t*. She says "oken" for "open," "kek" for "take."

The child takes pleasure in quasi-dramatic games and actions with her parents as well as with her doll. Sometimes, when saying good-night, she pretends to refuse a kiss, and lets me make a *fausse sortie*, as if annoyed or indifferent, and then calls "dada come back" (or "comed," for she uses this form for present and past indiscriminately, which compels me to set a lower value on her appreciation of inflections), and gives the kiss after all. (At twenty-three and a half months, however, she uses "made" correctly). I think she considers the thing a joke, but not without a shade of fear that it may be taken seriously. The last time, she completed the performance by saying "goody girl" in a tone of extreme self-complacency.

Seeing lines of dots on a printed page, thus . . . (in a table of contents), she said, " Oh ! pins," and made repeated attempts to pick them out. This would seem to have some bearing, however slight, on the gradual character of the process by which our vision of solid objects and perceptions of things as in three dimensions is acquired.

She now has a settled formula to ask for things she wants, and also to express acquiescence when told she is not to have them, e. g., " baby have *pápá* (pepper)," " baby have *pápá* no." The " no " is not given as it would be by an adult, as a distinct exclamation following a pause. There is no stop and no raising of the voice. When she is impatient, " baby have, baby have, baby have," is rapidly repeated. She is very persistent in trying to get a desired object, and if she cannot have it at once does not give it up, but proceeds to make the best terms she can ; e. g., she asks for bacon, and is told it is not for her, but her parents must have it first. She answers, " *then* baby have bacon." Here is an elementary notion of bargain and compromise. The child is already *πολιτικὸν ζῶον*.

Bacon has lost its former generality, meats which appear at breakfast being now divided into egg, bacon, *sis* (fish), and beef. Once, after calling a new dish " bacon," and being corrected, she said " bacon no "—recognizing, one may say, the logical division into bacon and not-bacon. The child is now able, however, to take up new words very quickly. She has reached, so far as concerns the names of things, the advanced stage of knowledge in which the provisional character of generalizations is recognized.

At about twenty-three months ten days she cried violently on finding that her doll's head was coming off, and was pacified only when it was put out of sight with a promise that it should be mended. Her own report of the cause of her grief was " Bessie's head poor." The dramatic personification of the doll may probably count for something in this. But one is not strictly entitled to assume that she would cry less for damage to any other toy.

There are increasing signs of a desire to find explanations. Seeing in an illustrated advertisement a device of a griffin rampant supporting a kind of banner, the child invented a meaning of her own for it : " pussy *ling* (ring) bell." The figure of a man making pottery, which was part of the same advertisement, became " man open door," so as to form a single composition with the griffin. On hearing sounds in the street, knocks at the door, etc., the child readily (and, as a rule, spontaneously) assigns causes for them, saying " band," " organ," " man," " post," etc., as the case may be. Strange sounds, and at times sounds of a known class coming from an unfamiliar direction, appear to frighten her.

I should add that the greater part of these notes was already written before I saw M. Bernard Perez's very interesting book, " Les trois premières Années de l'Enfant " (Paris, 1878). I have retouched and rearranged them as little as possible, preferring the certainty of leaving them in an inartificial state to the risk of spoiling by manipulation whatever value they may possess as records made at the time.—*Mind.*

THE ORIGIN OF FRUITS.

By Professor GRANT ALLEN.

IN the whole museum of Nature the eye of the artist can find nothing lovelier than flowers ; but the second rank in beauty may be fairly claimed on behalf of fruits. Whether we look at the golden oranges, the pink-cheeked mangoes, the purple star-apples, and the scarlet capsicums of the south, or at our own crimson cherries, blushing grapes, bright holly-berries, and rosy apples, we are equally struck with the delicacy of their melting tints and the graceful curves of their rounded form. Our painters have reveled in their rich coloring ; and even our sculptors, whose fastidious art compels them to reject that meretricious charm, have loved to chisel their swelling contours in snowy stone. As they hang pendent from their native boughs, clustering in brilliant masses, or scattered here and there as points of brighter light amid the dark foliage which throws up in strong relief their exquisite hues, we may recognize in their beauty the ultimate source of all that refined pleasure which mankind derives from the varied shades of earth and sea and sky, of flower and bird and butterfly, and even of the "human face divine" itself. From the contemplation of ruddy or snowy berries in primeval forests the frugivorous ancestors of our race first acquired the taste for brilliant hues, whose final outcome has produced at length our modern picture-galleries and palaces, our flower-gardens and conservatories, our household ornament and our decorative art.

In a previous paper on "The Origin of Flowers,"[1] we endeavored to trace the mutual reactions of insects and blossoms upon one another's forms and hues. But we then deferred for a while the consideration of the further question—"Why do human beings admire these bright whorls of colored leaves, whose primitive function consisted in the attraction of bees and butterflies? Through what community of origin or nature does the eye of man find itself agreeably stimulated by the tints which were first developed to suit the myriad facets of primeval insects?" The answer to this question we have now to attempt, by showing the various steps through which the coverings of certain seeds acquired, for the vertebrate orders—the birds and quadrupeds—exactly the same allurements of color, scent, and taste, which flowers had already acquired for the articulate orders—the bees and butterflies.

[1] *See* Popular Science Monthly Supplement, No. XIV., p. 151.

To the attractive hues of fruit, I believe, we must ultimately trace back our whole artistic pleasure in the pure physical stimulation of beautiful colors, displayed by natural objects or artificial products.

Our present inquiry, then, will yield us some account of that primitive delight in red, purple, orange, and yellow, which we usually take for granted as an innate instinct of humanity, savage or civilized. When, some few months back, we analyzed the various elements of pleasure which make up our æsthetic enjoyment of a daisy, we were compelled, for the time being, to leave the original beauty of its pink-and-white rays wholly unexplained. We regarded the delight in color, relatively to the subject we were then examining, as an ultimate and indecomposable factor in our developed consciousness. To-day, however, I hope we shall be able to go a little further back, and to show that this delight, like all other feelings of our nature, is no mere chance and meaningless accident, but the slow result of a long adaptation whereby man has gradually become fitted to the high and responsible station which he now occupies at the head of organic existence.

The sole object of flowering is the production of seeds—that is to say, of embryo plants, destined to replace their parents, and continue the life of their species to future generations. Flowers and seeds go together; every flower producing seed, and every seed springing from a flower. Ferns and other like plants, which have no blossoms, bring forth spores which grow into shapeless little fronds, instead of true seeds containing a young plantlet. But all flowering species produce some kind of genuine fruit, supplied with more or less nutriment for the tender embryo in its earlier days. And this matter of nutriment is so important to a right comprehension of our subject that I venture, even at the imminent peril of appearing dull, to digress a little into the terrible mysteries of Energy, which comprise the whole difficulty of the question.

Wherever movement is taking place in any terrestrial object, the energy which moves it has been directly or indirectly supplied from the sun. In the green parts of plants, the solar rays are perpetually producing a separation of carbon and oxygen, the former element being stored up in the tissues themselves, while the latter is turned loose upon the atmosphere in a free state. Whenever they recombine, motion and heat will result, as we see alike in our grates, our steam-engines, and our own bodies. An animal is a sort of machine—viewed from a purely physical standpoint—in which the energetic materials laid up by plants are being reconverted into the warmth which reveals itself to our touch, and the evident movement which we see in its limbs. The vegetable or animal substances which are capable of yielding these energies to our bodies we know as food or nutriment. They perform exactly the same part in the physical economy of men or beasts as that which fuel performs in the physical economy of the steam-engine. Of course, from the *mental* point of view, we have the immense difference between a self-conscious, self-guiding organism, and a dead machine requiring to be supplied and regulated by an external consciousness ; yet in the fundamental physical necessity for energetic material, either as food or as fuel, both mechanisms follow essentially the self-same mechanical laws.

But what has all this to do with the origin of fruits? Very little at first sight, indeed, yet everything when we look at the bottom of the question. In fact, what is thus true of animals and steam-engines is equally true of plants. No motion can take place in a growing shoot without the aid of solar energy, directly supplied by the sunshine, or indirectly laid by in the older tissues. In the green parts of a plant this energy is immediately derived from the bounteous light which bathes and vivifies the leaves on every side ; but in many other portions of the vegetable organism, energies previously accumulated by older organs are perpetually being utilized, for the production of movement and growth, by lazy structures which cannot work for themselves, and so feed upon the useful materials collected for them by more industrious members of the plant-commonwealth. Especially is this the case with those expensive organs which are concerned in perpetuating the species to future generations. A flower or a seed cannot directly transform waves of light into chemical separation of atoms ; they depend for their growth and the due performance of their important functions upon similar separations already carried on for their behoof by the green leaves on whose bounty they rely for proper subsistence. Carbon, set free from oxygen in the leaves, has been carried to them in loose combinations by the sap; and as the bud unfolds or the seed germinates, the oxygen once more unites with this carbon (just as it unites in the furnace of the steam-engine, or the recesses of the animal body), and motion is thereby rendered possible. But without such an access of free oxygen to recombine with the energetic materials, the blossom or the embryo could never grow at all. So we may regard these portions of a plant, incapable of self-support, and dependent for their due function upon energetic compounds laid by elsewhere, as the exact analogues of the animal or the steam-engine. They are in fact similar mechanisms, where food is being used up, and fuel is being consumed ; and we find accordingly, as we might naturally expect, not only that motion results, but also that heat is evolved in quantities quite sufficient to be measured by very delicate thermometers.

Now, every growing portion of a plant shares, more or less, in this animal function of feeding upon previously-fabricated nutriment. But there are two sets of organs, both intended ultimately to subserve the same purpose, in which that function becomes especially apparent. The first is in the case of the whole regular reproductive mechanism, including in that term buds, flowers, fruits, and seeds ; the second is in the case of such subsidiary reproductive devices as tubers, rhizomes, corms, and all the other varieties of underground stems or roots, which botanists divide into so many puzzling technical classes, while ordinary people are content to lump them roughly together as bulbs. If we glance briefly at each of these two cases, we shall be able to comprehend more fully their connection with the doctrine of energy, and also to see more clearly the problem before us when we endeavor to unravel the origin of fruits.

A germinating pea or a young blade of wheat is supplied by its parent with a large stock of nutriment in the shape of starch, albumen, or other common food-stuffs. If we were to burn the wheat instead of planting it, the energy contained in its substance would be given off during the act of combustion as light and heat. If, again, we were to adopt a more usual course, by grinding, baking, and eating it, then the inclosed energy would minister to the warmth of our bodies, and do its little part in enabling us to walk a mile or to lift a heavy weight. But if, in lieu of either plan, we follow the original design of Nature by covering the seed with moist earth, the chemical changes which take place within it, still resulting in heat and motion, produce that special form of movement which we know as germination. New cells form themselves about the feathery head, a little sprout pushes timidly its way through the surrounding soil, and soon a pair of rounded leaves or a spike of pointed blades may be seen spreading a mass of delicate green toward the open sunlight overhead. By the time that all the stored-up nutriment contained in the seed has been thus devoured by the young plantlet, these green surfaces are in a position to assimilate fresh material for themselves, from the air which bathes them on every side, under the energetic influence of the sunbeams that fall each moment on their growing cells. But I need hardly point out the exact analogy which we thus perceive between the earliest action of the young plant and the similar actions of the frugivorous animals which subsist upon the food intended for its use.

If, however, we look at the second great case, that of bulbs and tubers, we shall see the same truth still more clearly displayed. You cannot grow a blade of wheat or a sprouting pea in the dark. The seed will germinate, it is true; but, as soon as the primitive store of nutriment has been used up, it will wither away and die. Naturally enough, when all its original energy is gone, and no new energy is afforded to it from without in the form of sunshine, it cannot miraculously make growth for itself out of nothing. But if you put a hyacinth-bulb in a dark cellar, and supply it with a sufficiency of water, it will grow and blossom almost as luxuriantly as in a sunny window. Now, what is the difference between these two cases? Simply this: the wheat-grain or the pea has only nutriment enough supplied it by the parent-plant to carry it over the first few days of its life, until it can shift for itself; while the hyacinth has energetic materials stored up in its capacious bulb to keep it in plenty during all the days of its summer existence. If we plant it in an open spot where it can bask in the bright sunshine, it will produce healthy green leaves, which help it to flower and to carry on its other physiological actions without depending entirely upon its previous accumulations ; but if we place it in some dark corner, away from the sun, though its leaves will be blanched and sickly-looking, it will still have sufficient nutriment of its own to support it through the blossoming season without the external aid of fresh sunshine.

Where did this nutriment come from, however? It was stored up, in the case of the seed, by the mother-plant; in the case of the bulb, by the hyacinth itself. The materials produced in the leaves were transferred by the sap into the flower or the stem, and were there laid by in safety till a need arose for their expenditure. All last year—perhaps for many years before—the hyacinth-leaves were busily engaged in assimilating nutritive matter from the air about them, none of which the plant was then permitted to employ in the production of a blossom, but all was prudently treasured up by the gardener's care in the swelling bulb. This year, enough nourishment has been laid by to meet the cost of flowering, and so our hyacinth is enabled to produce, through its own resources, without further aid from the sun, its magnificent head of bright-colored and heavily-scented purple bells.

Each species of plant must, of course, solve for itself the problem, during the course of its development, whether its energies will be best employed by hoarding nutriment for its own future use in bulbs and tubers, or by producing richly-endowed seeds which will give its offspring a better chance of rooting themselves comfortably, and so surviving in safety amid the ceaseless competition of rival species. The various cereals, such as wheat, barley, rye, and oats, have found it most convenient to grow afresh with each season, and to supply their embryos with an abundant store of food for their sustenance during the infant stage of plant-life. Their example has been followed by peas and other pulses, by the wide class of nuts, and by the majority of garden-fruits. On the other hand, the onion and the tiger-lily store nutriment for themselves in the underground stem, surrounded by a mass of overlapping or closely-wound leaves, which we call a bulb ; the iris and the crocus lay by their stock of food in a woody or fleshy stalk ; the potato makes a rich deposit of starch in its subterraneous branches or tubers; the turnip, carrot, radish, and beet, use their root as the storehouse for their hoarded food-stuffs ; while the orchis produces each year a new tubercle by the side of its existing root, and this second tubercle becomes in turn the parent of the next year's flowering stem. Perhaps, however, the common colchicum or meadow-saffron affords the most instructive instance of all; for during the summer it sends up green leaves alone, which devote their entire time to the accumulation of food-stuffs in a corm at their side; and, when the autumn comes round, this corm produces, not leaves, but a naked flower-stalk, which pushes its way through the moist earth, and stands solitary before the October winds, depending wholly upon the stock of nutriment laid up for it in the corm.

If we look at the parts of plants which are used as food by man or other mammals, we shall see even more clearly the community of nature between the animal functions and those of seeds, flowers, and bulbs. It is true that the graminivorous animals, like deer, sheep, cows, and horses, live mainly off the green leaves of grasses and creeping plants. But we know how small an amount of food they manage to extract from these fibrous masses, and how constantly their whole existence is devoted to the monotonous and imperative task of grazing for very life. Those animals, however, who have learned to live at the least cost to themselves always choose the portions of a plant which it has stored with nourishment for itself or its offspring. Men and monkeys feed naturally off fruits, seeds, and bulbs. Wheat, maize, rye, barley, oats, rice, millet, peas, vetches, and other grains or pulses, form the staple sustenance of half mankind. Other fruits largely employed for food are plantains, bananas, bread-fruit, dates, cocoanuts, chestnuts, mangoes, mangostines, and papaws. Among roots, tubers, and bulbs, stored with edible materials, may be mentioned beets, carrots, radishes, turnips, swedes, ginger, potatoes, yam, cassava, onions, and Jerusalem artichokes. But if we look at the other vegetables used as food, we shall observe at once that they are few in number, and unimportant in economical value. In cabbages, Brussels sprouts, lettuce, succory, spinach, and water-cress, we eat the green leaves ; yet nobody would ever dream of making a meal off any of these poor food-stuffs. The stalk or young sprout forms the culinary portion of asparagus, celery, seakale, rhubarb, and angelica, none of which vegetables are remarkable for their nutritious properties. In all the remaining food-plants, some part of the flowering apparatus supplies the table, as in true artichokes, where we eat the receptacle, richly stocked with nutriment for the opening florets; or in cauliflower, where we choose the young flower-buds themselves. In short, we find that men and the higher animals generally support themselves upon those parts of plants in which energy has been accumulated either for the future growth and unfolding of the plant itself, or for the sustenance of its tender offspring.

And now, after this long preamble, let us come back to our original question, and seek to discover what is the origin of fruits.

In botanical language, every structure which contains the seeds resulting from the fertilization of a single blossom is known as a fruit, however hard, dry, and unattractive, may be its texture or appearance. But I propose at present to restrict the term to its ordinary meaning in the mouths of every-day speakers, and to understand by it some kind of succulent seed-covering, capable of being used as food by man or other vertebrates. And our present object must be simply to discover how these particular coverings came to be developed in the slow course of organic evolution.

Doubtless the earliest seeds differed but little from the spores of ferns and other flowerless plants in the amount of nutriment with which they were provided and the mode in which they were dropped upon the nursing soil beneath. But as time went on, during the great secondary and tertiary ages of geology, throughout whose long course first the conifers and then the true flowering plants slowly superseded the gigantic horsetails and tree-ferns of the coal-measures, many new devices for the dispersion and nutrition of seeds were gradually developed by the pressure of natural selection.[1] Those plants which merely cast their naked embryos adrift upon the world to shift for themselves in the fierce struggle of stout and hardy competitors must necessarily waste their energies in the production of an immense number of seeds. In fact, calculations have been made which show that a single scarlet corn-poppy produces in one year no less than 50,000 embryos; and some other species actually exceed this enormous figure. If, then, any plant happens by a favorable combination of circumstances to modify the shape of its seed in such a manner that it can be more readily conveyed to open or unoccupied spots, it will be able in future to economize its strength, and thus to give both itself and its offspring a better chance in the struggle for life. There are many ways in which natural selection has effected this desirable consummation.

The thistle, the dandelion, and the cotton-bush, provide their seeds with long tufts of light hair, thin and airy as gossamer, by which they are carried on the wings of the wind to bare spaces, away from the shadow of their mother-plant, where they may root themselves successfully in the vacant soil. The maple, the ash, and the pine, supply their embryos with flattened wings, which serve them in like manner not less effectually. Both these we may classify as *wind-dispersed* seeds. A second set of plants have seed-vessels which burst open explosively when ripe, and scatter their contents to a considerable distance. The balsam forms the commonest example in our European gardens; but a well-known tropical tree, the sand-box, displays the same peculiarity in a form which is almost alarming, as its large, hard, dry capsules fly apart with the report of a small pistol, and drive out the disk-shaped nuts within so forcibly as to make a blow on the cheek decidedly unpleasant. These we may designate as *self-dispersed* seeds. Yet a third class may be conveniently described as *animal-dispersed*, divisible once more into two sub-classes, the involuntarily and the voluntarily aided. Of the former kind we have examples in those seeds which, like burs and cleavers, are covered with little hooks, by whose assistance they attach themselves to the fur or wool of passers-by. The latter or voluntarily aided sort are exemplified in fruits proper, the subject of our

[1] I trust that in the sequel the critical botanist will excuse me for having neglected the strict terminology of carpological science, and made no distinction between seeds and fruits. Some little simplification is absolutely necessary for general readers in this the most involved department of structural botany.

present investigation, such as apples, plums, peaches, cherries, haws, and bramble-berries. Every one of these plants is provided with hard and indigestible seeds, coated or surrounded by a soft, sweet, pulpy, perfumed, bright-colored, and nutritious covering, known as fruit. By all these means the plant allures birds or mammals to swallow and disperse its undigested seed, giving in, as it were, the pulpy covering as a reward to the animal for the service thus conferred. But before we go on to inquire into the mode of their development we must glance aside briefly at a second important difference in the constitution of seeds.

If we plant a grain of mustard-seed in moist earth and allow it to germinate, we shall see that its young leaves begin from the very first to grow green and assimilate energetic matter from the air around them. They are, indeed, compelled to do so, because they have no large store of nutriment laid up in the seed-leaves for their future use by the mother-plant. But if we treat a pea in the same manner, we shall find that it long continues to derive nourishment from the abundant stock of food treasured up in its big, round seed-leaves. Now of course any plant which thus learns to lay by in time for the wants of its offspring gives its embryo a far better chance of surviving and leaving descendants in its turn, than one which abandons its infant plants to their own unaided resources in a stern battle with the unkindly world. Exactly the same difference exists between the two cases as that which exists between the wealthy merchant's son, launched on life with abundant capital accumulated by his father, and the street Arab, turned adrift, as soon as he can walk alone, to shift or starve for himself in the lanes and alleys of a great city.

So, then, as plants went on varying and improving under the stress of over-population, it would naturally result that many species must hit independently upon this device of laying by granaries of nutriment for the use of their descendants. But side by side with the advancing development of vegetable life, animal life was also developing in complexity and perfect adaptation to its circumstances. And herein lay a difficult dilemma for the unhappy plant. On the one hand, in order to compete with its neighbors, it must lay up stores of starch and oil and albumen for the good of its embryos; while, on the other hand, the more industriously it accumulated these expensive substances, the more temptingly did it lay itself open to the depredations of the squirrels, mice, bats, monkeys, and other clever thieves, whose number was daily increasing in the forests round about. The plant becomes, in short, like a merchant in a land exposed to the inroads of powerful robbers. If he does not keep up his shop with its tempting display of wares, he must die for want of custom; if he shows them too readily and unguardedly, he will lay himself open to be plundered of his whole stock-in-trade. In such a case, the plant and the merchant have recourse to the self-same devices. Sometimes they surround themselves with means of defense against the depredators; sometimes they buy themselves off by sacrificing a portion of their wealth to secure the safety of the remainder. Those seeds which adopt the former plan we call *nuts*, while to those which depend upon the latter means of security we give the name of *fruits*.

A nut is a hard-coated seed, which deliberately lays itself out to escape the notice and baffle the efforts of monkeys and other frugivorous animals. Instead of bidding for attention by its bright hues, like the flower and fruit, the nut is purposely clad in a quiet coat of uniform green, indistinguishable from the surrounding leaves, during its earlier existence; while afterward it assumes a dull-brown color as it lies upon the dusky soil beneath. Nuts are rich in oils and other useful food-stuffs; but to eat these is destructive to the life of the embryo; and therefore the nut commonly surrounds itself with a hard and stony shell, which defies the stoutest teeth to pierce its thickened walls. Outside this solid coating it often spreads a softer covering with a nauseous, bitter taste, so familiar to us all in the walnut, which at once warns off the enemy from attacking the unsavory morsel. Not content with all these protective devices, of color, taste, and hardness, the nut in many cases contains poisonous juices, and is thickly clad in hooked and pointed mail, which wounds the hands or lips of the would-be robber. In brief, a nut is a seed which has survived in the struggle for life by means of multiplied protections against the attacks of enemies. We cannot have a better instance of these precautions than the common cocoanut palm. Its seed hangs at a great height from the ground, on a tall and slender stem, unprovided with branches which might aid the climber, and almost inaccessible to any animal except the persevering monkey. Its shell is very thick and hard, so extremely impermeable that a small passage has to be left by which the germinating shoot may push its way out of the stronghold where it is born. Outside this shell, again, lies a thick matting of hairy fibres, whose elasticity breaks its fall from the giddy height at which it hangs. Yet, in spite of all these cunning precautions, even the cocoanut is not quite safe from the depredations of monkeys, or, stranger still, of tree-climbing crabs. The common Brazil-nuts of our fruiterers' shops are almost equally interesting, their queer, shapeless forms being closely packed together, as they hang from their native boughs, in a hard outer shell, not unlike that of the cocoanut. It must be very annoying to the unsuspecting monkey, who has succeeded after violent efforts in breaking the external coat, to find that he must still deal with a mass of hard, angular, and uncanny nuts, which sadly cut his tender gums and threaten the stability of his precious teeth—those invaluable tools which serve him well in the place of knives, hammers, scissors, and all other human implements.

A fruit, on the other hand, lays itself open in every way to attract the attention of animals, and so to be dispersed by their aid, often amid the nourishing refuse of their meals. It is true that, with the fruit as with the nut, to digest the actual seed itself would be fatal to the life of the young plant. But fruits get over this difficulty by coating their seeds first with a hard, indigestible shell, and then with a soft, sweet, pulpy, and nutritious outer layer. The purely accidental or functional origin of this covering is testified by the immense variety of ways in which it has been developed. Sometimes a single seed has shown a slight tendency to succulence in its outer coat, and forthwith it has gone on laying up juices from generation to generation, until it has developed into a one-seeded berry. Sometimes a whole head of seeds has been surrounded by a fleshy stem, and the attention of animals has thenceforward encouraged its new habit by insuring the dispersion of its embryos. A few of the various methods by which fruits attain their object we shall examine in detail further on; it will suffice for the present to point out that any property which secured for the seed dispersion by animal agency would at once give it an advantage over its fellows, and thus tend to be increased in all future generations.

So, then, as birds, squirrels, bats, monkeys, and the higher animals generally, increased on the face of the earth, every seed which showed a tendency to surround itself with succulent pulp would obviously gain a point thereby in its rivalry with other species. Accordingly, as we might naturally expect, fruits, which have been developed to suit the taste of birds and mammals, are of much more recent geological origin than flowers, which have been developed to suit the taste of insects. For example, there is no family of plants which contains a greater number of fruity seeds than the rose tribe, in which are comprised the apple, pear, plum, cherry, blackberry, raspberry, strawberry, quince, medlar, loquat, peach, apricot, and nectarine, besides the humbler hips, haws, sloes, and common hedge-fruits, which, though despised by lordly man, form the chief winter sustenance of such among our British birds as do not migrate to warmer climates during our chilly December days. Now, no trace of the rose tribe can be discovered until late in tertiary times; in other words, no fruit-bearers appear before the evolution of the fruit-eaters who called them into existence: while, on the other hand, the rapid development and variation of the tribe in the succeeding epoch show how great an advantage it derived from its tendency to produce edible seed-coverings.

But not only must these coverings be succulent and nutritious, they must also be conspicuous and alluring. For the attainment of these objects the fruit has recourse to just the same devices which had already been so successfully initiated by the insect-fertilized flowers. It collects into its pulpy substance a quantity of that commonly-diffused vegetable principle which we call sugar. Now sugar, from its crystalline composition, is peculiarly adapted for acting upon the exposed nerves of taste in the tongue of vertebrates; and the stimulation which it affords, like all healthy and normal ones, when not excessive in amount, is naturally pleasurable to the excited sense. Of course, in our own case, the long habituation of our frugivorous ancestors to this particular stimulant has rendered us peculiarly sensitive to its effects. But even from the first, there can be little doubt that a body so specially fitted to arouse sensation in the gustatory nerve must have afforded pleasure to the unspecialized palates of birds and rodents: for we know that even in the case of naturally carnivorous animals, like dogs, a taste for sugar is extremely noticeable. So, then, the sweet juices of the fruit were early added to its soft and nutritive pulp as an extra attraction for the animal senses.

Perfume, of course, follows in the wake of sweetness. Indeed, the difference between taste and smell is much smaller than most people imagine. When tiny floating particles of a body, in the gaseous state, affect certain exposed nerves in the cavity of the nose, we call the resulting sensation an odor; when larger particles of the same body, in the liquid or dissolved state, affect similar exposed nerves in the tongue, we call the resulting sensation a taste. But the mechanism of the two senses is probably quite similar, while their exciting causes and their likes or dislikes are almost identical. As our great psychological teacher, Mr. Herbert Spencer, well puts it, "smell is anticipatory taste." So we need not be surprised to find that the delicate fragrance of peaches, strawberries, oranges, and pineapples, is a guide to their edibility, and a foreshadowing of their delicious flavor, leading us on by an instinctive action to place the savory morsels between our lips.

But the greatest need of all, if the plant would succeed in enticing the friendly parrot or the obsequious lemur to disperse its seed, is that of conspicuousness. Let the fruit be ever so luscious and ever so laden with sweet sirups, it can never secure the suffrages of the higher animals if it lies hidden beneath a mass of green foliage, or clothes itself in the quiet garb of the retiring nut. To attract from a distance the eyes of wandering birds or mammals, it must dress itself up in a gorgeous livery of crimson, scarlet, and orange. The contrast between nuts and fruits is exactly parallel to the contrast between the wind-fertilized and the insect-fertilized flowers. An apple-tree laden with its red-checked burden, an orange-bough weighed down with its golden spheres, a rowan or a holly-bush displaying ostentatiously its brilliant berries to the birds of the air, is a second edition of the roses, the rhododendrons, and the May-thorns, which spread their bright petals in the spring before the fascinated eyes of bees and butterflies. Some gay and striking tint, which may contrast strongly with the green foliage around, is needed by the developing fruit, or else its pulpiness, its sweetness, and its fragrance, will stand it in poor stead beside its bright-hued compeers.

How fruits began to acquire these brilliant tints is not difficult to see. We found already in the case of flowers that all external portions of a plant, except such green parts as are actually engaged in assimilating carbon, under the influence of solar energies, show a tendency to assume tints other than green. This tendency would, of course, be checked by natural selection in those seeds which, like nuts, are destroyed by animals, and so endeavor to escape their notice; while it would be increased by natural selection in those seeds which, like fruits proper, derive benefit from the observation of animals, and so endeavor to attract their attention. But it is noticeable that fruits themselves are sour, green, and hard, during their unripe stage—that is to say, before the seeds are ready to be severed from the mother-plant; and that they only acquire their sweet taste, brilliant color, and soft pulp, just at the time when their mature seeds become capable of a separate existence.

Perhaps, however, the point which most clearly proves the purely functional origin of fruits is found in the immense variety of their structure, a variety far surpassing that of any other vegetable organ. It does not matter at all what portion of the seed-covering or its adjacent parts happens first to show the tendency toward succulence, sweetness, fragrance, and brilliancy. It serves the attractive purpose equally well whether it be calyx, or stalk, or skin, or receptacle. Just as, in the case of flowers, we found that the colored portion might equally well consist of stamens, petals, sepals, bracts, or spathe—so, but even more conspicuously, in the case of fruits, the attractive pulp may be formed of any organ whatsoever which exhibits the least tendency toward a pulpy habit, and an accumulation of saccharine deposits.

Thus, in the pomegranate, each separate seed is inclosed in a juicy testa or altered shell; in the nutmeg and the spindle-tree, an aril or purely gratuitous colored mass spreads gradually over the whole inner nut; in the plum and cherry, a single part, the pericarp, divides itself into two membranes, whereof the inner or protective coat is hard and stony, while the outer or attractive coat is soft, sweet, and bright-colored; in the strawberry, the receptacle, which should naturally be a mere green bed for the various seed-vessels, grows high, round, pulpy, sweet, and ruddy; in the rose, the fruit-stem expands into a scarlet berry, containing the seed-vessels within, which also happens in a slightly different manner with the apple, pear, and quince; while in the fig, a similar stem incloses the innumerable seeds belonging to a whole colony of tiny blossoms, which thus form a compound fruit, just as the daisy-head, with its mass of clustered florets, forms a composite flower. Strangest of all, the common South American cashew-tree produces its nut (which is the true fruit) at the end of a swollen, pulpy, colored stalk, and so preserves its embryo by the vicarious sacrifice of a fallacious substitute. These are only a few out of the many ways in which the selective power of animals has varied the surroundings of different seeds to serve a single ultimate purpose.

Nor is any plan too extravagant for adoption by some aberrant species. What seed-organ could seem less adapted for the attraction of animals than a cone like that of pines and fir-trees? Yet even this hard, scaly covering has been modified, in the course of ages, so as to form a fruit. In the cypress, with its soft young cones, we can see dimly the first step in the process; in the juniper, the cone has become quite succulent and berry-like; and finally, in the red fruit of the yew, all resemblance to the original type is entirely overlaid by its acquired traits.

Equally significant is the fact that closely-allied species often choose totally different means for attracting or escaping observation. Thus, within the limits of the rose tribe itself we get such remarkable variations as the strawberry, where the receptacle forms the fruit; the apple, which depends on the peduncle, or swollen stalk, for its allurement; the raspberry, where each seed-vessel of the compound group has a juicy coating of its own, and so forth: while, on the other hand, the potentilla has no fruit at all, in the popular sense of the word; and the almond actually diverges so far from the ordinary habits of the tribe as to adopt the protective tactics of a nut. Similarly, in the palm tribe, while most species fortify themselves against monkeys by shells of extravagant hardness, as we see in the vegetable ivory, and the solid coquilla-nuts from which door-handles are manufactured, a few kinds, like the date and the doom-palm, trust rather to the softness and sweetness of their pulp, as aids to dispersion. The truth which we learn from these diverse cases may be shortly summed up thus: Whatever peculiarities tend to preserve the life of a species, in whatever opposite ways, equally aid it in the struggle for life, and may be indifferently produced in the most closely-related types.

And now let us glance for a moment—less fully than the subject demands, for this long exposition has run away with our space—at the reactive effects of fruit upon the animal eye. We took it for granted above that birds and mammals could discriminate between the red or yellow berry and the green foliage in whose midst it grows. Indeed, were other proof wanting, we should be justified in concluding that animals generally are possessed of a sense for the discrimination of color, from the mere fact that all those fruits and flowers which depend for their dispersion or fertilization upon animal agency are brightly tinted, while all those which depend upon the wind, or other insentient energies, are green or dull-brown in hue. But many actual observations, too numerous to be detailed here, also show us, beyond the possibility of error, that the higher animals do, as a matter of fact, possess a sense of color, differing in no important particular from that of civilized man.

Whether this sense was developed, however, by the constant search for berries and insects, or whether it was derived from a still earlier ancestry, it would be very difficult to decide. It is possible that, as we saw reason to believe in the case of the flowers and the insect vision, the colors of fruits and the color-sense of birds and mammals may have gone on developing side by side; each plant surviving in proportion as its seeds grew more and more distinctive, and each animal, in turn, standing a better chance of food in proportion as its discrimination of such seeds grew more and more acute. But as there are excellent reasons for crediting fishes and reptiles also with a high faculty for the perception of color, it may be safer to conclude that the sense was inherited by birds and mammals from our common vertebrate progenitors, being only quickened and intensified by the reactive influence of fruits.

Yet it must be remembered that the earliest fruit-eaters, though they might find the scarlet, crimson, or purple coats of their food an aid to discrimination in the primeval forests, would not necessarily derive any pleasure from the stimulation thus afforded That pleasure has been slowly begotten in all frugivorous races by the constant use of these particular nerves in the search for food, which has at last produced in them a calibre and a sensitiveness answering pleasurably to the appropriate stimulation. Just as the peach, which a dog would reject, has become delicious to our sense of taste; just as the pineapple, at which he would sniff unconcernedly, has become exquisite to our sense of smell—so the pure tints of the plum, the orange, the mango, and the pomegranate, which he would disregard, have become lovely to our sense of color. And, further still, just as we transfer the tastes formed in the first two cases to the sweetmeats of the East, or to the violets, hyacinths, and heliotropes of our gardens, so do we transfer the taste formed in the third case to our gorgeous peonies, roses, dahlias, crocuses, tiger-lilies, and chrysanthemums; to our silks, satins, damasks, and textile fabrics generally; to our vases, our mosaics, our painted windows, our frescoed walls, our Academies, our Louvres, and our Vaticans. Even as we put sugar and spices into insipid dishes to gratify the gustatory nerves, whose sensibility was originally developed by the savor of tropical fruits, so do we put red, blue, and purple, into our pottery, our decoration, and our painting, to gratify the visual nerves, whose sensibility was originally developed by the rich tint of grapes and strawberries, star-apples and oranges.

And here again, as in the case of flowers, the feeling once aroused has found for itself new objects in the voluntary selection of beautiful mates—that is to say, of mates whose coloring gratified the rising delight in pure tints. The taste formed upon blossoms produced, by its reaction, crimson butterflies and burnished beetles, the sun-birds of the East, and the humming-birds of the West. So, too, the taste formed upon fruits produced, by a like reaction, parrots, cockatoos, toucans, birds-of-paradise, nutmeg-pigeons, and a thousand other tropical creatures of exquisite plumage and delicate form. As we mount up through the mammalian series, we scarcely come upon any hues brighter than dull-brown or tawny-yellow among the marsupials, the carnivores, the ruminants, or the thick-skinned beasts; but when we arrive at the seed-eating classes, such as the rodents, the bats, and the quadrumana, we find a profusion of color in many squirrels, flying-foxes, and monkeys; while Mr. Darwin does not hesitate in attributing to the same selective action the rosy cheeks, pearly teeth, blue eyes, and golden hair, of the human species.

Nor is it only in the choice of mates that the nascent taste for color displays itself. Even below the limits of humanity bright-hued objects afford a passing pleasure to more than one æsthetically-endowed species. Monkeys love to pull crimson flowers in pieces, dart in pursuit of brilliant tropical birds, and are attracted by the sight of red or yellow rags. Those queer little creatures, the bower-birds, carry the same feeling a step further by collecting fragments of brilliantly-colored objects to decorate their gaudy meeting-places. But, when we reach the race of man, we find the love of color producing far more conspicuous secondary results. The savage daubs his body with red or blue paint, and plants his garden with the scarlet hibiscus or the purple bougainvillia. Soon, with the rise of pottery and cloth-making, he learns the use of pigments and the art of dyeing. Next, painting proper follows, with all the decorative appliances of Egypt, India, China, and Japan, until at last our whole life comes to be passed in the midst of clothing and furniture, wall-papers and carpets, books and ornaments, vases and tiles, statuettes and pictures, every one of which has been specially prepared with dyes or pigments, to gratify the feeling originally derived from the contemplation of woodland berries by prehistoric man, or his frugivorous ancestors. And all these varied objects of civilized life may be traced back directly to the reaction of colored fruits upon the structure of the mammalian eye.

What a splendid and a noble prospect for humanity in its future evolutions may we not find in this thought that, from the coarse animal pleasure of beholding food, mankind has already developed, through delicate gradations, our modern disinterested love for the glories of sunset and the melting shades of ocean, for the gorgeous pageantry of summer flowers, and the dying beauty of autumn leaves, for the exquisite harmony which reposes on the canvas of Titian, and the golden haze which glimmers over the dreamy visions of Turner! If man, base as he yet is, can nevertheless rise to-day in his highest moments so far above his sensuous self, what may he not hope to achieve hereafter, under the hallowing influence of those chaster and purer aspirations which are welling up within him even now toward the perfect day!—*Cornhill Magazine.*

SKETCH OF PROFESSOR O. C. MARSH.

By G. B. GRINNELL.

AMONG the younger workers in science in America, no name stands higher than that of Prof. O. C. Marsh. Enthusiastic, energetic, and capable of an unlimited amount of work, he has already contributed more than any one else to our knowledge of the ancient life of this continent. Many of his discoveries have proved of the greatest interest to the student of biology, and have a direct and highly-significant bearing on some of the most important scientific problems of the day. The genealogy of the horse, brought forward by Prof. Huxley in his New York lectures as the demonstrative evidence of evolution, was worked out mainly by Prof. Marsh, and was the result of his vigorous field-work and patient study.

Prof. OTHNIEL CHARLES MARSH was born in Lockport, New York, October 29, 1831, and his boyhood was spent mainly in that vicinity. As a boy he was passionately fond of field-sports, and devoted much of his time to fishing and shooting. The writer has heard him remark that he was a sportsman before he was a naturalist ; and it cannot be doubted that the open-air life of his early years gave him the vigorous health he has since enjoyed, while to the habits of observation acquired in the woods and fields much of his subsequent success in science has been due. He is still a keen sportsman, and very hard to beat with rod or gun. In 1852 he entered Phillips Academy at Andover, Massachusetts, where he graduated in 1856, the valedictorian of his class. He entered Yale College the same year, and graduated with high honors in the class of 1860. The next two years were spent in the study of chemistry and mineralogy in the Sheffield Scientific School at New Haven. He then went to Europe, and spent three years in the Universities of Berlin, Heidelberg, and Breslau. While in Germany he studied zoölogy and geology under the eminent teachers Ehrenberg, Rose, Bunsen, Peters, Beyrich, and Roemer. His vacations were devoted to Alpine explorations and other work in the field, during which he made several discoveries of interest, and published accounts of them in papers read before the Geological Society of Germany. He returned to New Haven in 1866, to fill the chair of Paleontology in Yale College, a position which he now holds.

During his school-days at Andover, and throughout his college course, Prof. Marsh was a devoted student of mineralogy, and many of his vacations were spent in Nova Scotia, collecting minerals and investigating the geology of that peninsula. It was here that he discovered, while yet in college, the two celebrated vertebræ of *Eosaurus Acadianus*, which still remain unique, and are thought to have been the first remains of reptiles found in the Palæozoic rocks of America. His studies in archæology also began in college.

To many readers, Prof. Marsh is best known in connection with his explorations in the Rocky Mountains, which he has crossed no less than eleven times on his various expeditions. His first visit to that country was a short excursion in 1868, which produced results of no little interest. From an alkaline lake in Wyoming he then obtained live specimens of larval Siredons, the remarkable change in which, occurring, under his own eye, after his return, called forth the paper "On the Metamorphosis of *Siredon* into *Amblystoma*." On this trip, too, a number of interesting Tertiary fossils were obtained from a well at Antelope Station, Nebraska, in the bed of an ancient lake, and at several other localities. The discoveries thus made indicated to Prof. Marsh the importance of this previously-unknown field, and he made preparations to undertake its systematic exploration. During the years immediately following his return from Europe, he had studied with much care the Cretaceous and Tertiary fauna of New Jersey ; but it now became apparent to him that the fossil resources of these deposits were of much less importance than those of the West. In June, 1870, the first of the Yale Scientific Expeditions was organized and took the field, returning after an absence of five months, richly laden with fossil treasures. Over one hundred species of extinct vertebrates, new to science, were discovered on this trip. Most of these were from two Tertiary lake-basins before unknown. During the four years which followed, Prof. Marsh led other expeditions, which were scarcely less successful than the first, and the vertebrate fossils thus collected soon came to be reckoned by tons, instead of by hundreds or thousands of specimens. These various expeditions were attended with much danger and hardship, as the regions explored were often infested with hostile Indians, and explorations could be carried on only under the protection of a strong escort of Government troops. Prof. Marsh's early experience as a sportsman was also of great advantage, as the fact that he was the quickest and best shot in the expedition was soon acknowledged, and commanded respect from the soldiers and rough mountaineers who accompanied him. The expenditure of time which the leadership of these expeditions involved was, however, so great, that recently parties of trained collectors have been sent out, who pack the fossils on the ground and ship them to the Peabody Museum of Yale College, where they are examined by Prof. Marsh and his assistants. The expenses incurred in these various explorations have been great, and were mainly borne by Prof. Marsh, who has already contributed more than $100,000 to this work.

Among the most interesting of Prof. Marsh's recent discoveries are, a new mammal (*Dryolestes*) ; a new order of Reptilia (*Stegosauria*), and many new and gigantic Dinosaurs, all from the Jurassic of the Rocky Mountains, and the first found in this formation in this country.

From the Cretaceous of Kansas he has obtained the first American *Pterodactyles*, including a new order (*Pteranodontia*), a new sub-class of birds with teeth (*Odontornithes*), including two new orders, the *Odontolcæ* and *Odontotormæ;* and many new Mosasauroid reptiles. In the anatomy of the latter group he has made a number of interesting discoveries which have been of great value in determining its relationship. From the Eocene Tertiary of the Rocky Mountains, he has brought to light the first monkeys, bats, and marsupials, found in this country; two new orders of mammals, the *Tillodontia*, which seem to be related to the Carnivores, Ungulates, and Rodents; and the *Dinocerata*, which were huge Ungulates, elephantine in bulk, bearing on their skulls two or more pairs of horn cores. From the same Eocene come the two earliest equines, *Eohippus* and *Orohippus*, and a host of other strange forms, all of them widely different from anything now living.

In the Miocene lake-basins of the West, Prof. Marsh has found numerous other forms, many of them apparently descendants of their predecessors in the Eocene, while others seem to stand alone. In the Miocene of the Plains occur the huge *Brontotheridæ*, a new family of Ungulates, first defined by Prof. Marsh. In size they equaled the *Dinocerata* of the Eocene, and like them their skulls were armed with horns. The same formation has also yielded to this explorer the first Miocene monkey found in America, while from the Oregon lake of this age he has described the oldest known Edentates. The new fossils obtained from the Pliocene lake-basins of the Plains and of Oregon are not less numerous than those from the earlier ones, but they are of less interest to the general reader. The remains of these ancient creatures, preserved in the Museum of Yale College, present a series which, for its interest and value to the biologist, is not surpassed by any collection in the world. Not less than four hundred new species of fossil animals have been collected by Prof. Marsh, and their remains are all at present in New Haven.

Prof. Marsh is President of the American Association for the Advancement of Science, and will preside at the St. Louis meeting this year; and, as retiring president, will deliver his address in 1879. At the meeting of the National Academy of Sciences in Washington, in April last, he was elected vice-president of that body, and, by the death of Prof. Henry, he has become its presiding officer. He is a member of several scientific societies in Europe, and has recently received from the Geological Society of London the Bigsby medal for his important discoveries in paleontology.

Prof. Marsh is a nephew of the late George Peabody, Esq., of London, and the most important gifts to science by this philanthropist are due to his influence. The Peabody Museum of Natural History, at New Haven, the Peabody Museum of Archæology and Ethnology, at Cambridge, as well as the Peabody Academy of Science, in Salem, Massachusetts, are largely the results of his advice and carefully-considered plans. He has followed his uncle's example in princely gifts to science, and, thus far, likewise, we may add, in remaining a bachelor.

Prof. Marsh is a firm believer in evolution, and enjoys the personal acquaintance and friendship of Darwin, Huxley, Wallace, Spencer, and other prominent advocates of this doctrine. He is at present in England with his scientific friends, but will return in time for the St. Louis meeting of the Association for the Advancement of Science.

Aside from his scientific reputation, Prof. Marsh became well known to the general public, a short time since, through his contest with Secretary Delano and the Interior Department. It will be remembered that while Prof. Marsh was on his perilous expedition to the "Bad-Lands," near the Black Hills, in the winter of 1874, he was twice driven back by the Sioux Indians, who supposed him to be in search of gold rather than bones. In endeavoring to propitiate the savages, he held various councils with Red Cloud and the other principal chiefs, and at last gained permission to proceed with his party only by promising Red Cloud to take his complaints and samples of his rations to the Great Father at Washington. The fulfillment of this promise, together with an exposure of the frauds which he had seen practised upon the Indians,[1] led to a sharp fight with Secretary Delano and the Indian ring. Secretary Delano began by calling the professor "*a Mr. Marsh*," and ended by retiring to private life and political death in Ohio. The scalps of several lesser officials and contractors were taken by the professor in the same fight, and subsequent events have more than substantiated all of the charges he made. This is perhaps the only instance in which a private citizen has successfully fought a department of the Government in his efforts to expose wrong-doing. Red Cloud has since sent the professor an elegant pipe and tobacco-pouch, as a token of his gratitude, and with them the complimentary message that "the Bone-hunting Chief," as he calls the professor, "was the only white man he had seen who kept his promises."

Prof. Marsh's scientific publications, which began while he was a student, number more than one hundred, and are mostly papers in scientific journals. One of the most important of these publications is his address as Vice-President of the American Association for the Advancement of Science, delivered in August, 1877, at Nashville, Tennessee, and published in The Popular Science Monthly for March and April, 1878. He is now engaged in the preparation of a series of monographs, with full illustrations, of his discoveries, which will be published under Government auspices. The first volume, upon the "Odontornithes, or Birds with Teeth," illustrated with forty quarto plates, is now in press, and will soon be published.

Among the more noteworthy of Prof. Marsh's scientific papers are the following:

[1] A statement of affairs at the Red Cloud Agency, made to the President of the United States, Yale College, July, 1875.

The Gold of Nova Scotia (*American Journal of Science* (2), vol. xxxii., pp. 395–400, November, 1861).

Description of the Remains of a New Enaliosaurian (*Eosaurus Acadianus*), from the Coal Formation of Nova Scotia (*American Journal of Science* (2), vol. xxxiv., pp. 1–16, November, 1862).

Catalogue of Mineral Localities in New Brunswick, Nova Scotia, and Newfoundland (*American Journal of Science* (2), vol. xxxv., pp. 210–218, March, 1863).

Description of an Ancient Sepulchral Mound near Newark, Ohio (*American Journal of Science* (2), vol. xlii., pp. 1–11, July, 1866).

Contributions to the Mineralogy of Nova Scotia (*American Journal of Science* (2), vol. xliv., pp. 362–367, November, 1867).

Observations on the Metamorphosis of Siredon into Amblystoma (*American Journal of Science* (2), vol. xlvi., pp. 364–374, November, 1868).

Notice of some New Mosasauroid Reptiles from the Greensand of New Jersey (*American Journal of Science* (2), vol. xlviii., pp. 392–397, November, 1869).

Notice of some Fossil Birds from the Cretaceous and Tertiary Formations of the United States (*American Journal of Science* (2), vol. xlix., pp. 205–217, March, 1870).

On the Geology of the Eastern Uintah Mountains (*American Journal of Science* (3), vol. i., pp. 191–198, March, 1871).

Description of some New Fossil Serpents from the Tertiary Deposits of Wyoming (*American Journal of Science* (3), vol. i., pp. 322–329, May, 1871).

Notice of some New Fossil Reptiles from the Cretaceous and Tertiary Formations (*American Journal of Science* (3), vol. i., pp. 447–459, June, 1871).

Note on a New and Gigantic Species of Pterodactyle (*American Journal of Science* (3), vol. i., p. 472, June, 1871).

Notice of some New Fossil Mammals from the Tertiary Formation (*American Journal of Science* (3), vol. ii., pp. 35–44, July, 1871).

Notice of some New Fossil Mammals and Birds from the Tertiary Formation of the West (*American Journal of Science* (3), vol. ii., pp. 120–127, August, 1871).

On the Structure of the Skull and Limbs in Mosasauroid Reptiles, with Descriptions of New Genera and Species (*American Journal of Science* (3), vol. iii., pp. 448–464, June, 1872).

Preliminary Description of New Tertiary Mammals; Part I. (*American Journal of Science* (3), vol. iv., pp. 122–128, August, 1872).

Preliminary Description of New Tertiary Reptiles; Part I. (*American Journal of Science* (3), vol. iv., pp. 299–304, October, 1872). Part II. (*American Journal of Science* (3), vol. iv., pp. 305–309, October, 1872).

Notice of some New Tertiary and Post-Tertiary Birds (*American Journal of Science* (3), vol. iv., pp. 256–262, October, 1872).

Notice of some Remarkable Fossil Mammals (*American Journal of Science* (3) vol. iv., pp. 343, 344, October, 1872).

Notice of a New and Remarkable Fossil Bird (*American Journal of Science* (3), vol. iv., p. 344, October, 1872).

Discovery of Fossil Quadrumana in the Eocene of Wyoming (*American Journal of Science* (3), vol. iv., pp. 405, 406, November, 1872).

On the Gigantic Fossil Mammals of the Order Dinocerata (*American Journal of Science* (3), vol. v., pp. 117–122, February, 1873).

On a New Sub-Class of Fossil Birds (Odontornithes) (*American Journal of Science* (3), vol. v., pp. 161, 162, February, 1873).

On the Structure and Affinities of the Brontotheridæ (*American Journal of Science* (3), vol. vii., pp. 81–86, January, 1874).

Notice of New Equine Mammals from the Tertiary Formation (*American Journal of Science* (3), vol. vii., pp. 247–258, March, 1874).

New Order of Eocene Mammals (*American Journal of Science* (3), vol. ix., p. 221, March, 1875).

On the Odontornithes, or Birds with Teeth (*American Journal of Science* (3), vol. x., pp. 403–408, November, 1875).

Principal Characters of the Dinocerata (*American Journal of Science* (3), vol. xi., pp. 163–168, February, 1876).

Principal Characters of the Tillodontia (*American Journal of Science* (3), vol. xi., pp. 249–251, March, 1876).

Principal Characters of the Brontotheridæ (*American Journal of Science* (3), vol. xi., pp. 335–340, April, 1876).

On a New Sub-Order of Pterosauria (*American Journal of Science* (3), vol. xi., pp. 507–509, June, 1876).

Recent Discoveries of Extinct Animals (*American Journal of Science* (3), vol. xii., pp. 59–61, July, 1876).

Notice of New Tertiary Mammals; Part V. (*American Journal of Science* (3), vol. xii., pp. 401–404, November, 1876).

Principal Characters of American Pterodactyles (*American Journal of Science* (3), vol. xii., pp. 479, 480, December, 1876).

Notice of a New and Gigantic Dinosaur (*American Journal of Science* (3), vol. xiv., pp. 87, 88, July, 1877).

Principal Characters of the Coryphodontidæ (*American Journal of Science* (3), vol. xiv., pp. 81–85, July, 1877).

Characters of the Odontornithes, with Notice of a New Allied Genus (*American Journal of Science* (3), vol. xiv., pp. 85–87, July, 1877).

Address on Introduction and Succession of Vertebrate Life in America (*American Journal of Science* (3), vol. xiv., pp. 338–378, November, 1877).

A New Order of Extinct Reptilia (*Stegosauria*) from the Jurassic of the Rocky Mountains (*American Journal of Science* (3), vol. xiv., pp. 513, 514, December, 1877).

New Species of Ceratodus, from the Jurassic (*American Journal of Science* (3), vol. xv., p. 76, January, 1878).

Notice of New Dinosaurian Reptiles (*American Journal of Science* (3), vol. xv., pp. 241–244, March, 1878).

Notice of New Fossil Reptiles (*American Journal of Science* (3), vol. xv., pp. 409–411, May, 1878).

Fossil Mammal from the Jurassic of the Rocky Mountains (*American Journal of Science* (3), vol. xv., p. 459, June, 1878).

Other scientific papers of interest by Prof. Marsh will be found in the same journal, as well as in the *Zeitschrift* of the Geological Society of Germany; *American Naturalist;* "Proceedings of the Philadelphia Academy of Natural Sciences;" "Proceedings of the American Philosophical Society; "Proceedings of the American Association for the Advancement of Science;" and in other periodicals.

EDITOR'S TABLE.

THE ENGLISH REPORT ON INTERNATIONAL COPYRIGHT.

THE report of the English commission on the general subject of copyright is now complete and before the public. It shows that there has been a searching investigation into the existing condition and working of copyright-laws in that country, with an honest view to such amendments as are necessary to more thorough protection of the right to literary property. The report is able and exhaustive, and recommends parliamentary measures which, if carried out, will be of great advantage to authors, and will be an honor to England. The commissioners found the subject encompassed with serious and perplexing difficulties, but they did not make these the occasion of shrinking from the duty that had been assigned to them. If any American wishes to preserve a decent self-respect, we advise him not to pass from the reading of the English copyright report to the report of the United States Senate upon the same subject, made in 1873, by Mr. Morrill, of Maine. The contrast between the two documents is remarkable. The English report is grave and formidable, and shows that there has been long and earnest work over a question that is felt to be of great national importance; the American report is a miserable tract of half a dozen pages, evincing by its meagreness the utter indifference of those who drew it up to the subject which they had been appointed to consider. The English report recognizes extensive defects in the legislation of that country upon the question, and recommends bold changes in it to secure a better state of things; the American report sees nothing wrong that it is desirable to amend, and recommends Congress to take no action in the matter. It treats the subject from the low and selfish point of view of the American political demagogue, enters with a relish into the sordid squabbles of book-manufacturers, and pays not the slightest attention to the important principles that should be recognized as at the basis of a just and enlightened policy of international copyright. The English report, on the contrary, treats the subject with dignity and seriousness, bringing out clearly the great principles that should control it, and taking high and impregnable moral ground in regard to the duty of the English Parliament in legislating with reference to it. It is a question of international ethics, and England has shot a long way forward by adopting the Christian standard of conduct in this relation, and saying we are prepared to do as we would be done by. The high-water mark of international morality hitherto reached has been to do as you *are* done by, to reciprocate, to concede benefits if benefits are granted, and to deny them if they are denied. England takes the lead in affirming that the thing which is right, just, and equitable, must be done, whether other nations reciprocate or not. She took an important step in this direction in entering upon the policy of free trade, and now proposes to carry it out in her international treatment of literary property and the rights of authors. The commission recommends to Parliament to grant copyrights to American authors whether the United States will do the same thing for English authors or not. They say: "It has been suggested to us that this country would be justified in taking steps of a retaliatory character, with a view of enforcing, incidentally, that protection from the United States which we accord to them. This might be done by withdrawing from the Americans the privilege of copyright on first publication in this country. We have, however, come to the conclusion that it is advisable that our law should be based on correct principles, irrespective of the opinions or policy of other nations. We admit the propriety of protecting copyright, and it appears to us that the principle of copyright, if admitted, is one of universal application. We, therefore, recommend that this country should pursue the policy of recognizing the author's rights, irrespective of nationality."

On a subject which presents so much that is conflicting and unsettled, it is not to be supposed that there would be complete unanimity of opinion among the fifteen members of this commission, who were chosen because they are men of intelligence, and capable of forming their own views. The subject, besides, was one of great extent and complication of rival interests, involving the policy to be pursued regarding home and foreign copyrights, abridgments of books, musical compositions, dramatization of novels, lectures, newspapers, paintings, photographs, translations, registrations, forfeitures, infringements, and scores of other matters hitherto left to a chaotic system of legislation. But, considering the task they had before them, the commissioners have come to substantial agreement as to the measures recommended. There were two or three wrong-headed and crotchety men, who made dissenting reports on various points, although concurring in the main practical results. Chief among these eccentric dissentients was Sir Louis Mallet; he could not agree with his coadjutors, and with some of the leading gentlemen who testified before them, as to the ground of rights in literary property. Many ingenious and fanciful arguments have been made to prove that men have no right to the property they create by brain-labor, or have only such a qualified right to it that to appropriate it without consent is not stealing. What a man earns by his hands, and by capital invested in tools and machinery, they admit he has a right to against the world; but what he earns by laborious thinking, and by capital invested in education, may be taken from him by anybody who wants it. Many funny reasons, as we have said, have been offered for allowing those who can make anything by it for themselves to plunder authors of the products of their toil, but Sir Louis Mallet has the honor of contributing the last curious pretext for this sort of robbery. He says: "The right conferred by a copyright-law derives its chief value from the discovery of the art of printing; and there appears no reason for giving to authors any larger share in the value of a mechanical invention, to which they have contributed nothing, than to any other member of the community." But, if authors are not to be permitted to hold their property because the discovery of the art of printing has contributed to its value, what right has anybody to hold any property that is the result of an invention or discovery to which he has not contributed? The doctrine would make sad havoc of the rights of capitalists and laborers in all countries, whose earnings and accumulations are due to the use of steam-engines, telegraphs, spinning-machinery, and a thousand other devices to which they have never contributed.

Sir Louis Mallet coincides in the practical recommendations of the report, although not agreeing with the grounds upon which they are made. Yet he exhibited a good deal of ingenious perverseness in embarrassing the inquiry. This was well illustrated by the case he undertook to make out against the necessity of international copyright by the success of the "International Scientific Series," where foreign authors are paid without the compulsion of an international copyright-law. His case, in a word, is this: By a satisfactory arrangement contributors to the "International Scientific Series" are liberally paid by the English publisher, and then fairly paid again by the American publisher—what more is wanted? The answer, of course, is very simple: There is wanted legal protection to the property. The American publishers concede that there is a property-value in the books they reissue, for which they are willing to pay under a voluntary contract; but how does that proceeding absolve the United States Government from the duty of protecting that property as it protects other property? Reasonable men will see that the convention of publishers in different countries, to carry out such a project, is but a weighty testimony to the just claims of authors which it is the duty and office of government to sustain and enforce by the proper legislation. It is the one great duty of government to protect the rights of its citizens, and prominent among these is the right of property. All civilized countries recognize the right of property in books, and there have been attempts to make this recognition international, that is, to induce nations to extend their morality beyond their geographical borders. In the absence of any such arrangement, a few parties agree that they will voluntarily recognize the rights of intellectual property, and the very doing of this is to be made a new excuse for neglecting to enforce the fundamental obligations of justice.

COOKERY AND EDUCATION.

It was a suggestive remark of Count Rumford that "the number of inhabitants who may be supported in any country upon its internal produce depends about as much upon the state of the *art of cookery* as upon that of agriculture; but, if cookery be of so much importance, it ought certainly to be studied with the greatest care. Cookery and agriculture are arts of civilized nations; savages understand neither of them."

There is a great deal of important truth wrapped up in this passage, of vital interest to society in general and to individual welfare, but which it has taken a hundred years to appreciate so fully that any considerable number of people can begin to coöperate in reducing it to practice. But, if what Rumford said is true, if the scale of population as well as the comfort and health of the people depends to such a degree upon the art of cookery, what are all the issues of politics over which men are fighting with such desperation in comparison with the systematic improvement of the culinary art? How greatly the public weal is dependent upon the condition of agriculture begins now to be widely understood, and since the time of Rumford great progress has been made in its scientific study through the establishment of special schools and colleges for the purpose. Agricultural education is now a recognized branch of popular culture which is destined to be greatly developed and extended in the future. The next great step must be to do the same thing for the art of cookery; and the friends of genuine social improvement may congratulate themselves that the progress of education is beginning to take effect upon this important department of domestic life. Cooking-schools are springing up in many places in this country and in England, and the English are taking the lead in organizing them as a part of their national and common school system.

Of the importance, the imperative necessity of this movement, there cannot be the slightest question. Our kitchens, as is perfectly notorious, are the fortified intrenchments of ignorance, prejudice, irrational habits, rule-of-thumb, and mental vacuity, and the consequence is that the Americans are liable to the reproach of suffering beyond any other people from wasteful, unpalatable, unhealthful and monotonous cookery. Considering our resources, and the vaunted education and intelligence of American women, this reproach is just. Our kitchens are, in fact, almost abandoned to the control of low Irish, stupid negroes, and raw servile menials that pour in upon us from various foreign countries. And, what is worse, there is a general acquiescence in this state of things, as if it were something fated, and relief from it hopeless and impossible. We profess to believe in the potency of education, and are applying it to all other interests and industries excepting only that fundamental art of the preparation and use of food to sustain life which involves more of economy, enjoyment, health, spirits, and the power of effective labor, than any other subject that is formally studied in the schools. We abound in female seminaries and female colleges, and high-schools, and normal schools, supported by burdensome taxes, in which everything under heaven is studied except that practical art which is a daily and vital necessity in all the households of the land.

Acquiescence in this state of things as something permanent and irremediable is no longer possible. If, as Rumford says, cookery is an art of civilized nations, it must improve with the advance of civilization. It is undoubtedly the most backward of all the arts, and various causes conspire to its continued neglect. But, whatever the difficulties to be overcome, the time has arrived when the advance of intelligence and the spirit of improvement must invade that last stronghold of traditional stupidity, the kitchen. Nor are the difficulties of doing this by any means so great as is commonly supposed; they will vanish as soon as the task of alleviation and amendment is earnestly undertaken. As soon as thought and cultivation are brought to bear upon the domestic operations of the kitchen, they will be elevated in the common respect, and a most formidable impediment will thus be removed. American women have been driven out of the kitchen because all its associations are degrading, and they demand education as a preparation for all those other activities to which educations leads. When the art of cookery becomes a matter of intelligent study, so that its practice will no longer be a badge of debasement and humiliation, occupation will be sought and honored in this field as elsewhere. The establishment of cooking-schools is, therefore, in the direct line of our domestic amelioration and emancipation. They are already, as we have said, established, and, considering the embarrassments of an initial movement of this kind, are in most successful operation. Though at present narrow in their scope, they will develop and widen so as to afford a training in the broader field of general household activity; but we are well content with what has been already gained. The South Kensington Cooking-School, in London, is a normal school for training teachers to go out and take charge of other schools in different parts of the country. How successful this institution has been may be inferred from the fact that it has already given us the best practical cook-book that we now have. We call attention to the notice of this work in the following pages, from which the reader will gather some interesting information as to what has been accomplished on the other side of the Atlantic in relation to this important subject, and which will afford important hints for carrying out a similar work in the United States.

SCIENCE IN RELATION TO TEACHING.

Of all the applications of science to the practical arts, there is none that can for a moment bear comparison with its application to the art of teaching. Scientific education, as currently understood, refers to something of greatly inferior importance: it means instruction in the sciences. Many of the teachers in our schools know something of these sciences, and do what they can to expound them. This, of course, is useful, but it is the lowest agency for the diffusion of science. Of the uses of science to themselves as professors of the art of teaching, or of its value in guiding the processes of education, it is not too much to say that the mass of teachers as yet know nothing. This, however, is the main and essential thing now to be imperatively demanded, and which, when attained, will do more toward the universal promotion of science than all other modes of influence combined. Scientific education is far less a question of the number of hours per week that are to be devoted to this kind of study than a question of bringing scientific knowledge to bear upon the operations of the school-room.

We took this ground decisively twenty years ago. When applied to by Mr. Greeley to write some articles for the *Tribune* on "Scientific Education," we devoted them to a statement of the ground that science requires all intelligent teachers to take in the pursuit of their profession. We illustrated and enforced the position that, to develop the mind and form the character, the starting-point of the teacher must be a knowledge of the brain and of nervous physiology, and that all teaching without this knowledge must be empirical, is certain to be faulty, and liable to be injurious. The discussion was premature. We sowed upon unprepared ground. It was objected that all beyond the bare introduction of more chemistry and physics in the schools was impracticable and fanciful; while to talk of "brain" instead of "mind" was dreaded as dangerous, and condemned as leading "straight down to materialism."

In a work published a dozen years ago, "On the Culture demanded by Modern Life," this view was reaffirmed and more fully illustrated. It was insisted that to gain definite ideas of the laws of mind so as to work the forces of education *quantitatively*, if we may so speak, for the production of permanent effects, we must recognize the law of mental limitations that is educible from cerebral physiology. In an essay treating of the philosophy of mental discipline we said:

"It no longer admits of denial or cavil that the Author of our being has seen fit to connect mind and intelligence with a nervous mechanism; in studying mental phenomena, therefore, in connection with this mechanism, we are studying them in the relation which God has established, and therefore in the only true relation. Nothing is more certain than that, in future, mind is to be considered in connection with the organism by which it is conditioned. When it is said that the brain is the organ of the mind, it is meant that in thinking, remembering, reasoning, *the brain acts*. The basis of educability, and hence of mental discipline, is to be sought in the properties of that nervous substance by which mind is manifested. When it is perceived that what we have to deal with in mental acquirement is organic processes which have a definite time-rate of activity, so that, however vigorously the cerebral currents are sustained by keeping at a thing, acquisition is not increased in the same degree; when we see that new attainments are easiest and most rapid during early life—the time of most vigorous growth of the body generally; that thinking exhausts the brain as really as working exhausts the muscles, while rest and nutrition are as much needed in one case as the other; when we see that rapidity of attainment and tenacity of memory involve the question of cerebral adhesions, and note how widely constitutions differ in these capabilities, how they depend upon blood, stock, and health, and vary with numberless conditions—we become aware how inexorably the problem of mental attainment is hedged round with limitations, and the vague notion that there are no bounds to acquisition except imperfect application disappears forever."

The general view (here illustrated in a special application) has been maintained in The Popular Science Monthly from the outset. We have published papers from the ablest scientific men of different countries, illustrating the control of physiological and psychological principles over the objects and methods of education. These able discussions, we are happy to say, have been increasingly appreciated; and it is gratifying to note that the view we have steadily urged for these many years begins to be widely accepted as the basis of a new departure in the progress of scientific education. A conspicuous illustration of this has recently been afforded by the course of the most influential journal in England. There has been a systematic movement in that country to get a larger share of scientific study in the lower schools; and, under the vigorous leadership of Sir John Lubbock, in the House of Commons, efforts have been made to modify school legislation so as to enforce this result. A majority has not yet been gained, but the opposition is giving way, and the end sought will undoubtedly soon be attained. Upon the last and recent defeat of Sir John Lubbock's measure, the London *Times* came out with a leading editorial on the right side, and which is chiefly remarkable for the advanced and unqualified position which it takes. We reprint this article of the *Times* in the present number of the Monthly, together with the comments of the editor of *Nature* upon it. How completely the writer sustains the views that we have long labored to inculcate, is well shown in the following instructive passage:

"As soon as physiologists had discovered that all the faculties of the intellect, however originating or upon whatever exercised, were functions of a material organism or brain, absolutely dependent upon its integrity for their manifestation, and upon its growth and development for their improvement, it became apparent that the true office of the teacher of the future would be to seek to learn the conditions by which the growth and the operations of the brain were controlled in order that he might be able to modify these conditions in a favorable manner. The abstraction of the 'mind' was so far set aside as to make it certain that this mind could only act through a nervous structure, and that the structure was subject to various influences for good or evil. It became known that a brain cannot arrive at healthy maturity excepting by the assistance of a sufficient supply of healthy blood; that is to say, of good food and pure air. It also became known that the power of a brain will ultimately depend very much upon the way in which it is habitually exercised, and that the practice of schools in this respect left a great deal to be desired. A large amount of costly and pretentious teaching fails dismally for no other reason than because it is not directed by any knowledge of the mode of action of the organ to which the teacher endeavors to appeal; and mental growth, in many instances, occurs in spite of teaching rather than on account of it. Education, which might once have been defined as an endeavor to expand the intellect by the introduction of mechanically compressed facts, should now be defined as an endeavor favorably to influence a vital process; and, when so regarded, its direction should manifestly fall somewhat into the hands of those by whom the nature of vital processes has been most completely studied. In other words, it becomes neither more nor less than a branch of applied physiology; and physiologists tell us with regard to it that the common processes of teaching are open to the grave objection that they constantly appeal to the lower centres of nervous function, which govern the memory of and the reaction upon sensations, rather than to those of higher ones which are the organs of ratiocination and of volition. Hence a great deal which passes for education is really a degradation of the human brain to efforts below its natural capacities. This applies especially to book-work, in which the memory of sounds in given sequences is often the sole demand of the teacher, and in which the pupil, instead of knowing the meaning of the sounds, often does not know what 'meaning' means. As soon as the sequence of the sounds is forgotten, nothing remains, and we are then confronted by a question which was once proposed in an inspectorial report: 'To what purpose in after-life is a boy taught, if the intervention of a school vacation is to be a sufficient excuse for entirely forgetting his instruction?'"

THE CLASSICS IN GERMANY.

Those of our readers who have perused the previous portions of Prof. Du Bois-Reymond's article on "Civilization and Science" will hardly need that we should call their attention to the concluding part herewith published. After a survey of the progress of the human mind as illustrated in the great scientific movement of modern times, he comes to the practical question of German education, considered in relation to those extreme utilitarian tendencies of the age against which he protests. How is the Americanization of European culture to be withstood in Germany?—that is his question. The reply has been, through the liberalizing influence of classical studies. The professor acknowledges himself a devotee to these studies, and has a high opinion of their educational value; but he admits that, although prosecuted with great vigor, they have failed to produce the desired effect. "What other country can boast of imparting so thorough and so learned a classical education, and that to so large a proportion of its youth, even of the less wealthy classes?" But all this is a humiliating failure. They neither acquired a critical familiarity with Latin and Greek vocabularies, nor did they arrive at any such conception of the thought of the ancients as to see in what way we are their intellectual descendants. "Their indifference toward broad ideas and historic sequence makes it difficult for me to believe that they are permeated with the spirit of antiquity, or that they had received a sound historical training." This, it will be remembered, is the complaint everywhere—in the English universities and the American colleges: not one in ten of those who consume years in the study of classics gets any intelligent acquaintance with the subject. It is, moreover, an old and cogent objection to the usual study of Latin and Greek, both in England and in this country, that, so far from favoring a critical knowledge of English, it hinders and defeats the mastery of the mother-tongue. Prof. Du Bois-Reymond alleges that the same effect is produced in Germany. Of the graduates of the gymnasia who had drilled so long, though ineffectually, in Latin and Greek, he says, "For the most part these young people wrote in ungrammatical and inelegant German." They "did not even suspect that any one could care about purity of language and pronunciation, force of expression, brevity, or pointedness of style." The study of classical authors is again arraigned with us as obstructing the proper study of the great English classics; and Prof. Du Bois-Reymond remarks, "This neglect of the mother-tongue in the youth of the present day is accompanied by a lack of acquaintance with the German classics that is oftentimes astounding." It is again said that the classical students of English and American colleges very rarely acquire any permanent interest in these studies, so as to keep them up as a part of the mental occupation in after-life. The same complaint is made in Germany. The professor says:

> "There are but few students, indeed, who in later years ever open an ancient author. So far from having any warm love for the classics, most persons regard them with indifference; not a few with aversion. They are remembered only as the instruments by means of which they were made familiar with the rules of grammar, just as the only conception they retain of universal history is that of learning by rote insignificant dates. Was it for this that these youths sat for thirty hours weekly on a school-bench till their eighteenth or twentieth year? Was it for this that they devoted most of their time to studying Greek, Latin, and history? Is this the result for the attainment of which the gymnasium remorselessly englooms the life of the German boy?"

Prof. Du Bois-Reymond therefore acknowledges a serious modification of opinion in regard to the employment of classical studies in the German schools. The gymnasia, or higher schools, have failed with their classics, and the industrial schools in which these studies are but little taught are entitled to increasing consideration. Classical studies, he urges, should be retrenched in the gymnasia, and greater attention given to mathematics and the physical sciences. This conflict, therefore, belongs to no nation, but is as broad as the interests of science and the course of civilization itself.

Prof. William Monroe Davis, of Cleveland, Ohio, died on the 21st of July, at the age of seventy years. He was born in New Hampshire, and his ancestry on the father's side went back to the Pilgrims of the Mayflower, while on the mother's side he was closely related to the family of President Monroe. He went to Cincinnati in his boyhood, and grew up there with but a limited education. It was only when married and having children to be trained that he first began the study of science; but such was his native genius that he soon mastered a position as an original thinker and investigator in astronomy. The distinction he had won could not be better shown than by the fact that, when Prof. Mitchell abandoned science and took to the vocation of war, Mr. Davis was called to succeed him as director in the Cincinnati Observatory, a position which he filled with satisfaction and credit. His health failing five years ago, he came to Cleveland to reside with his son-in-law, Mr. A. J. Rickoff, the eminent educationist of Ohio. He constructed a very valuable telescope, the lenses of which were ground by his own hands. He published in the July number of The Popular Science Monthly a paper containing an able and profound discussion of the nebular hypothesis and the phenomena of planetary rings and satellites, the immediate occasion of the article being the recent discovery and apparently anomalous motions of the moons of Mars. Prof. Davis had worked out his own views on these recondite questions, and expected to develop them in a series of essays for the Monthly, when his work was arrested by death. It is to be hoped that his manuscript notes may have been sufficiently full to make it practicable and desirable for his friends to print them in a collected form.

LITERARY NOTICES.

Lessons in Cookery: Hand-Book of the National Training-School for Cookery (South Kensington, London). To which is added The Principles of Diet in Health and Disease, by Thomas K. Chambers, M. D. Edited by Eliza A. Youmans. New York: D. Appleton & Co. Pp. 382. Price, $1.50.

Two things closely connected are much and justly complained of in this country—the everlasting multiplication of new cook-books and the general badness of cookery. Publications of every form and variety abound upon this subject, with no corresponding improvement in the art by which food is prepared. It would be going too far to ascribe the low state of our culinary practice to the qualities of the literature that deals with it, for in many cases cook-books have no influence at all upon kitchen operations; but it is equally certain that the current manuals do much to perpetuate the bad methods to which they are conformed. The reason of their failure to effect much improvement is obvious enough, for our popular manuals of cookery make no provision for learning the business in the way all other arts have to be learned if they are to be successfully prosecuted. They proceed upon the false principle that a practical vocation, depending upon a knowledge of the properties of numerous substances, involving constant manipulation and the production of delicate and complicated effects, can be learned by simply reading about it. This mischievous error, however, is beginning to be recognized in various quarters, and it is seen that cookery, like all other subjects, must be studied in a rational way, in accordance with the nature of the subject. England has the honor of taking the lead in a vigorous movement to make the art of practical cookery a branch of common education. The effort has been successful in so eminent a degree that it promises to be permanent and to become of immense advantage to the community. But no important step of advancement can be taken in this direction without a wide diffusion of its advantages; whatever has been gained by English experience is ours as well as theirs. One of the fruits of the establishment of the London Training-School is that we have at last got a hand-book of cookery upon the right method, and which, if used as it can be everywhere, will be certain to elevate this hitherto neglected branch of domestic economy. The claims of this work upon American households are so important, and so clearly presented by the editor in her preface to the American edition, that we cannot better serve the interested readers of the MONTHLY than by quoting the main portions of the statement:

"The present work on cookery appeared in England under the title of 'The Official Hand-Book of the National Training-School for Cookery,' and it contains the lessons on the preparation of food which were practised in that institution. It has been reprinted in this country with some slight revision, for the use of American families, because of its superior merits as a cook-book to be consulted in the ordinary way, and also because it is the plainest, simplest, and most perfect guide to *self-education in the kitchen* that has yet appeared. In this respect it represents a very marked advance in an important domestic art hitherto much neglected.

"A glance at its contents will show the ground it covers, and how fully it meets the general wants. The dishes for which it provides have been selected with an unusual degree of care and judgment. They have been chosen to meet the needs of well-to-do families, and also those of more moderate means, who must observe a strict economy. Provision is made for an ample and varied diet, and for meals of a simple and frugal character. Receipts are given for an excellent variety of soups, for cooking many kinds of fish in different ways, for the preparation of meats, poultry, game, and vegetables, and for a choice selection of entrées, soufflés, puddings, jellies, and creams. Besides the courses of a well-ordered dinner, there are directions for making rolls, biscuits, bread, and numerous dishes for breakfast and tea, together with a most valuable set of directions how to prepare food for the sick. The aim has been to meet the wants of the great mass of people who are not rich enough to abandon their kitchen to the management of professional cooks, and who must keep a careful eye to expense. But, while the costly refinements of artistic and decorative cookery are avoided, there has been a constant reference to the simple requirements of good taste in the preparation of food for the table.

"But the especial merit of this volume, and the character by which it stands alone among cook-books, is the superior method it offers of teaching the art of practical cookery. It is at this vital point that all our current cook-books break down; they make no provision for getting a knowledge of this subject in any systematic way. So much in them is vague, so much taken for granted, and so much is loose, careless, and misleading, in their receipts, that they are good for nothing to teach beginners, good for nothing as guides to successful practice, and only of use to those who already know enough to supply their deficiencies and protect themselves against their errors. In fact, the hand-book required to teach cookery effectually cannot be made by any single person in the usual manner, but it must be itself a product of such teaching.

"The present volume originated in this way, and embodies a tried and successful method of making good practical cooks. The lessons given in the following pages came from a training-kitchen for pupils of all grades, and the directions of its receipts are so minute, explicit, distinct, and complete, that they may be followed with ease by every person of common-sense who has the slightest desire to learn. They are the results of long and careful practice in teaching beginners how to cook, and have grown out of exercises often repeated with a view of making them as perfect as possible. It is commonly regarded as a good thing in a cook-book that its compiler has tested some of its receipts, and points out the troubles and failures likely to occur in early trials. But the completeness of the instructions in this work was attained through the stupidities, blunders, mistakes, questionings, and difficulties, of hundreds of learners of all capacities, doing the work over and over again under the critical direction of intelligent, practical teachers, who were bent upon finding out the best method of doing each thing, and the best method of teaching others how to do it. Not a single item necessary to perfect the required process is omitted. The steps are separated, and given in numerical order, so as to enforce attention to one thing at a time, and the right thing at the right time, while the precautions against mistakes are so careful that even the dullest can hardly go wrong. Each receipt in the volume is not only the formula for a dish, but it is also a lesson in a practical process, so that in the preparation of every article of food something is gained toward greater proficiency in the art of cooking well.

"A few words in regard to the origin of the school in which it was produced will still further illustrate the character of this work. A vigorous movement has been made in England to elevate this branch of domestic economy by establishing schools for training pupils in the art of cookery. These schools have grown immediately out of the need of greater general economy among the working-classes, as it was seen that the high prices of provisions were seriously aggravated by not knowing how to make the most of them in their kitchen preparation. The attention of the managers of the South Kensington Museum of Arts in West London was several years ago drawn to the subject; and, feeling that something required to be done, they established public lectures on the preparation of food, with platform demonstrations of various culinary operations. But it was quickly found that mere exposition and illustration, though not without use, were wholly inadequate to the object in view; because a cooking school, to be thorough, must provide for practice. Lecturing, and explaining to pupils, and barely showing them how things are done, are sure to fail, because cookery, like music, can only be learned by actually doing it. As well undertake to teach the piano by talking and exhibiting its capabilities as to teach a person how to make a dish properly by only listening and looking on. Provision had therefore to be made for forming classes to do themselves what they at first only saw others do.

"But this task was by no means an easy one. There were no preëxisting plans to follow; qualified teachers and suitable textbooks were wanting; it was an expensive form of education; the public thought it a doubtful innovation; and educational authorities discouraged it. But the parties interested decided that the time had come for a systematic and persistent effort. They felt their way cautiously, and in 1874 organized classes for graded courses of practice. The object was to give women the best possible instruction in practical cookery, and for this purpose the school was open to all. But, to make its work most largely useful, it was constituted as a normal school for training teachers to go out and establish other cooking-schools in different parts of the country. This has been since done with the most encouraging success, so that there are already a large number of cooking-schools in England connected with the national or common school system.

"As no cook-book to be found was worth anything to aid the practical instruction proposed, the teachers had to take this matter in hand at the outset. They began by drawing up a careful set of directions to be followed by the learners in doing their work. For each lesson in all the grades each pupil was furnished with a printed sheet of these directions, stating the ingredients of each dish to be prepared, the quantities and separate cost of these ingredients, what was to be done first, what next, and so on through the whole series of operations, nothing being assumed as known, and all the minute steps being indicated in the order that was found best. These guides were necessarily imperfect at first, and were subject to constant revision and extension as experience suggested corrections; in fact, they embodied the progress of the school in the successful attainment of its object. At each new printing the improvements that had been made were incorporated, and only after years of trial were these guides to practice at length combined and issued in a book-form. The lessons or receipts of this volume were all slowly elaborated in this painstaking manner, and the mode of working proved perfectly successful with the pupils. It was easy and pleasant, yet careful and thorough, and secured a rapid and gratifying proficiency.

"In saying that the South Kensington Cooking-School has been successful, I speak from direct knowledge of it. I was a pupil there for several weeks, and carefully observed its operations. The classes showed the most extraordinary mental and social diversity. There were cultivated ladies, the daughters of country gentlemen, old housekeepers, servants, cooks, and colored girls from South Africa, together with a large proportion of intelligent young women who were preparing to become teachers. They worked together with a harmony and good feeling that, I confess, somewhat surprised me, but they were all closely occupied and thoroughly interested in a common object. There were teachers to provide materials, to plan the daily work, to direct operations, and to be consulted when necessary; but the admirable method adopted left each learner to go through her task with but a small amount of assistance. Indeed, the completeness of the directions in hand seemed to assure the success of every pupil from the start. There was, of course, a difference in dexterity, and in facility of work previously acquired; but raw beginners went on so well that they were astonished at what they found themselves able to do.

"American ladies, when looking over these lessons, are apt to smile at their extreme simplicity and triviality, but it must be remembered that the difference between good and bad cookery is very much a matter of attention to trifles. Slight mistakes, small omissions, little things done at the wrong time, spoil dishes. The excellence of these lessons consists in their faithfulness in regard to minutiæ, and the habits they enforce of attention to trifling particulars. They make no claim to literary merit. The receipts are homely, direct, and meant only to be easily and distinctly understood. They are full of repetitions, because processes are constantly repeated, and it was necessary that the directions in each receipt should be full and complete. They are not enticing reading, because they were made to work by. The book, in fact, belongs in the kitchen where cookery is done; and it is now republished because its success there has been demonstrated. Many hundred persons totally ignorant of the subject have become efficient and capable cooks by pursuing the mode of practice here adopted—by going through these lessons—and the same results can be obtained by pursuing the same method anywhere. American housekeepers who have any real interest in home improvement, and are willing to take a little pains to instruct their daughters or their servants in the art of cooking well, will find the volume an adequate and invaluable help toward the attainment of this object. It will prove a useful text-book in the cooking-schools that are springing up in this country, and classes could be advantageously formed in it for kitchen practice in every female seminary in the land."

Appended to the volume is an admirable essay on "The Principles of Diet in Health and Disease," by Dr. Thomas K. Chambers, one of the highest living authorities upon that subject. This is a most valuable addition to the work. As food is prepared in order to be eaten, as the subject of cookery is therefore in close relations with that of diet, and commonly receives too little attention on the part of housekeepers, it was an excellent idea to furnish an authoritative summary of the facts and rules of the most recent dietetical science. Good cookery and rational diet are equal conditions of healthful enjoyment.

Annual Record of Science and Industry, for 1877. By S. F. Baird. New York: Harper & Brothers. Pp. 494. Price, $2.

The "Record" for 1877 is considerably less voluminous than its predecessors, and the reduction in size has been effected by summarily omitting one of the two main divisions of the work, namely, that containing abstracts of notable scientific papers. In truth, it would be simply impossible to compress within the limits of an ordinary volume an intelligible synopsis of the important scientific papers annually contributed to the proceedings of learned societies and the periodical press. Hence, we cannot but approve the action of Prof. Baird in omitting that feature of the "Annual Record." By so doing, he is enabled to give more space and fuller treatment to the "Summary of Scientific Progress," and the result is a remarkably satisfactory review of the scientific work of the year in the various departments of research. Each particular science, and, in some instances, particular departments of a science, are treated by writers eminent in their respective specialties.

The Ethics of Positivism: A Critical Study. By Giacomo Barzellotti, Professor of Philosophy at the Liceo Dante, Florence. New York: Charles P. Somerby. Pp. 327. Price, $2.

This book, the first edition of which appeared in Florence a few years ago, and is now translated into English and printed in this country with a new introduction by the author, is a study of those more recent aspects of philosophy which have culminated in the British school of psychologists. It seems to have been written with a principal view of instructing the Italians in regard to the great modern movements of thought that are going on most actively outside the limits of that country. But the writer's object is by no means purely expository of current thought: he dips into controversy with opinions of his own, and avows his aim to be to defend "the principles of morality against the attacks of an empirical utilitarianism." The appellation of positivism, which the author connects with his discussion, he informs us has been criticised by leading authorities as inexact, and we think the objection was certainly well taken. At any rate, the propriety of the term, as designating the English school of thinkers with which he is chiefly dealing, has been so strenuously contested as misleading by prominent members of that school, that it seems somewhat assuming in Prof. Barzellotti to persist in this questionable or disputed application of the word in the title of his book.

The work is similar in scope to Masson's "Recent British Philosophy," and its topics are discussed in an excellent spirit and in an intelligent and instructive manner; but it will be more valued as a delineation of a system of ideas than for any contribution it offers toward their further development. We notice that Prof. Barzellotti differs very widely from President Porter in his estimate of the philosophical position and influence of Herbert Spencer. For, while to the President of Yale College Spencer is little better than a pretender and a verbal trickster, whose illusive reputation is destined to vanish so speedily that the world will wonder how the delusion lasted so long, the Italian professor, on the other hand, accords to him a regnant place as the commanding mind of the most vigorous and powerful philosophical school of the present age. He says, "Modern psychological inquiry reaches its highest degree of development in Herbert Spencer." He closes an elaborate account of the doctrines and methods of this thinker as follows:

"Such is in outline the psychology of Herbert Spencer. The idea that rules it is that of a harmony of things which extends by degrees from one form of life to another and culminuates in mind. It is not an original idea, but it acquires particular aspects when thus treated according to the positive method; and, in the intermediate path which Spencer pursues, between popular empiricism and *a priori* speculations, the conception of an evolutionary process certainly assumes an original character. Spencer has been led into this course by his closely inductive genius. He is opposed to too abstract generalizations, and likes generalizations to imply carefully-observed facts; but, by a bold synthesis, he surpasses all that his predecessors have achieved by analysis only. This equilibrium of faculties makes Spencer worthy of being considered in more aspects than one. He marks in the history of psychological inquiry the latest stage that the inductive method has attained in England by the work of a powerful mind impressed with the refinements of modern science; and this is not less true, although some traits, and particularly a certain metaphysical touch in the works of this most distinguished philosopher, remind us of Schelling and Hegel. The tendency of the method of the English school, as it is applied by Spencer, seems to become ever more and more distinct from the general tendency of psychological studies on the Continent, and marks in him the climax of the course of thought exhibited, in successive phases, by James Mill, John Stuart Mill, and Alexander Bain. It is a movement of thought, implying the tendency to find the basis of mental science in the knowledge of concrete facts, and the progress of that tendency we can estimate by the successive advances made in psychological analysis by Hartley, James Mill, Bain, and Spencer. The inquiry into the facts of the world of consciousness, as we have indicated, had no definiteness in the vague mechanism of Hartley and James Mill; it was more logical in John Stuart Mill, more minute in Bain, and is to-day broader and more comprehensive in Spencer, who is the one so far that has brought the theory of the reduction of psychological facts to the finest point. But with respect to the substance of method and details of analysis he has, in common with Mill and Bain—in fact, with all the school—that which constitutes the organism of English psychology and gives it a physiognomy of its own in contemporary history."

Elements of Dynamic. An Introduction to the Study of Motion and Rest in Solid and Fluid Bodies. By W. K. Clifford, F. R. S. Part I., Kinematic. New York: Macmillan & Co. Pp. 221. Price, $2.50.

This little book plunges into depths where only mathematicians can follow; but its opening sentences are so characteristic of the author's clearness of perception and statement, that, as they involve no formula, and are withal instructive, we quote them:

"Just as geometry teaches us about the *sizes* and *shapes* and *distances* of bodies, and about the relations which hold good between them, so dynamic teaches us about the changes which take place in those distances, sizes, and shapes (which changes are called *motions*), the relations which hold good between different motions, and the circumstances under which motions take place.

"Motions are generally very complicated. To fix the ideas, consider the case of a man sitting in one corner of a railway-carriage, who gets up and moves to the opposite corner. He has gone from one place to another; he has turned round; he has continually changed in shape, and many of his muscles have changed in size during the process.

"To avoid this complication we deal with the simplest motions first, and gradually go on to consider the more complex ones. In the first place, we postpone the consideration of changes in size and shape by treating only of those motions in which there are no such changes. A body which does not change its size or shape during the time considered is called a rigid body.

"The motion of rigid bodies is of two kinds; change of place, or *translation*, and change of direction or aspect, which is called *rotation*. In a motion of pure *translation*, every straight line in the body remains parallel to its original position; for, if it did not, it would turn round, and there would be a motion of *rotation* mixed up with the motion of translation. By a *straight line in the body* we do not mean merely a straight line indicated by the shape or marked upon the surface of the body; thus, if a box have a movement of translation, not only will its *edges* remain parallel to their original positions, but the same will be true of every straight line which we can conceive to be drawn, joining any two points of the box.

"When a body has a motion of translation, it is found that every point of it moves in the same; so that to describe the motion of the whole body it is sufficient to describe that of one point. When a body is so small that there is no need to take account of the differences in position and motion of its different parts, the body is called a *particle*. Thus the only motion of a particle that we take account of is the motion of translation of any point in it.

"A motion of translation mixed up with a motion of rotation is like that of a corkscrew entering into a cork, and is called a *twist*.

"Bodies which change their size or shape are called *elastic* bodies. Changes in size or shape are called *strains*.

"The science which teaches how to describe motion accurately and how to compound different motions together is called *kinematic*."

The volume is a college text-book, and the genius and position of its author are a sufficient guarantee of its originality and excellence. Prof. Clifford has broken down so sadly in health that he has been compelled to suspend work at University College, in London, and leave England for the more genial climate of Southern Europe. His work on the "Fundamental Ideas of Mathematics and Physics explained to the Non-Mathematical," with which he has been long occupied for the "International Scientific Series," is well advanced, and it is to be hoped that he will recover his health to complete it, and carry out the other important intellectual projects of which his teeming head is full.

Physical Technics. By Dr. J. Frick. Translated by J. D. Easter, Ph. D. With 797 Illustrations. Philadelphia: Lippincott. Pp. 467. Price, $2.50.

Teachers of physical science and students who are without the aid of competent instructors and good laboratory apparatus will find this a very useful manual. The volume, in the first place, contains a great deal of valuable, practical instruction for making experiments in physics. The manipulation of apparatus, the construction of apparatus at the least possible cost, the points to be considered in the purchase of instruments, on these and many other like topics the author supplies a good deal of common-sense information, gathered in the course of his own experience as a teacher of science, and selected from technical manuals. Having aided the student in choosing his apparatus or constructing it, and given him some insight into the secrets of physical manipulation, the author, in the second part of the book, gives directions for making experiments illustrative of the principal laws of physics, as the equilibrium of forces, motion, acoustics, light, magnetism, heat, etc. The work appears to be very well adapted to meet the wants of the reader for whom it is intended.

Current Discussion: A Collection from the Chief English Essays of Questions of the Time. Edited by Edward L. Burlingame. Vol. II., Questions of Belief. New York: G. P. Putnam's Sons. Pp. 360. Price, $1.50.

The first volume of this new series of reprinted contemporary discussion was devoted to international politics, and very naturally gave special prominence to the treatment of the Oriental question which has latterly excited so much attention. It consisted of a judicious selection of the most important papers that have appeared in the English reviews by distinguished writers on the various aspects of Eastern politics. The second volume, devoted to what the editor terms, somewhat vaguely, "Questions of Belief," is occupied with radical speculations in theology, most of the space being taken up by the Symposiums from the *Nineteenth Century* that have appeared in The Popular Science Supplement. There is an article on "The Course of Modern Thought," by G. H. Lewes; one on "The Condition and Prospects of the Church of England," by Thomas Hughes; and the paper of W. H. Mallock entitled "Is Life worth living?" Nothing needs to be said in commendation of these able discussions, and they are brought out in a neat and attractive shape by the publishers.

Ferns of Kentucky. By J. Williamson. Louisville: J. P. Morton & Co. Pp. 154. $2.

The collector of ferns in Kentucky will find in this neat little volume a guide to the principal localities in which the different kinds occur, and a key for determining the different species which he meets in his rambles. The volume further contains hints on the cultivation of ferns, and on the proper method of drying and preserving them. Sixty full-page etchings and six woodcuts serve to illustrate the ferns of Kentucky.

Bulletin of the United States Geological and Geographical Survey of the Territories, F. V. Hayden, Geologist-in-Charge. Vol. IV., No. I. Washington: Government Printing-Office. Pp. 311.

The memoirs contained in this number of the *Bulletin* are all on zoölogical subjects, viz.: "The Ornithology of the Lower Rio Grande of Texas;" "Fishes from the Cretaceous and Tertiary, west of the Mississippi;" three papers on "*Tineina*;" "*Noctuidæ*, chiefly from California;" "The North American Species of *Alpheus*;" "Mammals of Fort Sisseton, Dakota;" "American *Herodiones*;" "Butterflies from Southern Utah;" "Herpetology of Dakota and Montana;" "Consolidation of the Hoofs in the Virginian Deer;" "A Breed of Solid-Hoofed Pigs;" "Prof. Owen on the *Pythonomorpha*."

Manual of the Apiary. By A. J. Cook, Professor of Entomology in the Michigan State Agricultural College. Chicago: T. G. Newman & Son. Pp. 286. Price, cloth, $1.25; paper, $1.

A large edition of this "Manual" having been sold within two years of its first publication, Prof. Cook was encouraged to revise the work and make it more complete in both its scientific and practical aspects. The result is a handsome volume, elegantly illustrated, and containing all the information needed by those who desire to keep bees. We have received, from the same author, a pamphlet on "The Hessian Fly," giving its natural history and habits, and describing the methods of protecting the wheat-plants against its ravages.

Manual of the Vertebrates of the Northern United States. By David Starr Jordan, Ph. D., M. D. Second edition, revised and enlarged. Chicago: Jansen, McClurg & Co. 1878. Price, $2.50.

It speaks well for this book, and for the growing activity in natural history studies, that it has grown to become so useful an apparatus in its own line. It is barely four years since that novel *brochure* appeared of Jordan and Van Vleck, "A Popular Key to the Birds, Reptiles, Batrachians, and Fishes, of the Northern United States, east of the Mississippi River." Soon came as an outgrowth the "Manual of the Vertebrates;" and now comes its second edition. To Elliott Coues must always be given the merit of leading grandly on this line by the "Key to American Birds." Prof. Jordan has, in this new book of over 400 pages, put the amateur student in the classification of the home vertebrates under a great debt of gratitude. The manual is a very efficient analyst of animal forms. It is truly *multum in parvo*, but perhaps a little too condensed.

Twenty-five-Cent Dinners for Families of Six. By Juliet Corson, Office of the New York Cooking-School, 35 East Seventeenth Street, Union Square. 72 pages. Price, 15 cents.

Miss Corson has published various useful books on the subject of cookery, and, among others, a little *brochure* entitled "Fifteen-Cent Dinners for Working-Men's Families." This attracted a good deal of attention, and set many people to thinking about the possibilities of living cheaply and well, if they only knew *how* to do it. Having thus raised the question of economical diet in a practical way, Miss Corson was applied to by letters from numerous parties to show what could be done on a little more liberal scale of expense, and "Twenty-five-Cent Dinners" is the result. There is a large amount of valuable, well-digested information in this pamphlet. Miss Corson not only speaks from experience, both in cooking and teaching (as she is superintendent of the New York Cooking-School), but from a special study of culinary economics, or how to get good food in sufficient allowance at the lowest cost. Her results will excite some surprise in people of careless habits in these matters, and who would be astonished to be told that good cookery would give them better diet than they are in the habit of getting, at half the cost. Miss Corson begins with some serviceable hints on marketing, and the economical selection of articles of food, and then offers various valuable suggestions on the best methods of cooking to make them go the farthest. Several chapters follow of well-selected receipts for economical dishes, and the whole is fully indexed at the close. Besides her suggestive preface, addressed "To Economical Housewives," she offers at the outset the daily bills-of-fare for one week, with the price of each dish, of each meal, of the three daily meals, and the total meals of the week. The dishes are wholesome, attractive, and by no means stinted, and their very moderate cost conveys an instructive lesson to lax and thriftless housekeepers. Miss Corson's little work is opportune in these stringent times, and its wide circulation would be productive of much public benefit.

Bulletin of the Minnesota Academy of Natural Sciences (1877). Minneapolis: Young & Winn print. Pp. 126. Price, 50 cents.

This number of the *Bulletin* contains, besides the annual address of the president, a report on the "Mycological Flora of Minnesota," another on "Ornithology," a paper on "Tornadoes and Cyclones," and the Curator's "Report." The additions to the Academy's Museum were larger in 1877 than in any previous year, besides being much more valuable.

PUBLICATIONS RECEIVED.

Short Studies of Great Lawyers. By J. Browne. Albany: *Law Journal* print. Pp. 382. $2.

The Nature of Things. By J. G. Macvicar, D.D. Edinburgh: *Blackwood*. Pp. 120.

How to take Care of our Eyes. By H. C. Angell, M. D. Boston: Roberts Brothers. Pp. 70. 50 cents.

Handbook of Modern Chemistry. By C. M. Tidy. Philadelphia: Lindsay & Blakiston. Pp. 795. $5.

Report of the Commissioner of Education (1876). Washington: Government Printing-Office. Pp. 1152.

The Native Flowers and Ferns of the United States. Parts 3, 4, 5. Illustrated by Chromo-lithographs. Boston: L. Prang & Co. 50 cents each.

New Encyclopædia of Chemistry. Parts 31 to 35 inclusive. Philadelphia: Lippincott. 50 cents each.

The Dance of Death. By W. Herman. New York: American News Company. Pp. 131.

In the Wilderness. By C. D. Warner. Boston: Houghton, Osgood & Co. Pp. 176.

Dosia. By H. Greville. Boston: Estes & Lauriat. Pp. 260. $1 50.

Instructions for observing the Total Solar Eclipse of July, 1878. Washington: Government Printing-Office. Pp. 30, with Plates.

Report of the Wisconsin Dairymen's Association (1878). Madison: Atwood print. Pp. 150.

Sound and the Telephone. By C. J. Blake, M. D. Pp. 14.

True and False Experts. By E. Gissom, M. D. From *American Journal of Insanity*. Pp. 36.

Report of the New York Meteorological Observatory (1877). New York: Lees print. Pp. 32.

Follies of the Positive Philosophers. By T.

L. Clingman. Raleigh, N. C.: Nichols print. Pp. 25.

Twenty-five Cent Dinners for Families of Six. By J. Corson. Pp. 72. 15 cents.

Separation and Subsequent Treatment of Precipitates. By F. A. Gooch. From "Proceedings of the American Academy." Pp. 8.

Vortrag über den Mexicanischen Calender-Stein. Von Prof. Ph. Valentine. New York: Marrer und Sohn. Pp. 33, with Plates.

Instinctive Operations of the Human System. By J. F. Hibberd, M. D. Cincinnati: *Lancet* print. Pp. 16.

Malaria and Struma. By L. P. Yandell, M. D. From *American Practitioner*. Pp. 15.

Honest Money. By T. M. Nichol. Chicago: The Honest Money League of the Northwest. Pp. 56.

Report of the Board of Schools, St. Louis (1876-'77). St. Louis: Daly & Co. print. Pp. 280.

Notes from the Chemical Laboratory of the Johns Hopkins University. Nos. 9—12.

Duty of Literary Men. By Rev. T. A. Goodwin. New York: Burnz & Co. Pp. 16.

Spelling Reformer. Vol. I., No. 5. Same publishers. Pp. 6.

The Currency. By J. Johnston. Chicago: Honest Money League of the Northwest. Pp. 38.

Physical Exercise and Consumption. By Dr. R. B. Davy. Cincinnati: From the *Lancet and Observer*. Pp. 16.

POPULAR MISCELLANY.

The Recent Solar Eclipse.—The telegraphic reports from the various stations for observing the solar eclipse of July 29th are of necessity meagre and confused. The atmospheric conditions were eminently favorable along the line of totality, indeed in the whole region west of the Mississippi, while throughout the East clouds generally concealed the phenomenon from view. Dr. Henry Draper, stationed at Rawlins, Wyoming Territory, took four photographs of the corona, two of them with his large spectroscope. These latter are declared to be "very sharp and full of detail." This is a very fortunate circumstance, for it will enable scientific men to ascertain the precise truth touching a very important difference between the observations of Dr. Draper and those of the other astronomers. Dr. Draper reports that he finds the corona spectrum marked with the usual Fraunhofer's lines of the sun's spectrum. These lines were not seen by the other observers, whether at the same station or at the many other stations in the track of the total eclipse. Mr. Lockyer, in a dispatch, says that "Newcomb's party and Barker made careful search for dark lines in the corona, but none were observed. Young," he adds, "telegraphed that there were no lines observed in the ultra-violet at Denver." Again, most of the spectroscopic observers report the presence of bright lines in the coronal spectrum, Prof. Young seeing several bright bands, and in particular the Kirchhoff line 1447. This observation, too, is negatived by that of Dr. Draper, whose photographs of the corona exhibit none of these bright lines. The world of science will await with profound interest the minute examination of all these coronal photographs; the result will decide whether, in accordance with the almost unanimous opinion of physical astronomers, the corona is a self-luminous liquid or solid body, or only reflected sunlight.

Prof. Langley, stationed at Pike's Peak, Colorado, reports that he "saw the corona elongated;" that it "resembled the zodiacal light." Further, that he "followed it a distance of *twelve diameters* of the sun on one side and three on the other." This observation, if confirmed (and we may observe that none of the other astronomers appear to have confirmed it), would go to prove an extension of the corona into space about five times greater than the highest estimate hitherto made. Search was made during the eclipse for an intramercurial planet. Herein only one of the observers, Prof. Watson, claims to have been successful: he reports having discovered an intramercurial planet, of magnitude four and a-half, in right ascension eight hours twenty-six minutes; declination north 18°. The solar protuberances were much less prominent than in most recent eclipses.

Prof. Colbert, of Chicago, stationed at Denver, Colorado, reports that his observations tend to show that the moon's path in the heavens lay a little farther to the southward than is indicated by the lunar tables, or else that the estimate of the moon's diameter is too large. Possibly both suppositions are correct. Of Edison's "tasimeter," Mr. Lockyer writes from Rawlins:

"The tasimeter, the new instrument on which Edison has been working unceasingly here, has proved its delicacy. During the eclipse he attached it to Thomson's galvanometer, which was set to zero. When the telescope carrying the tasimeter was pointed several degrees from the sun, the point of light rapidly left the scale as the corona was brought upon the fine slit by which the tasimeter itself was protected."

Progress of the Electric Light.—Progress is being steadily made with the electric light, both in the sense of improving the apparatus needed for utilizing it and in finding for it practical application. In Paris the railway-station Gare St.-Lazare is now very effectively lighted with the aid of the instrument known as Lontin's distributing machine. The contrast between the pure, clear white electric light and the dull-yellow gaslights in the surrounding streets is enough to convince the most skeptical of the superiority of electricity over gas as an illuminating agent. In the Lontin machine ordinary prepared carbon-wicks are employed, which are regulated by a Lontin burner: the light is remarkably steady, and the wicks burn in the open air without globes or shades of any kind. A strong objection to this machine, unfitting it for use in private houses, is the hissing noise it makes when in operation. The electric candle invented by Jobloshkoff is used for illuminating the Place de l'Opéra in the same city. Across the open area of the Place, and extending toward the new Avenue de l'Opéra, there is a double row of large lamp-posts down each side, each surmounted by a large cylindrical lamp of clouded glass, and containing twelve electric candles. The whole space is lighted as bright almost as day. As soon as a candle burns down, another is moved by mechanism into its place without much appreciable disturbance of the general effect. There is no flickering. The great drawback to the Jabloshkoff candle is its costliness, the illumination being as expensive as when gas is used.

Bathing as a Cause of Ear-Disease.—Inflammation of the middle ear, often resulting in chronic deafness, is a not infrequent consequence of bathing. The damage, according to Dr. Sexton, in the *Medical Record*, consists in the admission of water to the ear, either through the external auditory canal or the Eustachian tube. When water finds admittance to the former, if cold or salt, inflammation of the meatus alone may result; or, if violently injected, as in surf-bathing, or long retained in the canal from diving, the disease may affect the drum-head and middle ear. Whenever water is forced from the mouth and nostrils into the middle ear through the Eustachian tube, inflammation of the middle ear is almost sure to occur, even though the water be warm. According to the author, several thousand severe cases of aural disease result annually from bathing in New York City alone. The bather, when in the surf, should take the water on his chest or back, with mouth and nostrils closed, and never presenting the ear to the in-coming wave. A firm pledget of cotton-wool in the ears is some protection.

The Carpet-Beetle.—Notices have appeared from time to time during the last four or five years of a new carpet-beetle said to be far more destructive than the familiar carpet-moth. This insect has been identified by Dr. J. L. Le Conte as *Anthrenus scrophulariæ*, a European species. A good account of it is given in the *American Naturalist* by Mr. J. A. Lintner, who has studied this insect attentively since its first appearance on our shores. The larva, he says, measures at maturity about three-sixteenths of an inch in length, and it is in this stage of its existence that *Anthrenus* preys upon carpets. A number of hairs radiate from its last segment in nearly a semicircle, forming a tail-like appendage almost as long as the body. The front part of the body, which has no distinct head, is thickly set with short brown hairs and a few longer ones. Similar short hairs clothe the body. The body has the appearance of being banded in two shades of brown, the darker one being the central portion of each ring, and the lighter the connecting portion of the rings. Having attained its full larval growth, it prepares for its pupal change without forming a cocoon, but merely seeking some convenient retreat. Here it remains motionless until it has completed its pupation, when the skin is rent along the back and through the fissure the pupa is seen. A few weeks later the pupal skin is split down the middle of its dorsal aspect, and the brightly-colored wing-covers of the beetle are disclosed. Soon after their emergence from the pupal case during the fall, winter, and spring, the beetles pair and the females lay their eggs for another brood of larvæ. The *Anthrenus* once introduced into a house quickly infests it in every part. Thus, in a house at Cold Spring, New York, which had remained shut up for twelve months, they "took complete possession from the cellar to the attic, in every nook and crevice of the floors, under matting and carpets, behind pictures, eating everything in their way." No effectual means of combating this insect pest has yet been discovered; they are said to "grow fat" on camphor, pepper, tobacco, turpentine, carbolic acid, and the other ordinary applications.

The Earthquake-Scare in North Carolina.—Bald Mountain, in Western North Carolina, forming part of the Blue Ridge of the Alleghanies, has for two or three years been receiving a good deal of attention in the newspapers. Rumbling noises have now and then been heard in the mountain, and these were by the people of the surrounding country taken to be conclusive evidences of volcanic action. As is usual in such cases, these actual phenomena were magnified enormously by the popular imagination, and to them were added others which had no objective existence. Prof. Clarke, of the University of Cincinnati, having devoted the early days of his summer vacation this year to investigating the causes of these rumblings, declares, in a letter to the *New York Tribune*, that "Bald Mountain is no more an earthquake centre than is Central Park," and that "it is merely a locality in which some large rock-slides of an exceedingly gradual character are going on." Nevertheless, the mountain is an object well worthy of study. It forms one side of a pass through the Blue Ridge, Chimney Rock forming the other. While the latter mountain is made up of smooth sheets of what appears to be gneiss, Bald Mountain is all over cracked and fissured, the fissures in some places forming large caves. The recent disturbances have chiefly affected a low spur of the mountain, rising about one thousand feet above the valley. From below the appearance is as if the whole side of the spur was sliding down.

Prof. Clarke first climbed up the side of this spur to a cave which had been discovered a very short time previously. Here he found himself below a precipitous mass of rock two or three hundred feet high, at the foot of which immense numbers of fallen bowlders had formed crevices and caves innumerable. But the new cave was the largest of all. The floor of the cave was everywhere covered with fallen rocks. The newspaper accounts tell of powerful "currents of ice-cold air" issuing from the caverns; but Prof. Clarke found no strong currents, and a difference of only four degrees of temperature between the inside and the outside air. The "smoke of the Bald Mountain volcano" is not smoke at all, but fine dust formed by the grinding and clashing of the rocks. Prof. Clarke next visited "the Crack," a crevice very probably of quite recent origin. This is merely a rent in the rock about one hundred feet in length, seventy-five in depth, and nowhere over ten in width. The explanation given of these cracks and the noises is found in the geological constitution of the mountain, which is built up of sheets of an easily decomposable gneiss, inclined at a slight angle and sliding downward. These sheets of gneiss are full of cracks running at approximately right angles to the pseudo-stratification. The caves are merely spaces which have been left when an upper sheet of rock has slidden off and become inclined against a lower. Nowhere is any sign of volcanic action to be seen. As for earthquakes, the surrounding country is as free from them as any other in the whole country. Prof. Clarke accounts as follows for the rumbling noises: The rocks, as we have seen, are cracked across their stratification. When a large sheet of gneiss is gradually sliding down, there comes eventually upon some part of it a strain sufficient to produce a fracture. This breaking is, of course, attended by a noise, to which the immense caves and crevices serve as resounding chambers.

Material Resources of European Russia.—Russia in Europe, considered with regard to its economic products, may be divided into five distinct zones or regions, viz.: Starting from the north, the tundras, the forest and agricultural regions (forming three zones), and the steppe. The peculiarities of each of these are described by a writer in the *Geographical Magazine*, who derives his information from authentic sources. Of the tundras, those bare, damp, arctic wastes, mostly situated between the arctic circle and the polar ocean, he says that in winter they are frozen, and that in summer they thaw to the depth of a foot or so. The tundra area is about 144,820 square miles, and almost the sole vegetable productions are turf-moss and reindeer-moss. This region does not promise ever to be of any considerable economic value. The forest zone extends from the limit of trees southward to 60° north latitude, and embraces the greater part of Finland, the governments of Olonetz, Vologda, most of Archangel, and the northern districts of Novgorod, Vyatka, and Perm. Area, 815,790 square miles. Population, between thirteen and fourteen souls per square mile. The economic products are fur, timber, tar, and potash. The four northern governments of Archangel, Vologda, Olonetz, and Uleaborg, cannot expect ever to attain a much higher degree of cultivation than at present. The inhabitants prefer the chase to agriculture, and devote only three months in the year to the latter. The agricultural zone extends from the sixtieth parallel to the steppe. Of this zone, the northern and central portions are a diluvial deposit, forming a thin, sandy soil that requires plentiful manuring; but the southern zone, the "black-earth" region, yields rich harvests without manuring or labor. Thus this zone may be divided into two belts, northern and southern. The northern belt includes fifteen entire governments and parts of others, with a total area of 371,900 square miles; average population fifty-four to the square mile. The region yields too little wheat for the support of its inhabitants, i. e., of the minimum allowance, 2.3 *chetverts* per head, only 1.7 *chetvert* is produced at home. The industrial wealth of Russia is mostly confined to this northern agricultural zone, the centre of manufacturing industry being the government of Moscow. The forests are gradually being diminished, through supplying fuel to carry on these industries, and there is the same improvident waste of timber which is to be seen in our backwoods. The output of coal in the Moscow district rose from 1,500,000 *puds* in 1860 to 9,000,000 *puds* in 1872; in the same year the Polish yield was 17,500,000 *puds*. The coal-deposits on both sides of the Ural, though rich and easily worked, are only used for the neighboring iron and copper works. The southern agricultural zone is so destitute of timber that the only fuel obtainable there, besides the droppings of cattle, is dry, half-wooded grain-stalks. The total area of the "black earth" is estimated at 250,760 square miles, extending over twenty-two governments, eight of which belong to the steppe region. In addition to these, six of the West Russia governments and Poland are noted for their fertility. The wheat produced in the black-earth country amounts to more than two-thirds of Russia's total yield, while potatoes are chiefly grown in the Polish and Baltic provinces. The population of the black-earth region forms 53 per cent. of the entire population of the country, and its crops 68 per cent. of the total yield. The manufacture of sugar from the beet is carried on extensively in the Kiev government. The crying want of this region is good roads. The chief vegetation found on the steppe is grasses, spiniferous and leafless plants, bulbous plants, etc. Forest-growth and cultivation are found only near the rivers; fuel is very scarce. The population of the steppe zone is very sparse, and the chief dependence of the inhabitants is on their cattle. In the south and southeast portions of the empire horses are bred in great numbers. The steppe zone is also rich in oxen and sheep. The grape is cultivated here to a considerable extent. Southern Russia is furthermore the chief source of salt-supply to the other governments of the empire.

Meteorological Notes.—Prof. Loomis's ninth paper on meteorology in the *American Journal of Science and Arts* for July is based on the observations of the United States Signal Service made between September, 1872, and October, 1874.

In tracing the rise and phenomena of the great storms which traverse the northern United States and British America, observations made at Portland, Oregon, were studied. During the period named, comprising twenty-six months, there were sixty-three instances of low barometer, corresponding to eighteen different storms.

Each of these instances of low pressure appears to have moved eastward, and can be traced to the Atlantic coast. All occurred in the six colder months of the year, and were most numerous in January. Their origin appears to have been northwestward of Portland, and probably over the Pacific Ocean.

Simultaneously with low barometer at Portland, there occurred high barometer eastward from that city, at an average distance of about fifteen hundred miles. The areas of low barometer advancing eastward crossed the continent in an average period of five days. The path traversed, however, was not a direct one. The low-pressure areas were developed as far north as latitude 50°; but in the middle of the continent the centres of low pressure were in latitude 40°, whence the direction was north of east, reaching the coast in latitude 45°.

From observations, which include those made in a previous paper, it appears that areas of low pressure are not only preceded, but are followed, by areas of high barometer. These conditions, each succeeding the other, traverse the continent with wonderful uniformity. Mountain-ranges from 6,000 to 10,000 feet high do not arrest, and but slightly modify, the eastward movement of these great atmospheric waves.

The high barometer following the areas of low pressure in their progress is usually attended by winds of great violence, from the north and northwest, attaining in some cases a velocity of from thirty to fifty-seven miles an hour. Extreme cold occurred too in many instances, the mercury falling in one case to −36° Fahr.

A fact of great interest presented by Prof. Loomis in a former paper is more fully illustrated in the present one; it is this, that while the air continually flows inward and spirally upward in a storm-area, or area of low barometer, it as continually flows outward at great elevations to areas of high barometer, where it descends to the earth's surface. Here it resumes its motion inward toward the storm-centre, gathering vapor in its progress, to be condensed into rain. It is seen from this that a constant vertical circulation occurs. The tables and charts presented by Prof. Loomis, showing these facts, are elaborate and conclusive. The direction of the movement of the upper air is determined by that of the clouds which float in it.

"The clouds," says Prof. Loomis, "were in all cases seen to be moving away from the low centre outward, toward an area of high pressure, where the air descends to the earth; here it again moves inward, and finally upward, in the gyrations of the storm."

Death to the English Sparrow. — The right of the European house-sparrow to settle in the United States is hotly contested in the *American Naturalist*, by Dr. Elliott Coues, who regards that bird as an unmitigated nuisance. The author makes no secret of his aversion for the sparrow and his contempt for the sparrow's friends. The former is a "wretched interloper" that "does not do any appreciable good; does a very obvious amount of damage; and has no place in the natural economy of this country." The sparrow's friends are divided into five categories, viz.: 1. The silly ones (though Dr. Coues by a circumlocution avoids the use of this plain language, it is clear to see that he *means* it). This class is composed chiefly of "children, women, and old fogies." 2. Those who were instrumental in getting the birds here. 3. Quasi-ornithologists. 4. The *claqueurs* of the quasis. 5. A very few intelligent and scientific persons. Having thus cleared the ground, Dr. Coues presents the specific articles of his indictment of the sparrow. In substance they are: 1. That the sparrows neglect entirely or perform very insufficiently the business they were imported to do, *videlicet* destroying worms and insects. 2. That they do "attack, harass, fight against, dispossess, drive away, and sometimes actually kill, various of our native birds which are much more insectivorous by nature than themselves." 3. That they commit great depredations in the kitchen-garden, orchard, and grain-field. 4. In this specification the author delicately alludes to certain evidences of a lack of moral restraint in the sparrow, offensive to many persons. *Item*, nervous invalids are fretted and annoyed into positive illness by the unceasing noisiness of these birds. 5. "They (the sparrows) have at present practically no natural enemies, nor any check whatever upon limitless increase," though, even with the most unobjectionable species of birds, a check would be desirable. And now what course must we adopt in order to abate this sparrow nuisance?—for abate it we must, or else the sparrows will eat us all out of house and home. Dr. Coues's recommendations on this head are: 1. *Let the birds shift for themselves.* Take down the boxes and all special contrivances for sheltering and petting the sparrows; stop feeding them; stop supplying them with building-material. 2. *Abolish the legal penalties for killing them.* "Let boys kill them if they wish. Let them be trapped and used as pigeons or glass balls in shooting-matches among sportsmen." This last recommendation shows very plainly that Dr. Coues has lost all patience with the sparrow. For ourselves, we hope the evil will be checked by some different means.

Agencies of Nitrification.—The researches of Schloesing and Müntz in nitrification have resulted in the very important discovery of a *nitrifying* organism analogous to the ferment organism of yeast. The evidence of the existence of a nitrifying organism is found in the fact that the process of nitrification, however actively it may be going on, is immediately stopped when chloroform-vapor is introduced, the effect being precisely the same as that seen when chloroform-vapor comes in contact with yeast. Again, these authors find that when nitrification has thus been stopped for several weeks, the addition of a small quantity of a nitrifying body will start the process again. They also find that the temperature of boiling water is sufficient to destroy all power of nitrification, and that soil which has once been heated to that point produces, in air free from germs, carbonic acid and ammonia, but no nitrates. If, however, this soil is moistened with water containing a little untreated soil, the production of nitric acid again commences. This new theory, as we learn from *Nature*, has been tested in England with results fully confirmatory of the views set forth by Schloesing and Müntz. Hence the evidence is very strong that the nitrates in soil owe their origin to oxidation brought about by living organisms.

How Ants distinguish Each Other.—Ants are eminently pugnacious, and opposing hosts belonging to the same species may any day in summer be seen waging internecine wars on one another. But how are they able to distinguish friend from foe in their tumultuous strife? Mr. McCook, member of the Academy of Natural Science of Philadelphia, has made sundry experiments which appear to show that *difference of odor* constitutes the means of discrimination. Of course, it is not possible to demonstrate this hypothesis directly by showing the existence, either of distinct odors, or of different intensity of odor, in opposing hosts. But, if we introduce into the scene of conflict some strong foreign odor which shall obliterate the odors peculiar to the two groups of combatants, we may deprive them of the power of telling friend from foe, and make them live together in harmony as one community. Such was the idea which occurred to Mr. McCook. He collected a number of combatants, and placed them, friend and foeman, together in a glass jar upon some soil. The battle was continued, and when it was again at its height a pellet of paper saturated with cologne-water was introduced into the jar. The effect was instantaneous. The ants showed no signs of pain, displeasure, or intoxication; indeed, some ran freely over the paper. But in a very few seconds the combatants had unclasped mandibles, released their hold of enemies' legs, antennæ, and bodies, and after a momentary confusion began to burrow galleries in the earth with the utmost harmony. The *quondam* foes dwelt together for several days in unity and fraternity, amicably feeding, burrowing, and building. Another experiment was as follows: A large number of warring ants were placed in a box partly filled with soil, and communicating by a glass tube with a smaller box. The larger box was about ten inches long and eight inches in depth and width; both boxes had sliding glass covers. Cologne was introduced as before into that end of the box in which the combatants were principally engaged. In less than two minutes every sign of hostility had ceased except in the case of one small group and two single combatants in the opposite end; but a small pellet of perfumed paper, dropped in their neighborhood, put an end to the battle here. Previous to this, occasional stragglers had passed along the connecting glass tube into the smaller box. Most of them seemed to be of one faction, only one of the opposition having entered, upon whom six or eight ants were expending their wrath. This was the only remaining centre of strife, when Mr. McCook replaced ants and earth upon their native territory. The battle was continuing there, between greatly-diminished numbers of course, after the removal of the large battalions into the box, but the application of a feather dipped in cologne to the neighborhood of the warriors caused the instant cessation of controversy. The next day there were no ants found upon the surface, but digging two inches under ground, close by the fence, he observed a few. The battle was evidently over. There had been in the mean time a great change of temperature, from 96° to 47° Fahr., and this may have had some effect in sending the ants underground.

How the Lake-Dwellers lived.—A recently-published work on "The Lake-Dwellings of Switzerland" throws much needed light on the mode of life followed by the inhabitants of those curious constructions. That they must have been expert fishermen is shown by the large number of fish-skeletons, especially the skulls of very large pike, found buried among the piles. So, too, the bones, which lie about in the lake-dwellings in astonishing numbers, of stags, roes, wild-boars, beavers, squirrels, etc., are an evidence of the abundance of game, and of the ability of the settlers to capture even the higher description of wild animals. But the lake-dwellers did not depend on the chance products of hunting and fishing. They had already domesticated many of the animals, which to-day are the companions of man—as cows, sheep, goats, pigs. A great variety of seeds and plants were also cultivated by them for their own use and that of their domesticated animals. They cultivated flax of excellent quality; and their textile and other manufactures show considerable proficiency and skill. Tools and utensils of flint, of bronze, and of iron, have been found in the sites of these lake-dwellings, and the question arises whether the inhabitants were one people through the three successive ages of Stone, Bronze, and Iron, or whether each age was heralded by a new invasion. The evidence goes to prove the former hypothesis, of one race successively advancing from one stage of civilization to another.

Rapid Decay of Timber.—Till recently chestnut-timber has been always employed for beams in constructing houses in Rome, but, in most of the houses built since the occupation of the city by the Italian Government, pine joists have been used. After a few years the roofs and floors in which the pine had been employed were found to be falling, the joists having rotted at the point of junction with the walls, while the intermediate portions remained sound. The cause of this decay was discovered by accident on taking down the scaffold which had been erected for the use of the workmen engaged in building the hall of the Ministry of Finance. A correspondent of Prof. Tyndall's, writing from Rome, states that around one of the scaffold-poles, which was imbedded some four feet in the ground, had accumulated a heap about six feet high of pozzuolana mortar—that is, mortar made of lime and the peculiar argillaceous sand, of volcanic origin, known as pozzuolana. The underground portion and that above the mortar-heap were perfectly sound; that covered by the mortar was utterly rotten. Hence it was clear that the mortar was to blame. In what respect, then, does Roman mortar differ from that used in Venice, for instance, where pine-timber has stood in mortar for centuries without impairment? The sole difference was in the use of pozzuolana, which therefore seems to have some special chemical affinity for pine, while, as regards chestnut, it is neutral. It is stated that, in consequence of this peculiar action of the Roman mortar on the pine-timbers of the numerous buildings erected on the Esquiline Hill since 1870, many of the roofs and floors have had to be renewed.

NOTES.

In consequence of the growing interest in Industrial drawing and of the few facilities in the State for instruction in this subject, the Faculty of Cornell University have consented to receive teachers as special students, and to afford them all the advantage which the university offers in the various departments of drawing. The departments now established are free-hand drawing, mechanical engineering, civil engineering, and architecture. Special students will enter the same classes as the general students, and on the same terms. No one but teachers will be received—no entrance examination will be required, and no diplomas will be given.

The remains of a mastodon were lately found near Elkhart, Indiana, which evidently belonged to a monster specimen, one of the largest yet discovered. The section of a tusk which was unearthed gave evidence of having been about ten feet long. A monster tooth, six inches over the top, exceedingly well preserved, was dug up, and a shoulder-bone, which shows the animal to have been at least twelve feet high. The bones are to be presented to the city Museum Association lately formed at Elkhart. Several large specimens of the remains of mastodons have been found in Elkhart and adjoining counties within the past four or five years.

The German Association of Naturalists and Physicians will assemble this year at Cassel on September 18th, the sessions continuing for one week. Among the addresses promised are the following: "Relations of Darwinism to Social Democracy," by Oscar Schmidt; "Symbiosis, Parasitism," etc., by Prof. De Bary; "The Education of the Physician," by Prof. Fick; "The Color-Sense and Color-Blindness," by Dr. J. Stilling.

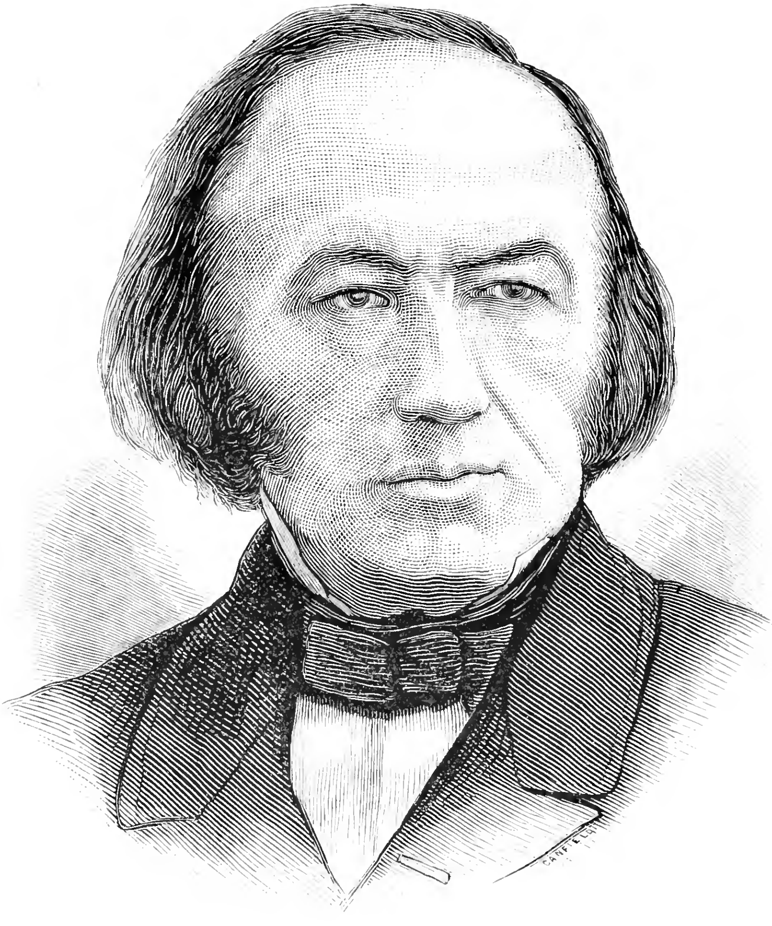
We regret to announce the death, at Philadelphia, of William M. Gabb, paleontologist, at the early age of thirty-nine years. His life-work commenced in 1862, when he was appointed as paleontologist on the staff of Prof. Whitney in the Geological Survey of California. In 1868 he visited Santo Domingo and made a survey of that island. He went on a similar mission to Costa Rica in 1873. "His various contributions to science," says the *American Journal of Science*, "are a great honor to the country, and eminently so to the State of California, for which a large share of his work was done."

Dr. Carl Rokitansky, for thirty years Professor of Pathological Anatomy in the University of Vienna, died in that city on July 23d, aged seventy-four years. His greatest work, a "Manual of Pathological Anatomy," was translated into English, and published in London by the Sydenham Society.

The death of Admiral Sir George Back is announced, aged eighty-one years. Back entered the naval service of Great Britain in 1808, and the following year was taken prisoner by the French, and held in captivity till 1814. In 1819 he did noble service with Franklin in exploring the extreme northernmost coast of America. His perseverance and his fertility of resource on that expedition were above all praise. In 1825 he again visited the arctic regions under the same commander. On both of these expeditions the explorers were rescued from death in the inhospitable north by the heroic exertions of Back. He commanded polar expeditions in 1833–'35 and 1836–'37.

The Commissioner of Agriculture has recently appointed Prof. J. H. Comstock, of Cornell University, and Prof. A. R. Grote, of Buffalo, New York, director of the Buffalo Society of Natural Sciences, as special examiners, under the direction of Prof. C. V. Riley, entomologist of the department, in an investigation now being initiated of the insects injurious to the cotton-plant. Several local observers in various parts of the South have also been appointed, and it is the intention of Prof. Riley to make a complete report on all insects affecting the Southern staple and the best means of counteracting their injuries, that shall be to the people of the South what the report of the entomological commission on the Rocky Mountain locust is to the people of the West. The department is especially fortunate in securing the services of Prof. Grote for this undertaking, as he has already given the subject much attention, and has carefully worked out the life-history of the cotton-worm, one of the worst enemies of the cotton-plant. The results of these investigations are contained in a paper read at the Hartford meeting of the American Association for the Advancement of Science, and published in the "Proceedings" of that year.

To ascertain the influence of light upon cement, Heinzel divided into three portions a lot of cement, and exposed one of these (A) to the air and full light, another (B) to the air and diffused light, and secluding the third (C) in darkness from the air. After six months it was found that A made a weak mortar by absorbing 38 per cent. of its weight in water, and it had become friable; B with $33\frac{1}{3}$ per cent. of water made a mortar too adhesive to the trowel, and it yielded up some of its water; C with $33\frac{1}{3}$ per cent. of water made an excellent mortar, easily stirred and flowing, and it parted with some of its water. After setting for twenty-eight days, the relative strengths were A 3, B 37.9, C 44.6.



CLAUDE BERNARD.

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THE GEOLOGICAL HISTORY OF NEW YORK ISLAND AND HARBOR.

By J. S. NEWBERRY.

I. NEW YORK in Ancient Geological Times.—The rocks which compose New York Island and underlie the adjacent country on the north and east are chiefly gneiss and mica-schist, with heavy intercalated beds of coarse-grained, dolomitic marble and thinner layers of serpentine. These are all distinctly stratified, and have once been sedimentary beds deposited horizontally—sandstones, shales, and limestones—but now, upheaved and set on edge, are by metamorphism converted into compact crystalline strata with the obliteration of all fossils—if fossils they contained. The age of these rocks has not yet been accurately determined, although they have usually been supposed to be Lower Silurian, and a continuation of those which contain the marble-beds of Western Massachusetts and Vermont. There are some reasons, however, why they should be regarded as still older. That they do not form the southern prolongation of the marble belt of Vermont is indicated by the facts that both the marble-beds and the rocks associated with them are so unlike in the two localities that they can hardly be parts of the same formation. In Vermont, the marbles occur in what is essentially a single belt, are fine-grained, usually banded and mottled, are nearly pure carbonates of lime, and the rocks immediately associated with them are gray siliceous limestones, quartzites, and slates. In Westchester County, and on New York Island, on the contrary, the marbles are very coarsely crystalline dolomites (double carbonates of lime and magnesia), which occur in a number of parallel belts, are generally of uniform white or whitish color, and have no rocks associated with them that can represent the quartzites and argillites of Vermont. On the whole, the group of strata which forms New

York Island has so great a similarity to some portions of the Laurentian series in Canada that it is difficult to resist the conviction that they are of the same age.

The Canadian series is supposed to be not less than 50,000 feet in thickness, consisting of somewhat different elements in different parts, but mainly of gneiss and crystalline schists with numerous beds of dolomitic marble and serpentine, and containing, as most characteristic minerals, magnetic iron-ore and apatite (phosphate of lime). The beds stand at a high angle, and, although having once formed great folds and even mountains, by ages of surface-erosion they have been worn down to a merely undulating surface. On the east bank of the Hudson, at and above New York, we have almost precisely the same state of things, viz.: 1. A belt of crystalline rocks forming apparently a continuous series to and beyond the Connecticut line; 2. Strata set nearly vertical, once forming high hills or mountains, now worn down by long exposure to a mere rolling surface; 3. The series composed chiefly of gneiss and crystalline schists, with heavy beds of dolomitic marble and thinner bands of serpentine; and, 4. Containing in its western portion where it joins the New Jersey iron belt—with which it is inseparably connected—important beds of magnetic iron-ore, while apatite is one of the most common disseminated minerals. From these and other reasons which might be mentioned, the New York rocks are regarded by the writer as of Laurentian age. They seem to have formed a ridge which was a part of a range of highlands that ran down on the eastern side of our continent, having the same general direction with the Alleghanies, but being very much older than the more recent folds of that chain. Indeed, judging from the character of the rocks composing it, the immense amount of surface-erosion it has suffered, and the absence of overlying strata, we must regard it as one of the oldest portions of the continent.

Staten Island is in part a continuation of the New York belt of Laurentian rocks—the eastern side being composed of granite and serpentine, the western of trap and Triassic sandstone—and owes its relief to that fact. South of this point the ridge sinks down and is covered

PROFILE SECTION FROM THE HUDSON TO THE CONNECTICUT.

FIG. 1.

with more recent strata, but it apparently reappears at Trenton and Philadelphia. Thus it would seem to be a sort of spur of the Blue Ridge, the oldest chain of the Alleghany belt, diverging from it in Fulton County, New York, and following a nearly parallel course southwestward.

During the Palæozoic ages, the New York ridge seems to have been a land-surface; for the Silurian, Devonian, and Carboniferous rocks were deposited on both sides of it in New England, New York, and Pennsylvania, but no traces of them have been found upon it. In each of these ages the sea flowed in over some portion of the continent, and deposited on the inundated surfaces sediments containing more or less complete representatives of the prevalent forms of life; and these, now fossilized, afford means for identifying and classifying the strata.

In the Cambrian age the continent, composed of Laurentian and Huronian rocks, was broad and high, and the Cambrian strata (Acadian group) were deposited only along its margin.

At the beginning of the Silurian age the sea rose over its shores, covering most of the land-surface, but leaving the Canadian highlands, the Adirondacks, the Blue Ridge, with its New York spur, unsubmerged. Then during all the thousands of years in which the Trenton limestone group was accumulating by organic agencies, the slow growth and deposition after death of the hard parts of animals, and the other thousands of years in which the Hudson River and Utica shales were formed in a shallowing sea, this old land was exposed to wear from rain and wind, sun and frost.

In like manner when the Upper Silurian and Devonian seas in turn flooded more limited portions of the adjacent lands, covering them with new layers of sediment, the old ridges and highlands which have been enumerated, with large additions to their areas made in the Silurian age, were suffering constant abrasion and reduction of altitude.

In the Carboniferous age all the country for a great distance east, north, and west of New York, was above the sea, but along the coast in Rhode Island and Eastern Massachusetts were marshes where a luxuriant vegetation was forming peat-beds that were destined, in after-times, to become seams of coal; and in Pennsylvania, and thence westward in Ohio and Illinois, were vast tracts of swamp—half water, half land—which are now the most extensive coal-basins in the world. During all these ages the belt of highlands which separates the valley of the Hudson from that of the Connecticut was probably much higher than now, and stood as a witness of the varying phases of the unending war between land and sea, and saw the continent created and destroyed again and again; but in all these changes it took no part.

In the latter part of the Carboniferous age the Alleghanies proper were gradually elevated, the convex folds forming mountain-ridges, the depressed or synclinal arches becoming the slowly-deepening coal-basins. In the end all the country between the Atlantic and the Mississippi stood as a broad and elevated continental area. Subsequently the sea rose and fell upon its margin, leaving there the record of its oscillations in the deposits of the recent geological ages, but no considerable portion of its surface has since been submerged.

The Triassic age was a stormy one in the region about New York.

The trough between the New York axis and the Blue Ridge was occupied by water, and in this trough the Triassic shales and sandstones were deposited. A similar trough east of New York, where now is the valley of the Connecticut, was also a lagoon or estuary in which similar sediments accumulated, but not so quietly as the strata composing the older formations in the same region were laid down. It is evident that Nature's forces were in great activity during the period under consideration, for we find the greatest diversity in the product of these forces. The Triassic beds consist of shales, sandstones, and conglomerates. Of these the shales accumulated in comparatively clear and quiet water; and at various levels we find them filled with the remains of fishes that inhabited the lagoons where they were deposited. These fishes occur in thousands, confined to layers a few inches thick, mostly complete and mature individuals, showing that they were killed suddenly by some poisoning of the water in which they lived, its complete withdrawal, or a substitution of fresh for salt, or *vice versa*. These fish-bearing shales alternate with conglomerates that are sometimes beds of large bowlders—the result of violent water-action along a shore—or with strata of ripple-marked, sun-cracked sandstone, pitted with the impressions of rain-drops, and bearing the footprints of thousands of animals, great and small, which made these mud-banks their feeding-grounds. Here and there we find twigs of coniferous trees of the Araucarian family, or fragments of the fronds of cycads and ferns; much more frequently casts of the trunks and branches of trees mingled pell-mell, and evidently collections of drift-wood.

The footprints referred to above are generally three-toed, and resemble the tracks of birds. In dimension they vary from one to twenty inches long, and are supposed to have been made by a peculiar group of biped, birdlike reptiles, which possessed the world in Mesozoic times, and inhabited the shores of North America in great numbers during the Triassic age.

The alternations of coarse and fine strata, with their characteristic fishes and footprints, are repeated in the Trias on the west side of the Hudson until they form a series which has a thickness of several thousand feet. As the ripple-marks, sun-cracks, and other evidences of exposure to the air, occur at several levels, they prove the gradual subsidence of the trough where those sediments accumulated, with which the filling from the wash of the land kept pace, affording a succession of fresh surfaces where the winds and waves as well as living creatures left their autographs. Although as yet but partially examined and imperfectly read, these records, like the Assyrian tablets, have told us many interesting things, and they constitute a treasury of ancient lore which is destined for ages to supply new material for the geological history of this region.

From what we have already learned of the circumstances in which the Triassic rocks of our neighborhood were formed, we may conclude that a depressed area once existed between the New York ridge and the New Jersey highlands, and that this trough was an estuary swept by the tides, much like the Bay of Fundy. Here, as there, the shallows and mud-flats exposed by the ebb were places of resort for many of the animals inhabiting the district; but there is this difference, that in the lapse of time the fauna of the country has completely changed, and the fishes which inhabited the waters of the Triassic estuary, as well as the reptilian monsters that perambulated its shores, have now utterly disappeared from the face of the earth.

The fishes of the Trias, being found at various localities both in New Jersey and the Connecticut Valley, early attracted attention, and many of them were described by Mr. W. C. Redfield—for many years a leading scientist of New York. More recently large collections of them have been made by the writer, so that now they are pretty well known. They form some twenty species of four genera—all ganoids—related to the *Lepidosteus* and *Amia* of our interior lakes and rivers.

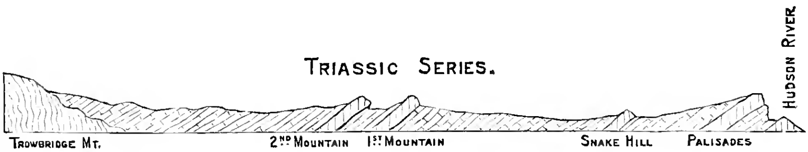
Of the molluscous life of the age in this region we know almost nothing, since the marine deposits which contain its remains are not now above the ocean-level, and the fresh-water and estuary beds exposed to our observation have yet yielded none. Of the land-animals scarcely any traces have been found except their footprints. These prove that a motley crowd of reptiles and amphibians, some of huge size, and, according to our notions, of uncouth and hideous shapes, thronged the shores of our Triassic bay in such numbers, so swift and so well armed for attack and defense, that this must have been anything but a congenial place of residence for a peaceably-disposed citizen.

The hills which overlooked the Triassic lagoons—as they now do their exposed beds, the plains of New Jersey—were covered with forests of Araucarian pines, and the lowlands with thickets of sago-palms and ferns, while gigantic scouring rushes lined the marshy shores. There were no oaks, maples, nor walnuts in the forests, and probably no flower-bearing shrubs or herbs in the undergrowth, for nearly all the fruits and flowers belong to the angiosperms and palms, neither of which had yet made their appearance on the earth's surface. Hence, the vegetation must have been sombre and uninteresting, compared with that of the present day, and, as there were no grasses in it, ill-adapted to the wants of man or the higher animals.

At the close of the Triassic age this region became the scene of great and destructive physical changes, which must have completely altered its aspect. Along the Triassic belt, both east and west, subsidences took place, or displacements by lateral pressure which tilted up all the strata until they stood at an angle with the horizon of 15°, where they still remain—those on the east dipping eastward, those of New Jersey toward the west. At the same time deep fractures reached the source of molten matter below, and this was forced up, either in dikes through vertical fissures, or in sheets between the beds of the stratified rocks. Cooling in place, these trap-sheets are now conformable to the associated strata, and seem at first sight to be normal portions of it, but the metamorphism which they have produced in the beds above and below them show that they are intrusive. The erosion which has since acted upon the surface of this region has cut away the softer sandstones and shales, leaving the outcropping edges of the trap-sheets in high-relief, and these are now known as the Palisade Range, First and Second Newark Mountains, etc.

It has been suggested that the New Jersey and Connecticut basins were once connected by strata which occupied all the interval between them, and that by the subsidence of the sides or the elevation of the central portion an arch was formed the crown of which has been removed by erosion. It seems, however, scarcely probable that some thousands of feet of Triassic rocks, including thick beds of hard and resistant trap, should have been so completely carried away from the interval of 100 miles now separating the Triassic basins, that not a trace of them should be anywhere left. There is apparently good evidence also that the trap-sheets of the Connecticut Valley issued from fissures there, and appertained to a distinct line of disturbance; and, further, that the materials composing the Triassic series in each belt were derived from the adjacent highlands, and were spread by currents which swept up and down two narrow troughs.

To some persons, the most interesting fact in regard to the Trias yet remains to be mentioned, and this is that from the quarries sunk in its sandstone-beds—of which the most important are at Bellville, New Jersey, and Portland, Connecticut—has been taken the brown-stone to which we owe the architectural beauty and monotony of the best portions of our city. Copper is also frequently found impregnating the Triassic rocks, but it has generally proved only a snare to those who have attempted to work it, the deposit being small and unreliable.



Profile Section from Trowbridge Mt. to the Hudson River.

Fig. 2.

During the time in which the Jurassic rocks were deposited in other places, the Atlantic coast of North America seems to have been above the sea-level, for we find here no strata which are certainly of that age. Some writers have called *Jura-Trias* the beds described as Triassic on the preceding pages, but up to the present time no facts have been brought to light which justify this usage. Possibly the uppermost beds of the series may hereafter be found to contain Jurassic fossils, but none such have yet been discovered, while a number of well-known European Triassic species have been obtained from what are considered as the highest portions of the group in Virginia and North Carolina.

In the Cretaceous age the region about New York sunk below its Triassic level, and the sea came in over a belt of country which was before, and is now, dry land. The waves in their advance cut away much of the shore which opposed their progress, both rock and soil, and spread a sheet of sea-beach composed of gravel and sand as far as they reached inland. This old beach we now know as the *Raritan sands*, and they contain great quantities of leaves, branches, and trunks of trees, which had grown on the sinking coast. On examination, they prove to be entirely different from those contained in the Triassic rocks, consisting mainly of the remains of angiospermous plants—the highest botanical group, and such as form the prevailing vegetation of the present day. Among these Cretaceous plants we find the leaves of oaks, magnolias, and other genera now living in our forests. These prove that, in the long interval—the Jurassic age—which intervened between the Triassic and Cretaceous, the vegetation of the world had been completely revolutionized; at least, that most of the genera and species which prevailed during the Triassic age had passed away, and been superseded by such as had been before unknown.

When the water stood at a moderate depth over the sunken shore, the *Amboy clays* settled down upon the sandy bottom. These were apparently derived from the feldspar of the granites which compose the neighboring highlands; the quartz, unaffected by chemical action, and less finely comminuted, remaining as sand and gravel nearer its place of origin.

As the water deepened, true marine conditions supervened along the coast, and the first two of the New Jersey *marl-beds* were formed from the remains of animals which inhabited the sea, and such as were washed into it from the adjacent shore. The green-sand of these marl-beds is derived chiefly from the countless number of microscopic shells of the *Foraminifera*, which filled the waters of the Cretaceous sea here, as in many other places. Its green color is due to *glauconite*, a silicate of lime, potash, alumina, etc. White chalk is likewise composed chiefly of the shells of *Foraminifera*, but these lived in deeper water, and were of different kinds from those that produced the green-sand. The fertilizing property of the marls is due to the potash and phosphorus they contain.

The marl-beds are also vast cemeteries, in which are stored the more or less perfect remains of the larger land and water animals of Cretaceous times. Among these we find the shells of Ammonites—the great coiled cephalopods—and a large number of other mollusks characteristic of the Cretaceous fauna. There have likewise been discovered in the marl-beds numerous remains of large reptiles, both herbivorous and carnivorous. Among these are *Hadrosaurus* and *Lælaps*—the representatives of *Iguanodon* and *Megalosaurus* of the Old World—*Mosasaurus*, and many others. *Hadrosaurus* was herbivorous, while *Lælaps* was a carnivore. Both were biped, terrestrial reptiles, thirty feet long, standing fifteen to twenty feet high, and of very peculiar and interesting structure. The former will be remembered as that of which the spirited restoration, made by Prof. Hawkins for the Central Park, was destroyed by the order of Judge Hilton. *Mosasaurus* was a snake-like, marine lizard, some sixty or seventy feet long, and of pronounced carnivorous habits. These, with their associates, probably densely populated the land and sea, while the air was the special domain of the huge flying dragons—the pterodactyls. With such a numerous and so enterprising a population, it is evident that life in this time and region was full of variety.

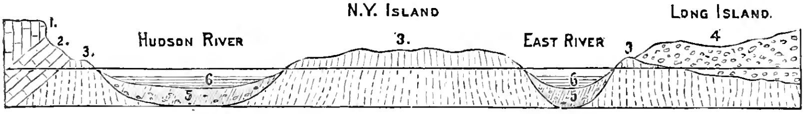
At the close of the Cretaceous age the animal life, both sea and land, was again revolutionized, but by causes which we cannot yet fully understand, as the physical conditions remain nearly the same, and the flora suffered little change. The facts, however, are unquestionable. All the great reptilian fauna disappeared as if by magic, and gave place to herds of mammals, numerous and large it is true, but far inferior in size and armament to their predecessors. In the sea, the whole Ammonite family disappeared at once, and other great changes took place, so that in the upper or Tertiary bed of green-sand, deposited in the same place and under nearly the same conditions as the lower and Cretaceous two, *but we know not how many thousands of years after*, not a single one of all the species of Cretaceous mollusks, radiates, or marine vertebrates, mingled its remains with those of the new-comers.

II. New York in the Ice Period.—The excavation of New York Harbor and the trough of the Hudson seems to have been effected in late Tertiary times. During the first portion of the Tertiary age—the Eocene—the coast from New York southward was low, and the sea washed the base of the Alleghany Mountains, covering the coast-plain and depositing upon it the uppermost and most recent of the marl-beds of New Jersey. But in the middle and later Tertiary epochs—the Miocene and Pliocene—all the northern portion of the continent stood higher above the sea than now, for we find there no marine deposits of that age; and the immense numbers of fiords, or submerged valleys which fringe the coast, are, as Dana long since pointed out, the results of subaërial erosion and proofs of elevation. A genial climate then prevailed to the Arctic Sea, and all the continent was covered with a more luxuriant flora, and inhabited by a more varied fauna, than can now be found anywhere on its surface.

This was, indeed, for America, the golden age of animals and plants, and in all respects but one—the absence of man—the country was more interesting and picturesque than now. We must imagine, therefore, that the hills and valleys about the present site of New York were covered with noble trees, and a dense undergrowth of species, for the most part different from those now living there ; and that these were the homes and feeding-grounds of many kinds of quadrupeds and birds, which have long since become extinct. The broad plain which sloped gently seaward from the highlands must have been covered with a sub-tropical forest of giant trees and tangled vines teeming with animal life. This state of things doubtless continued through many thousands of years, but ultimately a change came over the fair face of Nature more complete and terrible than we have language to describe. From causes which are not yet fully understood, and into the discussion of which we cannot here enter, the climate of the northern hemisphere became gradually more severe, and that of Greenland, from being what it had been for ages, like that of our Southern States, became arctic as we now find it, and its luxuriant forests were replaced by fields of snow and ice. But the change did not stop here, for with increasing cold the ice-sheets spread southward and covered successively the mountains of Labrador, the Canadian highlands, and the hills of New England and New York. At the culmination of the Glacial period the ice reached as far south as Staten Island and Trenton, and all the country north of this line was buried under a great moving mass of ice, in places several thousand feet in thickness. At this time the present climate of Greenland had been transferred to New York; in the strongest possible contrast to that earlier time when the present climate of New York prevailed in Greenland. In the advent of the Ice period not only were all kinds of animals and plants exterminated or driven southward, and thus what had been a paradise was converted into a howling wilderness, but even the topography of the country was greatly modified. The ice-sheet moving from the north ground down or rounded over all projecting rock-masses, and filled up valleys with the *débris*, producing great abrasion in some places, and accumulations in others, until the whole face of the country was changed. In the vicinity of New York the ice moved from north-northwest to south-southeast, and was of such thickness that it crossed the trough of the Hudson diagonally, and probably, because this had been filled with transported material, was by it little deflected from its course. In other localities the old river-valleys were sometimes completely obliterated, and the drainage of the surface given new channels and even new direction. To this cause we may attribute the blocking up of the old line of drainage from the lake-basin through the Hudson, and its diversion to the present course of the St. Lawrence.

Now that the glaciers have left this region and have retreated again to the far north, we everywhere see evidence of the stupendous changes they wrought in the country over which they moved. North of the line which marks the margin of the glacier, we find the contour-lines rounded over and softened, ridges of granite converted into domes, and the hardest rocks grooved and striated, or ground smooth and even polished. The whole surface of New York Island, where the rock is exposed, shows marks of glacial action, the upturned edges of gneiss being ground off to form a nearly plane surface, or, where ridges of more massive rock had existed, these are rounded over to form *roches moutonnées.* Fine examples of the latter may be seen in Central Park and on the east side of the island near Harlem.

The material which occupies so much of the troughs of the Hudson and East River is mostly glacial drift, clay, gravel, sand, and bowlders, scraped from the highlands by the great ice-sheet into these preglacial gorges. It is probable they were once filled to the brim, and that they were subsequently reëxcavated in part by the floods of water which resulted from the melting ice. After these ceased, and they were occupied by water standing at its present level, and moved only by tidal action, they were more or less silted up by the deposit of fine mud brought down by the larger and smaller streams, here checked in their



1 Trap 2. Triassic 3. Laurentian 4. Drift 5. Boulder Clay 6. Silt.

Fig. 3.

flow and losing their transporting power. The southern and lower portion of New York Island, which was under the lee of the higher, was covered with deposits left by the retreating glacier, and these were never afterward entirely removed. Here are now beds of sand and gravel which have in places been penetrated to the depth of one hundred feet or more. On the higher parts of the island and the adjacent country, the rock is generally bare or covered with soil, but even here depressions are filled with bowlders, clay, or gravel, often to the depth of several feet, and large transported bowlders are everywhere scattered over the surface. These latter have sometimes been derived from the rocks of the island, but most of them seem to have come from distant points, and always from the north and west. Rounded masses of trap are very common among the bowlders, and these have been brought across the Hudson, for there is no trap in place on the east side of the river. The trap-ledge which forms the summit of the Palisades is everywhere worn and scratched by glacial action, and the markings which it bears are generally concordant in direction with those of the rocks of New York Island and Westchester County, viz., about north-northwest and south-southeast. Even on the river-face of the hills which form the east bank of the Hudson, the bearing of the glacial scratches is essentially the same, showing that the movement of the great ice-sheet was little affected by any such trifling irregularity of the surface beneath it as the Hudson Valley.

We have no measure of the amount of erosion which New York Island and the adjacent country suffered during the Ice period, but it is not improbable that a mass a hundred feet in thickness was taken from the surface of all the region occupied by the ice.

Most of the finer material ground up by the glaciers was washed out to sea and deposited as the "Champlain clays." Of these there is very little showing in the vicinity of New York, since none of the coast from this point southward has been raised to display them; but a great continental elevation has since taken place toward the north, bringing them at Croton Point 100 feet, at Albany 250, at Burlington 400, at Montreal 500, at Labrador 800, at Davis Straits 1,000, and at Polaris Bay 1,800 feet above the present sea-level.

The coarser portion of the grist ground by the glacier remains as beds of gravel and sand, or heaps of bowlders scattered over the surface of the country where they were left as local moraines, or as the gravel-bars of streams flowing beneath the glacier. The greatest accumulation of material transported by the ice in all the country about New York is seen on Long Island, which is indeed a great terminal moraine heaped up along the margin of the continental glacier. As is generally known, Long Island is mostly composed of heaps of gravel and sand, which sometimes form hills from 200 to 300 feet in height, and in these no solid rock has been found in any exploration yet made. The formation of this huge gravel-bank seems to have been, in brief, as follows: The great ice-sheet, moving down from the north in Connecticut and Southern New York, passed over a region occupied mostly by hard, crystalline rocks. These were extensively worn away by it, and much of the material taken from the surface was pushed on as by a great scraper to its margin. When the ice-sheet reached the line of Long Island Sound, it passed from the area of upturned crystalline rocks on to the comparatively soft horizontal Tertiary and Cretaceous strata, which here formed a plain stretching seaward, from the highlands, just as they now do in New Jersey and more southern States. These were scooped out to form the basin of Long Island Sound, and the material excavated from it, as well as much brought from the country lying farther north, was banked up between this basin and the ocean. Thus it will be seen that, of the water-connections of New York Harbor, Long Island Sound is much the most modern; and yet, as a part of it occupies the site of the valley of a large stream—the Housatonic, with perhaps the Connecticut—which passed through the Hell Gate gorge, its formation must have been begun in preglacial times.

As has been said, the rock foundations of Long Island are almost entirely concealed, but a number of cases are reported of the penetration in wells of strata containing Cretaceous fossils, and there is little doubt that the Cretaceous series of New Jersey and Staten Island, represented by the Raritan sands, and the Amboy, Keyport, and Staten Island clays, once formed a continuous margin to the continent, all the way around to Nantucket. These strata still probably underlie a large part of Long Island where they have been protected from erosion by the heavy beds of drift that cover them, while the shore-waves have eaten away all exposed portions. Evidence strongly confirmatory of the view that Cretaceous rocks have been scooped out of the basin of Long Island Sound is afforded by the fact that the drift of Long Island contains in immense numbers imperfectly-rounded blocks of a reddish-brown sandstone, filled with the impressions of dicotyledonous leaves—a rock nowhere yet found in place, but one which is probably the representative of the leaf-bearing Cretaceous sandstone of the Raritan River.

Whether the overlying Tertiary beds will be found on Long Island is perhaps doubtful, since they are not conterminous with the Cretaceous; but, from the fact that an outlier of this formation exists at Gay Head, Martha's Vineyard, it is highly probable that it was once continuous from Southern New Jersey.

On the preceding pages the history of the vicinity of New York has been traced backward for some millions of years. This history has been read from rock-graven records, which, although meagre and mutilated, give the generalities of the narrative with a truth and fidelity which shame all human history. It would be a pleasant duty to predict the future of this region, even in the same degree of fullness; but the future is as unknown to the geologist as to others. He learns, however, from his studies, that what we call *terra firma* is a type of instability, and that there is nothing stable but the law of change; and he can prophesy with confidence that in the distant future the history of the distant past will be, in part at least, repeated. Even now changes are in progress which, if they should continue a few thousand years, would very profoundly affect not only the aspects of this region, but its adaptability to human occupation. A number of facts indicate that the coast of New Jersey and Long Island is gradually sinking. From the marshes of New Jersey are taken the trunks of trees which could not have grown there except when it was drier ground, and on the shore stumps are seen, now under water, of trees which must have grown on land. So, too, the sea throws up in storms portions of turfy soil, once covered only by the air, and similar soil has been reached below the sea-level in pits dug through drifted sand along its margin. It is also said that the land boundaries have been changed and farms diminished even where the wash of the shore-waves produced no effect. The rate of this subsidence is very slow—only a few inches in a century—and it may at any time be arrested or reversed; but, should it continue, as it may, for some thousands of years, it would result in a submergence of land now valued at hundreds of millions of dollars, and a complete change of position in the seats of commerce and industry, which must always centre about this harbor. This possible catastrophe is, however, so uncertain and remote that it seems hardly sufficient to disturb the equanimity of at least this generation of inhabitants.

III. Why New York is the Commercial Metropolis of the United States.—The great commercial advantages of the site of the city of New York attracted the attention of the first voyagers who came to these shores. When Hendrick Hudson, passing through the Narrows, found within a commodious, landlocked harbor, and a broad and beautiful river, which floated his ships in safety more than a hundred miles into the interior of the continent, he clearly foresaw, and predicted, that this would be the great entrepot of foreign trade for the New World. The subsequent history of New York has fully demonstrated the advantages of its position, since a population of more than 2,000,000 has gathered immediately around its harbor, and it has become not only the business metropolis of a great nation, but the second in importance of the markets of the world. Those who have witnessed and shared the progress and prosperity of the city have been generally well satisfied to enjoy these, without any special inquiry into the causes which have produced them; and, indeed, it is not unlikely that they have accepted them as simply the fruit of their own intelligence and energy. It is doubtful, however, whether the merchants of New York have been more shrewd and enterprising than those of the other ports on our coast. It is not flattering to the vanity of men to assert that they are what their surroundings make them, but it is nevertheless in a great measure true, and New-Yorkers are probably no exception to the rule. The real secret of the unparalleled growth of New York lies in the peculiar topography of its vicinity.

The city is set on an island, of which the shore on every side is swept by tide-water. On the west it is bounded by the Hudson—river we call it, but really an arm of the sea—in which the ebb and flow of the tide are perceptible as far as Troy, one hundred and fifty miles from its mouth. On the east the island is encircled by tideways called Spuyten Duyvel Creek, Harlem River, and East River, the latter a deep channel which connects New York Harbor with Long Island Sound, and thus affords an important artery of internal commerce, and another outlet to the ocean. These two great natural canals, the Hudson and East Rivers, embracing the long and narrow island between them, unite in New York Harbor, one of the most beautiful and commodious in the world. Seen from the city, it seems to be completely landlocked, but communicates with the ocean through the Narrows, with Newark Bay through the Kill van Kull, and thence by Arthur's Kill with Raritan Bay.

Thus it will be seen that New York Harbor is the centre of a series of navigable tideways which add greatly to its adaptation to the wants of commerce, and constitute the most peculiar physical features in its surroundings. The little map given on the next page will show the connection of this system of water-ways more distinctly than any verbal description can.

To those who have not made topography a study, the interest and mystery of the origin of the navigable channels leading into New York

Harbor will not be apparent, and it may seem an easy explanation to assume that they have been formed by the ebb and flow of the tide which sweeps through them. The tides at New York, however, do not rise to a great height, and have very little eroding power. It should also be said that the channels are far too deep to have been cut by any agents now in operation. For instance, at Polhemus's Dock the depth of Hell

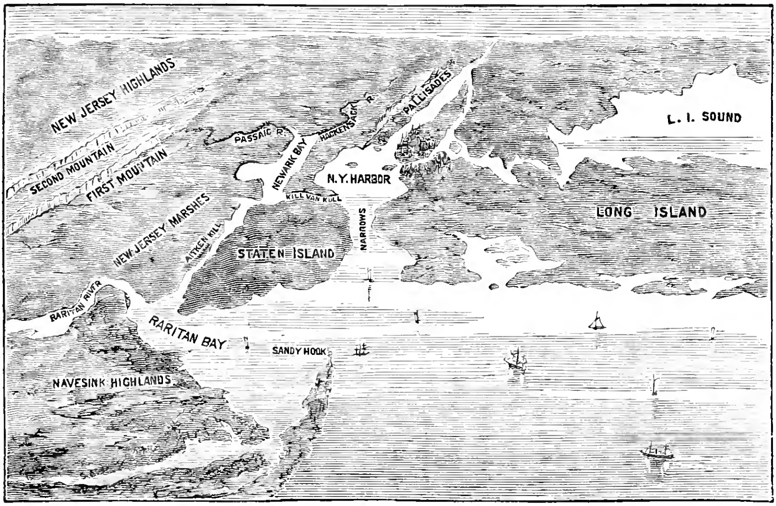


Fig. 4.—Bird's-eye View of New York Harbor and its Connections.

Gate channel is 170 feet, and there are many places in the East River where the depth is over 100 feet. The greatest depth of water in New York Harbor and the Hudson River is about sixty feet, but this does not represent the true depth of the channels, since they have been very much silted up, and their rock-bottoms are probably 200 or 300 feet below the water-surface. If they could be cleared of clay, sand, and gravel, they would be seen to be narrow gorges cut in solid rock as deep as that of Niagara, and resembling some of the cañons of the Western rivers. It is therefore certain that they could not have been produced by tidal action. There are only two ways in which such chasms could be formed: first, by earthquakes, opening fissures in the rocks; and, second, by the erosion of flowing streams. That they are not earthquake fractures is certain, since no such fissures are found in the country about in the line of these channels, and their rocky walls show no sign of disturbance, being similar on opposite sides, and doubtless continuous below. They have, in fact, been formed by draining streams when this part of the continent stood much higher than now above the ocean-level. The evidence of this is cumulative and conclusive. The facts which prove it are, briefly, as follows:

1. The trough of the Hudson has been shown, by the soundings of

the Coast Survey, to be distinctly marked upon the sea-bottom out to a point some eighty miles southeast of New York, and where the water is now over 500 feet deep. Here we reach the true margin of the continent, where the shore plunges rapidly down into the depths of the ocean ; and here was for ages the mouth of the Hudson River ; for the channel which leads to it could not possibly have been excavated except upon a land-surface.

2. Explorations made over a large part of the territory lying between the Atlantic and the Mississippi show that many of the draining streams are now flowing far above their ancient beds, and that these sometimes lie below the present ocean-level. For example, the Ohio flows in a valley the bottom of which is occupied by sand and gravel at least 100 feet thick. The rock-bottoms of the streams which empty into the Great Lakes are at their mouths sometimes 200 feet below the water-level. The Mohawk Valley is filled to a great depth with loose materials, the surface of which forms for long distances a nearly level plain, through which the present river meanders.

Innumerable instances of this kind could be cited, all of which go to prove that for ages the eastern half, at least, of this continent stood 500 to 600 feet higher above the ocean than now, and that during this time the draining streams with swiftly-flowing currents cut the surface into a network of deep channels not unlike the cañons of some of the rivers of the far West.

There seems to be good reasons for believing also that in this period of elevation the stream which drains the basin of the Great Lakes, called in different parts of its course the St. Mary's, the Detroit, the Niagara, and the St. Lawrence, flowed not through the modern channel, which passes the Thousand Islands and the Lachine Rapids, but, leaving the basin of Lake Ontario at its southeastern corner, traversed the now deeply-buried channel of the Mohawk, and entered the present valley of the Hudson somewhere near Albany—precisely where has not yet been determined, as heavy beds of drift cover and conceal its course for many miles in that vicinity. From Albany this ancient Hudson River flowed through a deeper and wilder valley than the present one, which is half filled with water, passed what is now New York Island, far below the present water-surface, was joined at the Battery by a large tributary from the east, issued from the highlands by a picturesque gate at the Narrows, and, traversing a littoral plain, emptied into the ocean eighty miles southeast from New York.

The limits of this article will not permit the presentation of all the facts which sustain this view, but a few of them will suffice to show that it hardly admits of doubt. These are briefly as follows :

An ancient connected line of drainage passes through the basin of the Great Lakes at least 200 feet below the present water-surface, deepening eastward, and reaching a level much below that of the bed of the St. Lawrence.

An old channel at least 200 feet deep connects Lake Huron and Lake Erie. Detroit is situated on the western side of it, and the rock lies there 130 feet below the surface.

Many of the streams now flowing into Lake Erie were once tributaries to the ancient river which traversed its valley and joined it far below the present water-level.

The old channel connecting Lake Erie and Lake Ontario apparently passed through Canada between Long Point and Hamilton. Heavy beds of drift, by which it is filled and concealed, here occupy the surface. The Niagara now flows over a rock-bed, for this is a comparatively modern river, which, following the line of lowest surface-levels, passed over a spur from the south shore of the lake-basin when the old channel was filled by glacial drift.

Some of the streams draining into the basin of Lake Ontario in former times cut their channels below the present ocean-level. All the salt-wells of Syracuse are sunk in one of these, which is filled with gravel and sand saturated with brine issuing from the Salina group that forms its walls. The rock-bottom of this old river-bed was reached in some of these wells at a depth of fifty feet below the present level of tide-water.

FIG. 5.—MAP SHOWING OLD DRAINAGE OF THE LAKE BASIN.

The valley of the Mohawk is a very deep channel of erosion, now half filled, which must have been traversed by a large stream flowing eastward at a level below that of the present ocean; and everything indicates that this was the ancient outlet of the basin of the Great Lakes.

The channel of the Hudson is apparently the only possible continuation of this long line of drainage. As has been remarked, it is of great and yet unknown depth. The clay by which it is partially filled has been penetrated to a depth of about 100 feet along its margins. How deep it is in the middle portion can only be conjectured; but Hell Gate channel, which has been kept comparatively free by the force of the tides, is in places known to be nearly 200 feet deep; and, since this is a channel of erosion formed by a stream draining into the Hudson, the ancient bed of the Hudson must be still lower.

From the depth and distinctness of the old river-course on the submerged plain outside of the Narrows, we may reasonably infer that the old channel at New York is not much less than 300 feet deep.

We are compelled to conclude from these and other facts of similar import: 1. That the topographical features of the vicinity of New York were for the most part fashioned by the erosion of a system of watercourses which, in preglacial times, when the continent was higher than now, cut their valleys much deeper than would now be possible.

2. That there was here a group of hills composed of crystalline rocks, a sort of spur from the Alleghany belt, and that this range of hills was then seventy or eighty miles inland from the ocean, separated from it by a plain similar in its topographical relations to that which lies between the highlands of our Southern States and the present shore of the Atlantic.

3. At the period under consideration a river draining the basin of the Great Lakes, and in size the second on the continent, followed the course of the Mohawk and Hudson, and, passing through the New York hills, there left the highlands and flowed quietly on to the ocean.

4. Where New York Harbor now is, this great river received two important tributaries—one from the east through Hell Gate channel, which joined it at the Battery, the other from the west through the gorge of the Kill van Kull. Of these, the first is now represented by the Housatonic, then a larger stream, with a longer course and more tributaries; the second was formed by the Passaic and Hackensack, which united at the head of what is now Newark Bay, and emptied into the Hudson at the entrance to the Narrows. The junction of these two considerable branches so near each other seems to have produced the expansion of the valley which is now New York Harbor. This must then have been a very picturesque spot, as its outlet oceanward was a narrow pass bordered by the hills of Staten and Long Island, 500 feet in height. On the north, it was overlooked on one hand by the great wall of the Palisades, which rose 700 feet above the river; on the other, by a bold shoulder or headland, 400 feet in height, now New York Island, then a promontory, which separated the Housatonic and the Hudson to their junction at its southern extremity.

5. After the lapse of unnumbered ages, during which this nook among the hills was slowly prepared for the important part it was to play in the history of the yet unborn being—man—a quiet subsidence

of the land or elevation of the water began in this region. Gradually the sea flowed in over its shores, crept up the valleys of the streams, checking their flow and converting them into tideways, until it washed the base of the highlands. Up to this time the surface of the littoral plain in its gradual submergence formed a broad expanse of shallow

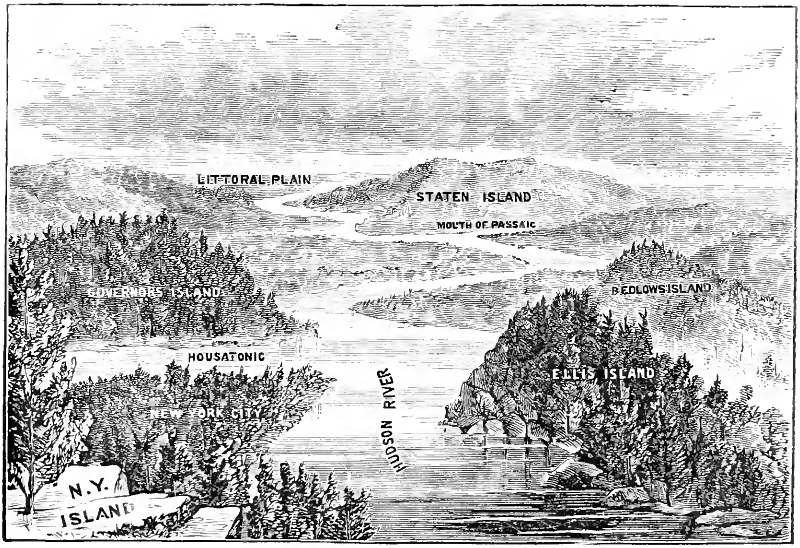


Fig. 6.—New York Harbor in Pre-glacial Times, from South End of New York Island.

water bounded by a monotonous line of beach, with no good harbors—a shifting, dangerous shore, such as is most dreaded by mariners. By further subsidence, however, the water flowed up into the valleys among the New York hills and into the deeper river-channels, making of the first safe, landlocked harbors, of the second navigable inlets or tideways. In this manner were produced the magnificent harbor and the system of natural canals connected with it, which determined the position and created the subsequent prosperity of the commercial emporium of the New World.

The subsidence which resulted in the formation of New York Harbor and its connections seems also to have affected all the coast, and the influx of the sea-water filled the valleys of the rivers which drained the Atlantic slope south of New York, and gave it the fringed and irregular outline which constitutes its most striking characteristic. James River, York River, the Potomac, the Susquehanna, and the Delaware, are, like the Hudson, half-drowned rivers—if we may use the expression—for all the lower portions of their valleys are estuaries, in which the tide sets up to the base of the highlands. But that portion of the littoral plain which separates these estuaries is too low, too much cut up with water-ways, and its harbors are too shallow and ill-defined, to afford proper sites for great shipping-ports. Hence the cities of this region—Richmond, Washington, Baltimore, and Philadelphia—are situated at the head of navigation, where the rivers come down from the highlands on to the plain; and they are located like Albany, remote from the seaboard, with which they are connected by long and somewhat tortuous channels of inland navigation. New York, on the contrary, is located directly on the coast, because here alone the highlands reach to the sea, and their submerged valleys and river-channels form commodious, rock-girt harbors, immediately accessible from the ocean. It will be seen at a glance that this fact gives it great commercial advantages, and has been the most potent influence in making this the chief port of entry for the country.

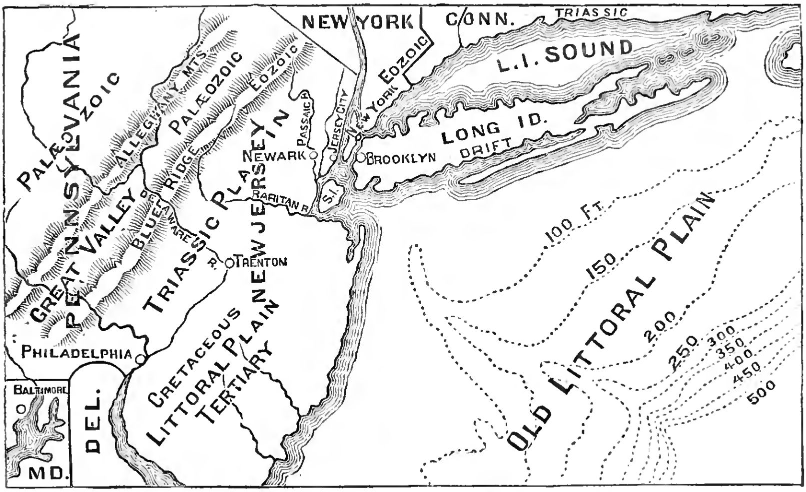


FIG. 7.—MAP SHOWING OLD CHANNEL AND MOUTH OF THE HUDSON.

On the Southern coast there is no harbor at all comparable with that of New York except Norfolk. This is deep, roomy, and accessible to the sea—advantages which are destined to give it permanent and increasing importance. But it is less central to the population and business of the country; and, while its inland water connections through Chesapeake Bay and the tidal rivers which open into it are more extensive than those which the harbor of New York possesses, they are less favorably situated in their relations to the present and future internal commerce of the country.

The great advantage which New York enjoys for trade with the interior consists in its accessibility from the basin of the Great Lakes where the most rapid accumulation of population and wealth of the last half-century has taken place, and where the business of the country is destined to concentrate in the future. As has been stated in the preceding pages, the drainage of the lake-basin apparently flowed for ages by New York; and it is an interesting fact that the great tide of population and business which has set in from the Eastern States toward the interior has chiefly passed through the gap cut in the highlands by the old river whose course we have endeavored to trace. The topographical features of this pass led to the construction of the Erie Canal, and it was comparatively easy to reëstablish there the old line of water communication. In later years the same influences caused the construction through it of the most important railroad line of the world. The natural advantages of this route are such as to give New York and her connections with the interior a positive and inalienable superiority over all competing ports and lines of traffic—a superiority which, though it may be temporarily abrogated by municipal misgovernment, or be diverted from public to private profit by individual or corporate rapacity, will ultimately and always assert itself, and give to this city a continuance of the prosperity that has attended her past career.

EDUCATION AS A SCIENCE.

By ALEXANDER BAIN, LL. D.,
PROFESSOR IN THE UNIVERSITY OF ABERDEEN.

V.—THE EMOTIONS IN EDUCATION.

THE Emotion of Power.—The state named the feeling or emotion of power expresses a first-class motive of the human mind. It is, however, shown, with great probability, not to be an independent source of emotion. It very often consists of a direct reference to possessions or worldly abundance. In other cases, I cannot doubt that the pleasure of malevolent infliction is an element; the love of domineering, or subjecting other people's wills, would be much less attractive than it is if malevolent possibilities were wholly left out.

Power in the actual is given by bodily and mental superiority, by wealth, and by offices of command. Hence it can be enjoyed in any high degree only by a few. It is, however, capable of great ideal expansion; we can derive gratification from the contemplation of superior power, and the outlets for this are numerous, including not merely the operations of living beings, but the forces of inanimate Nature. For example, the sublime is an ideal of great might or power.

We have now almost, but not quite, led up to the much-urged educational motive, the gratification of the sense of self-activity in the pupils. This must afterward undergo a very searching examination. Let us, however, first briefly review another leading class of well-marked feelings, those designated by the familiar terms, self-complacency, pride, vanity, love of applause. Whether these be simple or compound in their nature, they represent feelings of great intensity, and they are specially invoked in the sphere of education.

THE EMOTIONS OF SELF.—"Self" is a very wide word. "Selfish," "self-seeking," "self-love," might be employed without bringing any new emotions to the front. All the sources of pleasure, and all the exemptions from pain, that have been or might be enumerated under the senses and the emotions, being totalized, could be designated as "self" or "self-interest." But, connected with the terms self-esteem, self-complacency, pride, vanity, love of praise, there are new varieties of feeling, albeit they are but offshoots from some of those already given. It is not our business to trace the precise derivation of these complex modes, except to aid in estimating their value as a distinct class of motives.

There is an undoubted pleasure in finding in ourselves some of those qualities that, seen in other men, call forth our love, admiration, reverence, or esteem. The names self-complacency, self-gratulation, self-esteem, indicate emotions of no little force. They have a good influence in promoting the attainment of excellence; their defect is ascribable to our enormous self-partiality: for which cause they are usually concealed from the jealous gaze of our fellows. It is only on very special occasions that persuasion is made to operate through these powerful feelings; they are too ready to turn round and make demands that cannot be complied with.

A still higher form of self-reflected sentiment is that designated by the love of praise and admiration. We necessarily feel an enhanced delight when our own good opinion of self is echoed and sustained by the expressions of others. This is one of the most stirring influences that man can exert over man. It exists in many gradations, according to our love, regard, or admiration, for the persons bestowing it, as well as our dependence upon them, and according to the number joining in the tribute.

The bestowal of praise is an act of justice to real merit, and should take place apart from ulterior considerations. But in rewarding, as in punishing, we cannot help looking beyond the present; we have in our eye merits that are yet to be achieved. The fame that attends intellectual eminence is an incentive to study, and the educator has this great instrument at his command.

Praise, to be effectual and safe, has to be carefully apportioned, so as to approve itself to all concerned. As the act of praising does not terminate with the moment, but establishes claims for the future, thoughtless profusion of compliment defeats itself. Praise may operate in the form of warm, kindly expression, and no more; in which sense it is an offering of affection, and has a value in that character alone. A pleased smile is a moral influence.

Discipline, properly so called, works in the direction of pain; pleasures are viewed in their painful obverse. The positive value of delights is of consequence as the starting-point wherefrom to count the efficacy of deprivations. The pains opposed to the pleasures of self-esteem and praise are among the most powerful weapons in the armory of the disciplinarian. They are the chief reliance of such as deprecate corporeal inflictions. Bentham's elaborate scheme of discipline in the "Chrestomathia" is a manipulation of the motives of praise and dispraise, which he would fain make us believe to be all-sufficient.

Of the two divisions of the present class of emotions, namely, self-esteem on the one hand, and desire of praise on the other, the opposite of the first—self-reproach, self-humbling—is very little under foreign influence. To induce people to think meanly of themselves is no easy task; with the mass of human beings it is wellnigh hopeless. Any success that attends the endeavor is an offshoot from the second member of the class under discussion, namely, dispraise, depreciation. There is no mistaking our aim here; we can make our power felt in this form, whether it has the other effect or not. People live so much on one another's good opinion that the remission tells in an instant; from the simple abatement or loss of estimation there is a descent into the depths of disesteem with a result of unspeakable suffering. The efforts that the victim makes to right himself under censure only show how keenly it is felt. There can be little doubt that on the delicate handling of this instrument must depend the highest refinements of moral control.

The Emotions of Intellect.—The pleasurable emotions incident to the exercise of the intellectual powers have not the formidable magnitude that we have assigned to the foregoing groups. Indeed, on the occasions when they seem to burst forth with an intense glow, we can discern the presence of emanations from these other great fountains of feeling.

It is an effort of prime importance to trace exhaustively the inducements and allurements to intellectual exertion. What are the intrinsic charms of knowledge, whether in pursuit or in possession? The difficulty of the answer is increased rather than diminished by the flow of fifty years' rhetoric.

Knowledge has such a wide compass, embraces such various ingredients, that, until we discriminate the kinds of it, we cannot speak precisely either of its charms or of its absence of charm. Some sorts of knowledge are interesting to everybody; some interest only a few. The serious part of the case is, that the most valuable kinds of knowledge are often the least interesting.

The important distinction to be drawn here is between individual or concrete knowledge and general or abstract knowledge. As a rule, particulars are interesting as well as easy; generals uninteresting and hard. When particulars are not interesting, it is often from their being overshadowed by generals. When generals are made interesting, it is by a happy reflected influence upon the particulars. It would serve nearly all the purposes of the teacher to know the best means of overcoming the repugnance and the abstruseness of general knowledge.

Waiving for a time the niceties of the abstract idea, and the obstacles in the way of its being readily comprehended, we may here adduce certain motives that coöperate with the teacher's endeavors to impress it. A little attention, however, must first be given to the various kinds of interest that attach to individual or particular facts.

Any kind of knowledge, whether particular or more or less general, that is obviously involved in any of the strong feelings or emotions that we have passed in review, is by that very fact interesting. Now, a great many kinds of knowledge are implicated with those various feelings. To avoid pains, and obtain pleasures, it is often necessary to know certain things, and we willingly apply our minds to learn those things; and the more so, the more evident their bearing upon the gratification of our desires. A vast quantity of information respecting the world, and respecting human beings, is gained in this way; and it constitutes an important basis of even the highest acquisitions.

The readiness to imbibe this immediately fructifying knowledge is qualified by its being difficult or abstruse; we often prefer ignorance, even in matters of consequence, to intellectual labor.

All the natural objects that bear upon our subsistence, our wants, our pleasures, our exemptions from pain, are individually interesting to us, and become known in respect of their special efficacy. Our food, and all the means of procuring it, our clothing and shelter, our means of protection, our sense-stimulants, are studied with avidity, and remembered with ease. This department of knowledge, notwithstanding its vital concern, is apt to be considered as groveling; it has, howerer, the recommendation of truth. We do not encourage ourselves in any deceptions in such matters; and, if we make mistakes, it is owing to the obscurity of the case, rather than to our indifference, or to any motive for perverting the facts. Indeed, this is the department that first supplied to mankind the best criterion of certainty.

There is a different class of objects that appeal, not to the more pressing utilities of subsistence, safety, and comfort, but to the gratifications of the higher senses and the emotions: the pleasures of touch, sight, and hearing; the social and anti-social emotions. These comprise all the more striking objects of the world: the sun and celestial sphere, the earth's gay coloring and sublime vastness; the innumerable objects, inanimate and animate, that tickle some sense or emotion. In proportion as human beings are set free from the struggle for subsistence do they lay themselves open to the seinfluences, and so enlarge the sphere of natural knowledge. Individual things become interesting and known from inspiring these feelings. The culminating interest, however, is in living beings, and especially persons of our own species. The intellectual impressions thus left upon us are lively, but not necessarily correct as to the facts.

However all this may be, it is to individual things that we must refer the first beginnings of knowledge, the interest and the facility of acquisition. There are great inequalities in this interest and consequent facility; many individual objects inspire no interest at all in the first instance; while some of these become interesting afterward, in consequence of our discovering in them relationships to things of interest.

One notable distinction among the objects of knowledge is the distinction between movement or change, and stillness or inaction. It is movement that excites us most; still-life is rendered interesting by reference to movement. We are aroused and engrossed by all moving things; our attention is turned away from objects at rest to contemplate movements; and we imbibe with great rapidity the impressions of moving objects.

This brief survey of the sphere of individuality and of the various attractions presented by individuals is preparatory to the consideration of the most arduous part of knowledge—the knowledge of generals or generality. All the difficulties of the higher knowledge have reference to the generalizing process—the seeing of one in many. The arts of the teacher and the expositor are supremely requisite in sweetening the toil of this operation. At the present stage, however, the question is to assign the motives connected with general knowledge as distinct from individual knowledge.

General knowledge, represented by science, consists in holding together, by a single grasp, whole classes of objects, of facts, of operations. This must, by the very nature of the case, be more severe than holding an individual. To form an idea of one tree that we have repeatedly surveyed at leisure, round and round, is about the easiest exertion whether of attention or of memory. To form an idea of ten trees partly agreeing and partly differing among themselves is manifestly an entirely altered task; it is to exchange comparative simplicity for arduous complexity; yet this is what is needed everywhere in the higher knowledge.

The first emotional effect attendant on the process of generalizing facts, and serving to lighten the intellectual burden, is the flash of identity in diversity, an exhilarating charm that has been felt in every age by the searchers after truth. Many of the grandest discoveries in science have consisted, not in bringing to light any new individual fact, but in seeing a likeness between things formerly regarded as wholly unlike. Such was the great discovery of gravitation. The first flash of the recognition of a common power in the motions of the planets and the flight of a projectile on the earth was unutterably splendid; and, after a hundred repetitions, the emotional charm is unexhausted.

With the emotion of exhilarating surprise at the discovery of likeness among things seemingly unlike, there is another grateful feeling, the relief from an intellectual burden. This appears at first sight a contradiction to what has been already said respecting the greater laboriousness of general knowledge : but the contrariety is only apparent. To contract an impression of one single individual, after plenty of time given to attend to it, is the easiest supposable mental effort. But such is the multiplicity of things, that we must learn to know and remember vast numbers of individuals ; and we soon feel ourselves overpowered by the never-ending demands upon us. We must know many persons, many places, many houses, many natural objects; and our capability of memory is in danger of exhaustion before we have done. Now comes in, however, the discovery of identities, whereby the work is shortened. If a new individual is exactly the same as the old, we are saved the labor of a new impression ; if there is a slight difference, we have to learn that difference and no more. In actual experience, the case is that there are numerous agreements in the world, but accompanied with differences; and, while we have the benefit of the agreements, we must take notice of the differences. What makes a general notion difficult is that it represents a large number of objects that, while agreeing in some respects, differ in others. This difficulty is the price that we pay for an enormous saving in intellectual labor.

The overcoming of isolation in the multitude of particulars, by flashes of identity, is the progress of our knowledge in one direction; it is the satisfaction that we express when we say we understand or can account for a thing. Lightning was accounted for when it was identified with the electric spark: besides the exhilarating surprise at the sameness of two facts in their nature so different and remote, men had the further satisfaction of saying that they learned what lightning is. Thus by discoveries of identity we are enabled to explain the world, to assign the causes of things, to dissipate in part the mysteriousness that everywhere surrounds us.

When a discovery of identification is made among particulars hitherto looked upon as diverse, the interest created is all-sufficient to secure our appreciation. This is the alluring side of generalities. The repugnant aspect of them is seen in the technicalities that are invented to hold and express them—general or abstract designations, diagrams, and formulas. When it is proposed to indoctrinate the mind in these things, by themselves, and at a stage when the condensing and explaining power of the identities is as yet unawakened, the whole machinery seems an uncouth jargon. Hence the attempt to afford relief to the faculties by teaching the dry symbols of arithmetic and geometry, through the aid of examples in the concrete, and in all the abstract sciences to afford plenty of particulars to illustrate the generalities. This is good so far; but the real interest that overcomes the dryness arises only when we can apply the generalities in tracing identities, in solving difficulties, and in shortening labor; an effect that comes soonest to those that have already some familiarity with the field where the formulas are applicable. The liking for algebra and for geometry proceeds apace when one sees the marvels of curious problems solved, unlikely properties discovered, among numbers and geometrical figures. A certain ease in holding in the memory the abstract symbols, after a moderate application, is enough to prepare us for a positive relish in the pursuit. Such is the case with generalities in all departments. If we can hold on till they bear their fruits in the explanation of things that we have already begun to take notice of, the pursuit is sustained by a genuine and proper scientific interest, whose real groundwork, however deeply hidden, is the stimulus of agreement among differing particulars, and the lightening of the intellectual labor in comprehending the world. These are the feelings that have to be awakened in the minds of pupils when groaning under the burden of abstractions.

The opposition of the concrete and the abstract, while but another way of expressing the opposition of the particular and the general, brings into greater prominence the highly *composite* or combined character of individuality. The individual thing is usually a compound of many qualities, each of which has to be abstracted in turn, in rising to general notions; any individual ball has, in addition to its round form, the properties called weight, hardness, color, and so on. Now, this composite nature, by charming several senses at once, gives a greater interest to individuals, and urges us to resist that process of decomposition, and separate attention, to which are given the designations "abstraction" and "analysis." It is for individuals in all their multiplicity of influence that we contract likings or affections; and, according as the charm of sense, and especially the color-sense, is strong in us, we are averse to the classing or generalizing operation. A fire is an object of strong individual interest: to rise from this to the general notion of the oxidation of carbon under all varieties of mode, including cases with no intrinsic charm, is to quit with reluctance an agreeable contemplation. The emotions now described—the pleasure of identity, and the lightening of labor—are of avail to counterwork this reluctance.

The second of the two motives that we have coupled together—the easing of intellectual labor—may be viewed in another light. When objects are viewed as operating agents in the economy of the world, as causes or instruments of change, they work by their qualities or powers in separation, and not by their entire individuality or concreteness. An iron bar, or a poker, is an individual concrete thing; but, when we come to use it, we put in action its various qualities separately. We may employ it as a weight, in which case its other properties are of no account; we use it as a lever, and bring into play simply its length and its tenacity. We can put it in motion as a moving power, wherein its inertia is alone taken into account, with perhaps its form. In all these instances, the magnetical and the chemical and the medicinal properties of iron are unthought of. Now, this consideration opens up an important aid to the abstracting process, the analytic separation of properties, as opposed to the mind's fondness for clinging to concrete individuality.

When we are working out practical ends, we must follow Nature's method of working; and, as that is by isolating the separate qualities, we must perform the act of mental isolation, which is to abstract, or consider, one power to the neglect of the rest. When we want to put forth heavy pressure, we think of various bodies solely as they can exert weight, in however many other ways they may invite or charm our sense. This is to generalize or to form a general notion of weight; and the motive to conceive it is practical need or necessity.

This motive of practical need at once brings us to the very core of causation, viewed as a merely speculative notion. The cause of anything is the agent that would bring that thing into being, suppose we were in want of it. The cause of warmth in a room is combustion properly arranged: we use this fact for practical purposes; and we may also use it for satisfying mere curiosity. We enter a warm room; we may desire to know how it has been made warm, and we are satisfied by being told that there has been, or is now somewhere, a fire in communication with it.

Thus it is that in proportion as we come to operate upon the world practically ourselves, and from that proceed to contemplate causation at large, we are driven upon the abstracting and analyzing process, so repugnant to one large portion of our feelings. Science finds an opening in our minds at this point, when otherwise we might need the proverbial surgical operation.

These observations will serve to illustrate the working of the emotion named Curiosity, which is justly held to be a great power in teaching. Curiosity expresses the emotions of knowledge viewed as desire; and more especially the desire to surmount an intellectual difficulty once felt. Genuine curiosity belongs to the stage of advanced and correct views of the world.

Much of the curiosity of children, and of others besides children, is a sham article. Frequently it is a mere display of egotism, the delight in giving trouble, in being pandered to and served. Questions are put, not from the desire of rational information, but for the love of excitement. Occasionally the inquisitiveness of a child provides an opportunity for imparting a piece of real information; but far oftener not. By ingeniously circumventing a scientific fact, one not too high for a child's comprehension, we may awaken curiosity and succeed in impressing the fact. Try a child to lift a heavy weight first by the direct pull, and then by a lever or a set of pulleys, and probably you will excite some surprise and wonder, with a desire to know something further about the instrumentality. But one fatal defect of the childish mind is the ascendency of the personal or anthropomorphic conception of cause. This, no doubt, is favorable to the theological explanation of the world, but wholly unsuited to physical science. A child, if it had any curiosity at all, would like to know what makes the grass grow, the rain fall, the wind howl, and generally all things that are occasional and exceptional; an indifference being contracted toward what is familiar, constant, and regular. When anything goes wrong, the child has the wish to set it right, and is anxious to know what will answer the purpose; this is the inlet of practice, and, by this, correct knowledge may find its way to the mind, provided the power of comprehension is sufficiently matured. Still the radical obstacle remains—the impossibility of approaching science at random, or taking it in any order; we must begin at the proper beginning, and we may not always contrive to tickle the curiosity at the exact stage of the pupil's understanding. Every teacher knows, or should know, the little arts of giving a touch of wonder and mystery to a fact before the explanation is given; all which is found to tell in the regular march of exposition, but would be lost labor in any other course.

The very young, those that we are working upon by gentle allurement, are not properly competent to learn the "how" or "wherefore" of any important natural fact; they cannot even be made to desire the thing in the proper way. They are open chiefly to the charm of sense novelty and variety, which, together with accidental charm or liking, impresses the pictorial or concrete aspects of the world, whether quiescent or changing, the last being the most powerful. They further are capable of understanding the more palpable conditions of many changes without penetrating to ultimate causes. They learn that to light a fire there must be fuel and a light applied; that the growth of vegetables needs planting or sowing, together with rain and sunshine through a summer season. The empirical knowledge of the world that preceded science is still the knowledge that the child passes through in the way to science; and all this may be guided so as to prepare for the future scientific revelations. In other respects the so-called curiosity of children is chiefly valuable as yielding ludicrous situations for our comic literature.

THE PROGRESS OF ANTHROPOLOGY.[1]

By Professor T. H. HUXLEY.

WHEN I undertook, with the greatest possible pleasure, to act as a lieutenant of my friend the president of this section, I steadfastly purposed to confine myself to the modest and useful duties of that position. For reasons, with which it is not worth while to trouble you, I did not propose to follow the custom which has grown up in the Association of delivering an address upon the occasion of taking the

[1] Address before the Department of Anthropology of the British Association at its recent meeting held in Dublin, August 14, 1878.

chair of a section or department. In clear memory of the admirable addresses which you have had the privilege of hearing from Prof. Flower, and just now from Dr. McDonnell, I cannot doubt that that practice is a very good one ; but I would venture to say, to use a term of philosophy, that it looks very much better from an objective than from a subjective point of view. But I found that my resolution, like a great many good resolutions that I have made in the course of my life, came to very little, and that it was thought desirable that I should address you in some way. But I must beg of you to understand that this is no formal address. I have simply announced it as a few introductory remarks, and I must ask you to forgive whatever of crudity and imperfection there may be in the mode of expression of what I have to say, although naturally I shall do my best to take care that there is neither crudity nor inaccuracy in the substance of it. It has occurred to me that I might address myself to a point in connection with the business of this department which forces itself more or less upon the attention of everybody, and which, unless the bellicose instincts of human nature are less marked on this side of St. George's Channel than on the other, may possibly have something to do with the large audiences we are always accustomed to see in the anthropological department. In the Geological Section I have no doubt it will be pointed out to you, or, at any rate, such knowledge may crop up incidentally, that there are on the earth's surface what are called *loci* of disturbance, where, for long ages, cataclysms and outbursts of lava and the like take place. Then everything subsides into quietude ; but a similar disturbance is set up elsewhere. In Antrim, at the middle of the Tertiary epoch, there was such a great centre of physical disturbance. We all know that at the present time the earth's crust, at any rate, is quiet in Antrim, while the great centres of local disturbance are in Sicily, in Southern Italy, in the Andes, and elsewhere. My experience of the British Association does not extend quite over a geological epoch, but it does go back rather longer than I care to think about ; and, when I first knew the British Association, the *locus* of disturbance in it was the Geological Section. All sorts of terrible things about the antiquity of the earth, and I know not what else, were being said there, which gave rise to terrible apprehensions. The whole world, it was thought, was coming to an end, just as I have no doubt that, if there were any human inhabitants of Antrim in the middle of the Tertiary epoch, when those great lava-streams burst out, they would not have had the smallest question that the whole universe was going to pieces. Well, the universe has not gone to pieces. Antrim is, geologically speaking, a very quiet place now, as well cultivated a place as one need see, and yielding abundance of excellent produce ; and so, if we turn to the Geological Section, nothing can be milder than the proceedings of that admirable body. All the difficulties that they seemed to have encountered at first have died away, and statements that were the horrible paradoxes of that generation are now the commonplaces of schoolboys. At present the *locus* of disturbance is to be found in the Biological Section, and more particularly in the anthropological department of that section. History repeats itself, and precisely the same terrible apprehensions which were expressed by the aborigines of the Geological Section, in long far-back time, is at present expressed by those who attend our deliberations. The world is coming to an end, the basis of morality is being shaken, and I don't know what is not to happen, if certain conclusions which appear probable are to be verified. Well, now, whoever may be here thirty years hence—I certainly cannot—but, depend upon it, whoever may be speaking at the meeting of this department of the British Association thirty years hence will find, exactly as the members of the Geological Section have found, on looking back thirty years, that the very paradoxes and conclusions, and other horrible things that are now thought to be going to shake the foundations of the world, will by that time have become parts of everyday knowledge and will be taught in our schools as accepted truth, and nobody will be one whit the worse.

The considerations which I think it desirable to put before you, in order to show the foundations of the conclusions at which I have very confidently arrived, are of two kinds. The first is a reason based entirely upon philosophical considerations, namely, this: that the region of pure physical science, and the region of those questions which specially interest ordinary humanity, are apart, and that the conclusions reached in the one have no direct effect in the other. If you acquaint yourself with the history of philosophy, and with the endless variations of human opinion therein recorded, you will find that there is not a single one of those speculative difficulties which at the present time torment many minds as being the direct product of scientific thought which is not as old as the times of Greek philosophy, and which did not then exist as strongly and as clearly as they do now, though they arose out of arguments based upon merely philosophical ideas. Whoever admits these two things—as everybody who looks about him must do—whoever takes into account the existence of evil in this world and the law of causation—has before him all the difficulties that can be raised by any form of scientific speculation. And these two difficulties have been occupying the minds of men ever since man began to think. The other consideration I have to put before you is that, whatever may be the results at which physical science as applied to man shall arrive, those results are inevitable—I mean that they arise out of the necessary progress of scientific thought as applied to man. You all, I hope, had the opportunity of hearing the excellent address which was given by our president yesterday, in which he traced out the marvelous progress of our knowledge of the higher animals which has been effected since the time of Linnæus. It is no exaggeration to say that at this present time the merest tyro knows a thousand times as much on the subject as is contained in the work of Linnæus, which was then the standard authority. Now, how has that been brought about? If you consider what zoölogy, or the study of animals, signifies, you will see that it means an endeavor to ascertain all that can be studied, all the answers that can be given respecting any animal under four possible points of view. The first of these embraces considerations of structure. An animal has a certain structure, a certain mode of development, which means a series of stages in that structure. In the second place, every animal exhibits a great number of active powers, the knowledge of which constitutes its physiology ; and under those active powers we have, as physiologists, not only to include such matters as have been referred to by Dr. McDonnell in his observations, but to take into account other kinds of activity. I see it announced that the Zoölogical Section of to-day is to have a highly-interesting paper by Sir John Lubbock on the habits of ants. Ants have a polity, and exhibit a certain amount of intelligence, and all these matters are proper subjects for the study of the zoölogist as far as he deals with the ant.

There is yet a third point of view in which you may regard every animal. It has a distribution. Not only is it to be found somewhere on the earth's surface, but paleontology tells us, if we go back in time, that the great majority of animals have had a past history—that they occurred in epochs of the world's history far removed from the present. And, when we have acquired all that knowledge which we may enumerate under the heads of anatomy, physiology, and distribution, there remains still the problem of problems to the zoölogist, which is the study of the causes of those phenomena, in order that we may know how those things came about. All these different forms of knowledge and inquiry are legitimate subjects for science, there being no subject which is an illegitimate subject for scientific inquiry, except such as involves a contradiction in terms, or is itself absurd. Indeed, I don't know that I ought to go quite so far as this at present, for, undoubtedly, there are many benighted persons who have been in the habit of calling by no less hard names conceptions which our president tells us must be regarded with much respect. If we have four dimensions of space we may have forty dimensions, and that would be a long way beyond that which is conceivable by ordinary powers of imagination. I should, therefore, not like to draw too closely the limits as to what may be contradiction to the best-established principles. Now, let us turn to a proposition which no one can possibly deny—namely, that there is a distinct sense in which man is an animal. There is not the smallest doubt of that proposition. If anybody entertains a misgiving on that point, he has simply to walk through the museum close by in order to see that man has a structure and a framework which may be compared, point for point and bone for bone, with those of the lower animals. There is not the smallest doubt, moreover, that, as to the manner of his becoming, man is developed, step by step, in exactly the same way as they are. There is not the smallest doubt that his activities—not only his mere bodily functions, but his other functions—are just as much the subjects of scientific study as are those of ants or bees. What we call the phenomena of intelligence, for example (as to what else there may be in them, the anthropologist makes no assertion), are phenomena following a definite causal order just as capable of scientific examination, and of being reduced to definite law, as are all those phenomena which we call physical. And just as ants form a polity and a social state, and just as these are the proper and legitimate study of the zoölogist, so far as he deals with ants, so do men organize themselves into a social state; and, though the province of politics is of course outside that of anthropology, yet the consideration of man, so far as his instincts lead him to construct a social economy, is a legitimate and proper part of anthropology, precisely in the same way as the study of the social state of ants is a legitimate object of zoölogy. So with regard to other and more subtile phenomena. It has often been disputed whether in animals there is any trace of the religious sentiment. That is a legitimate subject of dispute and of inquiry; and, if it were possible for my friend Sir John Lubbock to point out to you that ants manifest such sentiments, he would have made a very great and interesting discovery, and no one could doubt that the ascertainment of such a fact was completely within the province of zoölogy. Anthropology has nothing to do with the truth or falsehood of religion—it holds itself absolutely and entirely aloof from such questions—but the natural history of religion, and the origin and the growth of the religions entertained by the different kinds of the human race, are within its proper and legitimate province.

I now go a step further, and pass to the distribution of man. Here, of course, the anthropologist is in his special region. He endeavors to ascertain how various modifications of the human stock are arranged upon the earth's surface. He looks back to the past, and inquires how far the remains of man can be traced. It is just as legitimate to ascertain how far the human race goes back in time as it is to ascertain how far the horse goes back in time; the kind of evidence that is good in the one case is good in the other; and the conclusions that are forced on us in the one case are forced on us in the other also. Finally, we come to the question of the causes of all these phenomena, which, if permissible in the case of other animals, is permissible in the animal man. Whatever evidence, whatever chain of reasoning justifies us in concluding that the horse, for example, has come into existence in a certain fashion in time, the same evidence and the same canons of logic justify us to precisely the same extent in drawing the same kind of conclusions with regard to man. And it is the business of the anthropologist to be as severe in his criticism of those matters in respect to the origin of man as it is the business of the paleontologist to be strict in regard to the origin of the horse; but for the scientific man there is neither more nor less reason for dealing critically with the one case than with the other. Whatever evidence is satisfactory in one case is satisfactory in the other; and if any one should travel outside the lines of scientific evidence, and endeavor either to support or oppose conclusions which are based upon distinctly scientific truths, by considerations which are not in any way based upon scientific logic or scientific truth—whether that mode of advocacy was in favor of a given position, or whether it was against it—I, occupying the chair of the section, should, most undoubtedly, feel myself called upon to call him to order, and to tell him that he was introducing considerations with which we had no concern whatever.

I have occupied your attention for a considerable time; yet there is still one other point respecting which I should like to say a few words, because some very striking reflections arose out of it. The British Association met in Dublin twenty-one years ago, and I have taken the pains to look up what was done in regard to our subject at that period. At that time there was no anthropological department. That study had not yet differentiated itself from zoölogy, or anatomy, or physiology, so as to claim for itself a distinct place. Moreover, without reverting needlessly to the remarks which I placed before you some time ago, it was a very volcanic subject, and people rather liked to leave it alone. It was not until a long time subsequently that the present organization of this section of the Association was brought about; but it is a curious fact that, although proper anthropological subjects were at the time brought before the Geographical Section—with the proper subject of which they had nothing whatever to do—I find that even then more than half of the papers that were brought before that section were, more or less distinctly, of an anthropological cast. It is very curious to observe what that cast was. We had systems of language—we had descriptions of savage races—we had the great question, as it then was thought, of the unity or multiplicity of the human species. These were just touched upon, but there was not an allusion in the whole of the proceedings of the Association at that time to those questions which are now to be regarded as the burning questions of anthropology. The whole tendency in the present direction was given by the publication of a single book, and that not a very large one—namely, "The Origin of Species." It was only subsequent to the publication of the ideas contained in that book that one of the most powerful instruments for the advance of anthropological knowledge—namely, the Anthropological Society of Paris—was founded. Afterward the Anthropological Institute of this country and the great Anthropological Society of Berlin came into existence, until it may be said that now there is not a branch of science which is represented by a larger or more active body of workers than the science of anthropology. But the whole of these workers are engaged, more or less intentionally, in providing the data for attacking the ultimate great problem, whether the ideas which Darwin has put forward in regard to the animal world are capable of being applied in the same sense and to the same extent to man. That question, I need not say, is not answered.

It is a vast and difficult question, and one for which a complete answer may possibly be looked for in the next century; but the method of inquiry is understood; and the mode in which the materials are now being accumulated bearing on that inquiry, the processes by which results are now obtained, and the observation of these phenomena, lead to the belief that the problem also, some day or other, will be solved. In what sense I cannot tell you. I have my own notion about it, but the question for the future is the attainment, by scientific processes and methods, of the solution of that question. If you ask me what has been done within the last twenty-one years toward this object, or rather toward clearing the ground in the direction of obtaining a solution, I don't know that I could lay my hand upon much of a very definite character—except as to methods of investigation—save in regard to one point. I have some reason to know that about the year 1860, at any rate, there was nothing more volcanic, more shocking, more subversive of everything right and proper, than to put forward the proposition that, as far as physical organization is concerned, there is less difference between man and the highest apes than there is between the highest apes and the lowest. Now, my memory carries me back sufficiently to remind me that, in 1860, that question was not a pleasant one to touch on.

The other day I was reading a recently-published valuable and interesting work, "L'Espèce Humaine," by a very eminent man, M. de Quatrefages. He is a gentleman who has made these questions his special study, and has written a great deal and very well about them. He has always maintained a temperate and fair position, and has been the opponent of evolutionary ideas, so that I turned with some interest to his work as giving me a record of what I could look on as the progress of opinion during the last twenty years. If he has any bias at all, it is one in the opposite direction to which my own studies would lead me. I cannot quote his words, for I have not the book with me, but the substance of them is that the proposition which I have just put before you is one the truth of which no rational person acquainted with the facts could dispute. Such is the difference which twenty years has made in that respect, and, speaking in the presence of a great number of anatomists, who are quite able to decide a question of this kind, I believe that the opinion of M. de Quatrefages on the subject is one they will all be prepared to indorse. Well, it is a comfort to have got that much out of the way. The second direction in which I think great progress has been made is with respect to the processes of anthropometry, in other words, in the modes of obtaining those data which are necessary for anthropologists to reason upon.

Like all other persons who have to deal with physical science, we confine ourselves to matters which can be ascertained with precision, and nothing is more remarkable than the exactness which has been introduced into the mode of ascertaining the physical qualities of man within the last twenty-five years. One cannot mention the name of Broca without the greatest gratitude; and I am quite sure that, when Prof. Flower brings forward his paper on cranial measurements on Monday next, you will be surprised to see what precision of method and what accuracy are now introduced, compared with what existed twenty-five years ago, into these methods of determining the physical data of man's structure. If, further, we turn to those physiological matters bearing on anthropology which have been the subject of inquiry within the last score of years, we find that there has been a vast amount of progress. I would refer you to the very remarkable collection of the data of sociology by Mr. Herbert Spencer, which contains a mass of information useful on one side or the other in getting toward the truth. Then I would refer you to the highly-interesting contributions which have been made by Prof. Max Müller and by Mr. Tylor to the natural history of religions, which is one of the most interesting chapters of anthropology. In regard to another very important topic, the development of art and the use of tools and weapons, most remarkable contributions have been made by General Lane Fox, whose museum at Bethnal Green is one of the most extraordinary exemplifications that I know of the ingenuity, and, at the same time, of the stupidity of the human race. Their ingenuity appears in their invention of a given pattern or form of weapon, and their profound stupidity in this, that, having done so, they kept in the old grooves, and were thus prevented from getting beyond the primitive type of these objects and of their ornamentation. One of the most singular things in that museum is its exemplification—the wonderful tendency of the human mind when once it has got into a groove to stick there. The great object of scientific investigation is to run counter to that tendency.

Lastly, great progress has been made in the last twenty years in the direction of the discovery of the indications of man in a fossil state. My memory goes back to the time when anybody who broached the notion of the existence of fossil man would have been simply laughed at. It was held to be a canon of paleontology that man could not exist in a fossil state. I don't know why, but it was so; and that fixed idea acted so strongly on men's minds, that they shut their eyes to the plainest possible evidence. Within the last twenty years we have an astonishing accumulation of evidence of the existence of man in ages antecedent to those of which we have any historical record. What the actual date of those times was, and what their relation is to our known historical epochs, I don't think anybody is in a position to say. But it is beyond all question that man, and not only man, but, what is more to the purpose, intelligent man, existed at times when the whole physical conformation of the country was totally different from that which characterizes it now. Whether the evidence we now possess justifies us in going back further, or not—that we can get back as far as the epoch of the drift is, I think, beyond any rational question or doubt; that may be regarded as something settled—but when it comes to a question as to the evidence of tracing back man further than that—and recollect drift is only the scum of the earth's surface—I must confess that to my mind the evidence is of a very dubious character.

Finally, we come to the very interesting question—as to whether, with such evidence of the existence of man in those times as we have before us, it is possible to trace in that brief history any evidence of the gradual modification from a human type somewhat different from that which now exists to that which is met with at present. I must confess that my opinion remains exactly what it was some eighteen years ago, when I published a little book [1] which I was very sorry to hear my friend Prof. Flower allude to yesterday, because I had hoped that it would have been forgotten among the greater scandals of subsequent times. I did there put forward the opinion that what is known as the Neanderthal skull is, of human remains, that which presents the most marked and definite characteristics of a lower type—using the language in the same sense as we would use it in other branches of zoölogy. I believe it to belong to the lowest form of human being of which we have any knowledge, and we know from the remains accompanying that human being that, as far as all fundamental points of structure were concerned, he was as much a man—could wear boots just as easily—as any of us, so that I think the question remains pretty much where it was. I don't know that there is any reason for doubting that the men who existed at that day were in all essential respects similiar to the men who exist now. But I must point out to you that this conviction is by no means inconsistent with the doctrine of evolution. The horse which existed at that time was in all essential respects identical with the horse which exists now. But we happen to know that going back further in time the horse presents us with a series of modifications by which it can be traced back from an earlier type. Therefore it must be deemed possible that man is in the same position, although the facts we have before us with respect to him tell in neither one way nor the other. I have now nothing more to do than to thank you for the great kindness and attention with which you have listened to these informal remarks.—*Nature.*

[1] "Evidence as to Man's Place in Nature."

MONERA, AND THE PROBLEM OF LIFE.

BY EDMUND MONTGOMERY, M. D.

III.—THE PHYSICAL PHASE OF THE PROBLEM.—(*Concluded.*)

IT has been shown in former articles that living motion is the result of alternate expansion and contraction on the part of the protoplasm; and we could not fail to perceive that this occupation of so much more or so much less space is the physical property of the protoplasm under different states of chemical composition. It remains to be ascertained by what agencies the chemical composition and decomposition of the living substance are affected. What are the influences that disintegrate the protoplasm? and what are the influences that reintegrate it?

A little attention to the visible changes which occur in the expanding material of different monera, when being checked in its onward course, soon demonstrates that it is the resistance of the medium, the counteraction of the energies composing the immediate environment, which causes chemical rupture in the organic substance. The molecule of protoplasm, like all very high compounds, and, in fact, like almost all nitrogenous compounds, is in a considerable degree explosive. During the expansion of the protoplasm, the medium is pushing against it with a force of its own; and it is this opposing energy, exerted by the medium, which, at some definite moment of its increasing composition and consequent expansion, causes this living substance at last to explode.

No unscientific conjecture has been allowed to enter into the above conception of this highly-important vital occurrence. It is as a mental sketch, in its outline, as positive and certain as any fact of Nature can possibly be.

In observing this process of decomposition, first the outer envelope of the projecting cone is seen to become disintegrated, and, in lower monera, also solidified. In these lower specimens the expanding material pushes still onward along the central axis of the cone, breaking through its apex, until it is at last also overcome by rigidity.

As the expanding material is perfectly translucent, the slightest optical change in it can be easily detected. The whitish, somewhat more opaque appearance of the stagnating protoplasm indicates that an important molecular alteration has taken place. That this alteration is of a chemical nature is actually proved by the products of decomposition being in many instances visibly gathered into a separate globule.

Thus the dynamical energy of the medium applies the match, gives the turning-stroke to the pending explosion, and it is by this dynamical act that the specific chemical rupture is effected, in consequence of which the protoplasm reassumes its former contracted state in space.

In physiology, the peculiar activity displayed by the protoplasm, and induced by the dynamical influence of the medium, is called the function of the acting substance. The function is said to be stimulated by the dynamical influence, and the material compounds which separate from the living substance during this operation are distinguished as products of functional disintegration.

The special function of living contraction, which we have been enabled so plainly to follow up in our primitive organisms, is typical of all motor and sensory functions whatever. Contractility is the fundamental expression of vital function. It is the first unmistakable, distinctly visible manifestation of living activity.

All these functional performances, these visible and otherwise directly sensible parts of organic activity, compose the open spectacle of life—the ostensible conspicuous display of vitality. They correspond to the manifest figurative exhibitions of an exquisitely-contrived clock, all set in motion during its unwinding. But beyond this variegated automatic show perceived on the outside, what depths of unsolved mystery, molecular and other, remain behind in the impenetrable recesses of organization, affording a boundless field for scientific exploration, as well as teleological speculation.

All those of the past and present who, in the stronghold of final causes, have fortified their faith in a spirit of guiding forethought—Voltaire, the sprightly scoffer, with Paley, the sifting advocate, and so many more who have sought to interpret the secret scheme of apparent design traceable in the all-befitting coaptation of things—to me it seems they have but slightly and superficially used their strong means.

The wonder lies essentially in the unification and integration of manifold influences into the compass of one single individual entity, not so essentially in the subsequent spontaneous correlation of that individual to those manifold influences. The wonder lies chiefly in the concentrated and unified organization of the relations, not so much in their functional display afterward. The problem is the established unity of the multifariously related individual, not the planning and fitting of these multifarious relations themselves. The power of our life is intrinsically wrought, not extrinsically derived.

This most weighty truth the science of organization maintains not on mere general grounds or formal conclusions drawn from assumed premises, but it is ready to prove it step by step by actual verification. The subsistence of the reverse supposition is altogether emotional and metaphysical; it rests on fictitious ontology. From foreign spheres an outside hand of power is made to reach forth, and to set going, by dint of will or deed, the precious clock of life, with all its play of sensation and motion, its revealing and its conquering beats. From out the indefinite infinitudes an unlimited skill is evoked, and upon it are imposed the effortless contrivance and accomplishment of all that is so laboriously painful, joyful, marvelous to us.

This, in its best sense, means blind surrender of all knowledge to implicit trust. But life, grown conscious amid incessant struggle and remorseless fate, feels now sufficiently inured and emboldened not to shrink from prying with utmost earnestness into the secret of its own significance. It yearns to comprehend.

However, one obstacle removed, another at once takes its place. It so happens, namely, that we ourselves are most ingenious contrivers, all of us inveterate mechanists from our birth, using with much advantage things that already are. And, very likely, because of such universal human propensity, the advanced thinkers of our race conceive that a chaos of some kind of original stuff must have served a similar purpose to an infinitely mightier contriver, maker, Nature, or whatever special appellation anthropomorphic or metaphysical predilection may dictate for it. Poor philosophy this, that has to beg the entire question. No, we are very far yet from having solved the riddle of final causes and natural synthesis. We stand on the outside, perplexed as ever, in spite of Hume's concentrative naturalism, and Kant's schools of criticism and transcendentalism. No word of prophetic speech, or weighing knowledge, has yet uttered the true meaning of things. Our mind, with its shallow dip, emotional and mechanical, does but pierce the rippling face of creative profundity.

One point, however, one steadfast point, is everywhere discernible among the phantasmal shifting of appearances and thoughts; and this one positive element of truth thus enunciates itself: Only by unremitting, infinitely graduated, indwelling travail, does at all times the fruit of existence receive its birth. The import of this guiding truth can be but superficially reprojected and numerically symbolized by the recognition of signs of inorganic evolution, and the heaping of ages upon ages of geological time. Its real value can be realized only by the discovery and penetration of its actual source of emanation—organization.

Perhaps our monera will materially assist us in gaining some estimate of the potency of organization. In its adequate composition will consist the arduous task of the philosophy of the future.

The study of moneric protoplasm has disclosed that so-called contractility is not merely a property of the living substance, but that it is its function, stimulated by the dynamical influences of the medium, and effected by means of chemical disintegration. The organic molecule, before it experienced its chemical, its functional rupture, was held together by the bond of inwrought chemical affinities. Now that dissociation has been accomplished, these chemical affinities are left unsatisfied. The disintegrated protoplasm forms but one complemental part of a higher, most definite combination. If the other complemental part should happen to be in readiness somewhere, and be brought, by some means or other, into actual contact with the mutilated protoplasm, then surely the existing affinities would exert their influence, and the higher compound would be restored in its former integrity and completeness. This—expressed in the language of chemistry—is exactly what in reality occurs.

The union of the disintegrated protoplasm with complemental material, furnished by the medium, can be directly witnessed without any possibility of misapprehension. We see the disintegrated protoplasm. We see it combine with substances drifted to it by the medium, and we see it in consequence reassume its former state.

Now, at last, we have actually entered the threshold of organization. We have discovered the fundamental fact of its statics. We know positively that reintegration of the living substance, restoration of the disturbed vital equilibrium, is the work of preëstablished chemical affinities, and that it requires extraneous matter of a specific kind to enable this restitution to take place.

The statical aspect of all organization offers nothing but a complication of this one event of chemical equilibrium, a vast complication in the molecular gradations of functionally disintegrated protoplasm, a vast complication also in the gradations of restitutive material.

The integration and differentiation of vital function on the one hand, and the preparation and composition of food-material on the other hand, form—as we will become fully aware further on—the two great divisions in the subject-matter of the science of organization, divisions corresponding to the fundamental biplicity of all advanced organization, its animal and its vegetative life. Organization in the sphere of animal life is the expression of the development of manifold outside relations in the vital unit. Organization in the sphere of vegetative life is the expression of the preparation of more and more elaborate material, fit to restore the functional waste of those developed relations.

I believe no candid critic can deny that the above related observations have laid open to inspection the secret mechanism of life; have reduced to the domain of operations known in the inorganic world the performances that, in a primitive state of life, visibly constitute vital activity.

With little more mental exertion than is required for the faithful interpretation of obvious appearances, a scientific feat has been accomplished which but yesterday seemed totally impracticable. I am aware that, on account of its strange simplicity, many will deem that, after all, not much advantage has been gained by it. But let no one deceive himself in this. By dint of this internal as well as external understanding of motility, we know at this very moment more, much more, about the property of life in the living substance than we do of any other property belonging to any other substance.

We clearly conceive the manner how, and the conditions by which, motility, this most prominent vital manifestation, constitutes an inherent property of the living substance. Do we as yet comprehend in the same way the intimate modes of activity which constitute the properties appertaining to inorganic substances? Is any kind of those peculiar motions which form the scientific essence of the various forces of inorganic Nature so strictly and deeply intelligible as has now become that specific motion which forms the scientific essence of the force of life?

Motion of any kind stands at present just in the same relation to dead matter as that special mode of motion called contractility stood, before this, to living matter. Mechanical motion, heat, electricity, etc., are all qualities occultisimal, known only by the relative measurement of the spaces of contraction and expansion which their manifesting substrata occupy, or are thought to occupy.

Comparative expansion and contraction are, and must be, the subject-matter of all quantitative science. All intensities are made quantitatively scientific by being "converted" into modes of space. Time itself is thus measured, and the intensity of heat can be ascertained only by the expansion and contraction of the manifesting substances. So with all. Our undulatory theories are expressions of the same helpful makeshift; an expanding and contracting substratum.

Motility is precisely such another expansion and contraction. But, now, we know not merely the fact. We know, besides, how it is effected. We know something about the working of it within the manifesting substance. By this qualitative penetration, this more substantial insight into natural operations, we have broken the consolidated crust of mere superficial shiftings in space, and have forced a scientific entry into deeper spheres of knowledge.

The comparisons between motility and other modes of motion are strictly appropriate. How much so cannot be adequately appreciated until the origin and development of sensation have been traced; of which all modes of motion are, in the last instance, accurately corresponding affections or reactions.

And, now, what has become of this most vexed problem of problems—the origin of life? Is not protoplasm a chemical compound like other substances, merely varying from them in its degree of molecular complexity? Its most characteristic manifestation, its distinguishing mode of motion, its peculiar force—the one specific activity constituting its most vital difference—is better known to us than any quality which forms the distinguishing feature between other substances. Do we greatly concern ourselves about the origin of MgO,SO_3+7H_2O, or any other mineral substance? Why, then, should the origin of some combination of C, H, N, O, be made a question of the life and death of our principal philosophies? Has it actually come to this, that the scientific foundation of our creed rests on the decision whether COO is or was once changed into CHO by natural or supernatural means; and this when there is plenty of H about in our world? Yes, it is even so, however incredible, however little flattering to our intellectual pretensions. The contending claims of naturalism and supernaturalism, the fate of the most momentous question touching the guidance of our life, turn actually, in the field of science, upon the paltry issue of the synthesis of ternary carbon compounds, whether this be chemically or whether it be superchemically effected. COO is undisputably an inorganic compound. CHO is undisputably an organic compound. This designates accurately the actual depth of the gulf existing between organic and inorganic Nature.

The chief vital manifestation of protoplasm, its contractility, can no longer startle us, for we know exactly how it is produced by well-known chemical and physical means. The combination of C, H, N, O, constituting protoplasm, is nothing but a very complicated chemical compound. CHO is a less complicated compound. COO is a still less complicated compound.

We do not in the least know how COO originates. We know a little better how CHO originates. And, perhaps, it will presently appear that we know still better how the combination of C, H, N, O, constituting protoplasm, originates. The advantage of intelligibility lies all on the side of organic Nature. It is astounding to contemplate in what a degree this may actually prove to be the case.

We owe an incalculable debt of gratitude to quantitative science. In our panic-stricken minds it has established the certainty of serene order everywhere. Through the never-failing verification of inflexible laws it attests the necessary connection and absolute interdependence of all accessible changes in Nature. Thus it has liberated us from a thralldom infinitely more pitiful than any form of common slavery—the thralldom of our own vicious and cruel superstitions. In many ways it has enriched our lives a thousand-fold, and we may, in future, expect from it an ever-increasing harvest of similar benefits.

It appears to me as if I could discern with some degree of distinctiveness—just beginning to loom in the distant twilight of consciousness—an entirely new era of knowledge; an era governed by the science of organization, by means of which more concentrative appreciation the synthesis of reality will receive a deeper explanation, and all facts of Nature appear in an organic light, in a qualitative interdependence, evolution being then understood as creative evolution, and not as mere transformation of modes of motion and atomical redistribution of matter. I have conjured up into the medium of shadowy words this most vague fancy of an organic epoch in science, because I firmly believe that we are already in possession of a clew to the means and ways by which the development of the living substance has been and is still being achieved; while, on the contrary, we possess no clew whatever to the means and ways which have led to the development of the now existing inorganic substances from the supposed primordial substratum.

We watch a moner for hours, for days. There it is, ever continuing without intermission to expand and to contract; alternately to suffer decomposition and to accomplish its recomposition. A blank sameness, an almost thought-paralyzing monotony of life, is thus exhibited by many of these primitive beings. Only always expansion and contraction, by means of that same kind of reintegration and disintegration. Nothing more, apparently. It would almost seem as if the anti-evolutionists were right after all in their main view of life. It, indeed, resembles most strikingly a perpetual seesaw; the very same thing always over again—a mere organic toy, ingeniously contrived, so as to maintain itself intact, in spite of encroaching outside influences; the unmeaning disturbance of a most delicate equilibrium, and the following exact reëstablishment of that very same equilibrium. This, reduced to its most simple biological expression, is the foundation of the opinions which oppose evolutionism by maintaining the permanence of organic species, or their archetypal origin.

All turns upon the decision of the following point: Does there exist an absolute equivalence, a total identity between the compound separated from the protoplasm by the dynamical influences of the medium and the restitutive compound taken up from the medium by dint of the specific affinities inherent in the protoplasm? Does there normally exist a complete fixity in the observed play of equilibrated activities? Does this ever-reiterated exhibition of motility fulfill only its own motory object? Or, translated into the language of volition, Does the organism merely move to feed, and feed to move? This, in truth, is the pith of this momentous question.

The chemical affinities inwoven in the protoplasm are, like all chemical affinities, of a most definite kind. This chemical definiteness is even outwardly manifest in the strict preservation of all peculiarities in the different living substances which constitute the varieties of monera. Now, this functional restitution of protoplasm is effected entirely by means of these inherent chemical affinities. It is clear, therefore, that, if a deviation is ever to occur in the beats of this chemically so firmly established vital pendulum, it can be operated only in two ways: Either the dynamical influences succeed in splitting off from the expanding protoplasm a slightly-differing molecule, affecting thus the total chemical equilibrium in such a manner as to bring about a somewhat altered reintegration of the same, or the restitutive material possesses, by dint of its own peculiar molecular composition, the power of forcing the disintegrated substance to reintegrate itself with some slight deviation.

In other words, variations in the molecular constitution of the protoplasm can only be effected either by the dynamical influences of the medium, or by the restitutive material of the medium. Spontaneous variations, starting from within the already-established molecular equilibrium of the protoplasm itself, would be like all other spontaneous changes, an inadmissible supposition, an effect without a cause.

In another stage of the inquiry we will learn the exaot effect which restitutive material, when not accurately complemental, does actually exert on the protoplasm. I will here only mention that it has, very demonstrably, only the power specifically to deteriorate the same, and not in the least the power to give it any impulse toward higher development. In the course of organic progress it is the living substance which lifts the food to the level of its own requirements; not the food which confers higher vital powers on the protoplasm.

There remains only one path, then, through which development can make its entry into the living substance, and this is—be it fully understood—the infinitely toilsome elaboration of molecular complexity by means of ever-reiterated functional disintegration. If it, namely, should happen, that the dynamical influences of the medium are so attuned as to shift and complicate—by force of their sundry specific modes of operation—the molecular equilibrium of the protoplasm, ever so immeasurably little at a time, then, by incessant perseverance, an appreciable organic effect may, at last, be attained.

There are strong reasons which make it highly probable—I do not say certain, because it lies in the nature of the process that it cannot be directly witnessed—but there are manifold occurrences which make it very evident that this mode of development is actually the one adopted in Nature.

In a general way we all know, with perfect certainty, that previous functional exercise of an organ fits the same all the better for further functional performances. Use develops functional structure; disuse involves its atrophy. All educational acquirement rests on this foundation, and also all degradation of skill or culture.

We will endeavor to form some mental representation of the activities which are elaborating these great and evident results.

The energy of the dynamical influences is exerted on protoplasm in the course of chemical composition. It is a substance in process of molecular cumulation which encounters, in its onward flow, the forces of the medium. The foremost part of an advancing conical projection, for instance, will consist of higher material than its lateral part, and will therefore be differently affected even by the same forces of the medium. But, if we further take into consideration that the influences of the medium are themselves of a manifold nature, each kind affecting the protoplasm with a specific energy of its own, it can be readily conceived that a most complicated molecular disturbance must ensue. This must be all the more the case in a substance in which the forces of the medium have not each their definite, circumscribed, and attuned channel of functional stimulation; but are attacking more or less every part of its circumference.

Dynamical considerations, too abstruse to be here introduced, make it extremely probable that a preponderance of effect in favor of the dynamical energies best attuned to the highest, foremost portion of the expanding living substance will give rise to a restitution of the entire mass more in the likeness of the higher protoplasm disintegrated by the more subtile dynamical influences. Thus the constitution of the protoplasm at the very beginning of its next pulse of recomposition will, by this slight increment of complication, resemble a whit more its molecular state, when at the height of its former expanding pulse. The decomposition caused by the combined specific energies of the medium will be followed by a somewhat higher composition.

The elaboration of organic substances in plants is at all times notably effected by a process similar to the one here indicated. It is brought about by a twofold chemical activity, incited by a specific dynamical influence of the medium. First there occurs a specific decomposition, and then, in consequence, a somewhat altered recomposition; or, technically expressed, there occurs reduction followed by substitution. It is believed that under the influence of light there is split off from carbonic acid one atom of oxygen, which is then replaced by one atom of hydrogen: ${}_2COO + H_2O - C_2H_2O_2 + OOO$.

But, before examining the conditions under which this fundamental and most weighty transformation of the inorganic into the organic takes place, I will state, in further support of the gradual development of the living substance, that the phenomenon of individual growth gives in itself plain evidence of organic development having actually occurred in the past. Growth is essentially a concise recapitulation of developmental changes.

But, not to complicate matters too much, I have here purposely left out of consideration all manifestations appertaining to growth, as well as those appertaining to propagation. Both these phases of organic existence do not belong to the domain of production, but entirely to that of reproduction. Propagation multiplies, growth reconstructs, organic results previously achieved.

Though it cannot be denied that the attentive observation of moneric protoplasm has restricted the physical phase of the problem of life to the limits of a purely chemical question, and though it may be conceded that organic development is truly effected by means of chemical activity dynamically incited, yet with many there will persist an ungratified curiosity concerning the origin of life. This dissatisfaction, expressed in clear words, can only amount to the following objection: "Granting that motility is merely the scientifically intelligible property of a specific chemical compound, yet it has not been shown how on our planet the first organic compound has actually started into existence."

Against this rather radical claim on the science of life might be urged, that we do not precisely know how, for instance, carbonic acid has naturally originated. But we will be told that one has only to bring carbon, under certain known conditions, together with oxygen, and that then carbonic acid will invariably result.

To this might again be replied that organic substances can also be made to originate in the same manner; that from inorganic material Woehler produced urea, Strecker taurin, Kolbe acetic acid, etc.

However, I am perfectly aware that this is not the kind of information which will satisfy the somewhat unscientific but historically justifiable craving for positive and circumstantial enlightenment concerning the origin of living substance. The desire is to understand the genuine organic synthesis which has legitimately led to the formation of such peculiar compounds as now actually manifest vital phenomena.

With the protest, clearly defined, and well sustained in these pages, that this question is not at all one of vitality, but merely one of specific chemistry, I will venture a few tentative gropings. Their verification would constitute not a biological but a purely chemical task.

The transformation of the inorganic into the organic world is at present, so far as we are aware, exclusively accomplished by the mediation of protoplasm, containing that peculiar kind of coloring-matter to which the greenness of vegetation is due, and which has received the name of chlorophyl. This chlorophyl-tinged protoplasm is the substratum in which carbonic acid is deprived of its oxygen, and organically incorporated. Here, and here alone, organic substance originates in Nature.[1] It is the one magic gate through which the inorganic effects its passage into the organic; the one transubstantiating medium by which the death-like spell of inertness is broken and the dormant energies of matter admitted to bloom forth into life.

By what agencies is this stupendous chemical feat, this vivifying transmutation, wrought? How is so signal a synthesis of material constituents dynamically incited? If we possessed no further knowledge concerning this initial shaping of organic compounds, it might be supposed that the chlorophyl-tinged protoplasm exerted some kind of catalytic influence on carbonic acid, causing by its mere presence decomposition of the same, and affording thereby to the free carbon an opportunity of entering into the organic nexus. But it is far otherwise—exceedingly more wonderful.

Prompted by Priestley's discovery of oxygen—the vivifying gas inhaled by animals and exhaled by plants, and its contrast to carbonic acid, the suffocating gas exhaled by animals and inhaled by plants—the entire scientific world, during the first decades of the present century, became deeply agitated by the recognition and elucidation of what was called the chemical and physiological balance of organic Nature."

It was taught—and to the present day this teaching forms the groundwork of most physiological conceptions—that plants imbibe and

[1] The experimental synthesis of organic compounds, found to be accomplished, under certain artificial conditions, by normally parasitic organisms, containing no chlorophyl, need not be taken into consideration in the above argument, however interesting in itself it may otherwise prove to be.

reduce carbonic acid furnished by animals, forming therefrom organic compounds of high calorific value; and that these food-compounds reunite in the animal with the oxygen inhaled by it, yielding by this combustion all the power exhibited in its vital manifestations.

While this—from our present point of view—fundamentally erroneous and most misleading conception exerted an all but universal sway over scientific minds, it happened that, under its influence, so early as 1844, our illustrious and veteran scientist and philosophical historian, Dr. John W. Draper, succeeded in establishing, by a series of beautiful experiments, a far deeper and vastly more essential connection in Nature.

This connection, if I am not greatly mistaken, is destined to become the redeeming thread by which Science will extricate itself from the mechanical maze of rigid resistance and equivalent mass-motion. By dint of so significant and mathematically available a clew, it may in time reach a somewhat more commensurate recognition of effects synthetically secured, of inherent cumulative elaboration, the unforfeitable boon of specific dynamical influences, which with restless toil are ever busy, widening the scope of qualitative wealth, intensifying the intestine sensitiveness and sympathetic response by which substances inwardly answer the inward call of other substances.

The marvelously slender thread of vivifying connection, traced to its origin by Draper, is an ethereal but most definite band of vital dependence, absolute dependence. It is a truly promethean beam, for without it no life, no fire on earth. You suppress from the entire amount of solar influence—calorific, luminous, and chemical—solely the yellow rays, and you have quenched life at its starting-point: no more elaboration of organic compounds by chlorophyl-protoplasm, no more food-supply, no more vitality. You have cut off the thread of life, the golden band of union by which the still embryonic vitality of our planet receives sustenance from the mighty parent-orb. This great discovery of Draper the recent researches of Sachs and Pfeffer have only essentially corroborated.

It is here, then, that the knot of organic complexity is being really tied in Nature, and this is, therefore, the exact point at which the mystery of organic synthesis has to be unraveled. A most specific dynamical influence meets here in a peculiar preëxisting substratum with certain inferior matter, and under this confluence of conditions, by a chemical process of reduction and substitution, molecular organization is effected.

In framing my hypothesis of the origin of organic compounds on our globe, I would closely adhere to the above facts. After what I have learned with regard to the yellow rays, I would not expect aboriginal organic synthesis to have taken place at the bottom of the sea, where all dynamical influences must be dispersed, or so suffused as to have lost their definite efficiency. I would then imagine some probable preëxisting substratum—some compound of silicium, for instance. Silicium is evidently a very wonderful substance, strangely like carbon in many respects. It is capable of existing in at least as many similar molecular modifications; and, above all, some of its compounds, though inorganic, occur in the colloid state.

It would not be an extravagant supposition to assume a film of some such colloid compound of silicium floating on the top of the sea, exposed to specific solar influences, imbibing carbonic acid from the air, and being traversed by currents of sea-water, holding carbonate of lime and other salts in solution. Under such favorable circumstances it is not altogether improbable that carbon may have actually by degrees been chemically substituted for silicium, and that thus the first hydrocarbons were allowed slowly to slide into existence.

When we consider what a prominent part silicious and cretaceous organisms play in the history of our globe, it would not be so very astonishing to learn that the inorganic substance has to be looked upon as the original matrix, and not merely as the skeleton of such organisms.

There may have been an age in which silicium was the leading element, followed by an age in which lime ruled organic composition, followed again by an age in which Carbon and Company is the thriving firm, to be supplanted by an age in which nitrogen will be foremost, till this also is forced into the background by phosphorus, etc.

It would not be difficult to fill a volume with plausible reasonings in support of the above nevertheless completely hypothetical conceptions. Side by side with the great and positive truths revealed by the study of incipient motility, truths most scrupulously verified during years of closest application, I would have grudged such fanciful conjectures even the little space here allotted to them, if it had not been my intention to invoke their assistance by way of contrast.

It cannot be too forcibly impressed on all who take an earnest interest in science that we have constantly to bear in mind the radical difference obtaining between verified scientific results and analogical scientistic suggestions. The former represent tasks performed, the latter tasks imposed. The former constitute our accredited store of premises, on the ground of which we may with some safety indulge our reasoning propensities; the latter is the more or less skillful performance under such reasoning license. To reason from premises not verified as forming an integral part in the necessary enchainment of natural events is, however, to move in a world of thought in no way contiguous to the realm of science.

Whoever, therefore, wishes to form an opinion regarding the truths here advanced, whether they be in strict accordance with Nature, or whether they be merely mistaken interpretations, need only to examine monera for himself.

Motility is the key to the understanding of vitality and organization. With little trouble any one can now convince himself that living motion is actually accomplished by the operations which I have here disclosed.

A certain organic substance expands under chemical composition, and afterward contracts under chemical decomposition. Its disintegration is incited by the dynamical influences of the medium; its reintegration is brought about by its own inherent chemical affinity, which affinitive power effects its combination with complemental material furnished by the medium.

In pursuing the inquiry here begun, the next step would be to show how complications of these sundry phases of the one central fact of motility lead to definite organization in various directions, and to the rise of sensation.

ELECTRICITY IN THUNDER-STORMS.[1]

By ELISHA FOOTE.

THE great development of electricity in thunder-storms has been a subject of much speculation. Its explanation, however, is still an unsettled question. Some views on this subject are presented in this paper.

We have no evidence that the production of fogs or clouds—the change from invisible to visible vapor, or from combined to uncombined moisture—produces any electricity. All experiments to establish such a supposition have had a negative result.

These particles of vapor we may suppose to be small spherules, each with its normal portion of electricity that surrounds or occupies the surface of the sphere. When two of these particles unite and form one, the combined particle will have twice the electricity of either of the separate parts, but not twice the surface. There will then be an accumulation of electricity upon the surface of the combined particle; and still more will this be so when thousands of these spherules unite to form a drop of water.

We may well conceive, therefore, that a cloud forming water should become surcharged with electricity, that will escape in violent explosions when the accumulation is too rapid or the circumstances are unfavorable to its being carried off by the surrounding moist air.

It is not, then, the formation of vapor, but its condensation to rain, that produces thunder and lightning. And this, it is believed, accords with all our experience. Clouds are constantly forming and disappearing; fogs and vapors are accumulated in some places in great abundance, but no electrical excitement has ever been observed. But, on the other hand, there is never a flash of lightning without a manifest

[1] Paper read before the Philosophical Society of Washington.

deposition of rain. To this there is no exception. There is, indeed, a manifest relation between the two. The more sudden and rapid the condensation, the more violent and terrific the explosion.

Sometimes, in thunder-storms we hear a loud crash, and then, soon after, comes an increased pouring down of water. Sound travels more rapidly than rain, and, although the report reaches us first, the interval between the events and the distance traveled plainly indicate that the explosion succeeded the condensation; and we naturally infer that it was caused by it. The loud crash and simultaneous lightning show the nearness of the explosion, at the origin of the rain-drops.

I next inquire whether we have experimental proofs corroborating these views.

A few years since an accidental escape of steam from a steam-boiler was found to strongly electrify a person who stood upon an insulator and held one hand in the escaping steam. This excited much interest at the time, and it was investigated by Armstrong and others, and led to our present steam-boiler electrical machine. The phenomena were at first supposed to throw much light upon the causes of atmospheric electricity. The subject was subsequently taken up by Faraday, who instituted a series of experiments, and came to a different conclusion. His theory, using his own words, was : [1]

> "The electricity is due to the friction of the particles of water which the steam carries forward against the surrounding solid matter of the passage, . . . and is in its nature like any other ordinary case of excitement by friction."

Again (section 2145), he says :

> "Finally, I may say that the cause of the evolution of electricity by the liberation of confined steam is not evaporation; and, further, being I believe friction, it has no effect in producing and is not connected with the general electricity of the atmosphere."

The great authority of Faraday has made this, ever since, to be the generally-accepted explanation of the phenomena. It may seem presumptuous to question it, but I cannot think that a careful examination of his experiments will justify all of his conclusions.

Faraday's apparatus consisted of a small steam-boiler, which he insulated, and for the discharge of steam he attached a pipe about four feet long, terminating in an iron globe. This had an orifice to which other appendages could be attached, and there was also a device for injecting water into the exit-pipe. His first experiments were directed to evaporation. He found that when the steam was at full pressure, and the valve was suddenly raised and taken out, and the evaporation was very rapid, no electricity was produced. He charged the boiler with electricity by an electrical machine before the valve was raised, and found that the escape of steam did not affect the charge. It was hence inferred that no electricity was produced by evaporation.

[1] "Researches in Electricity," vol. ii., section 2085.

The circumstances under which electricity was produced were the next subjects of his inquiry, and he says (section 2084):

> "The issue of steam alone was not sufficient to evolve electricity. Attaching appendages to the globe, with no water in it, after a few moments and when the apparatus became hot, the issuing steam excited no electricity; but when the steam-globe was filled up with water so far that the rest of the condensed water was swept forward with the steam, abundance of electricity appeared. If then the globe was emptied of its water, the electricity ceased; but, on filling it up again to the proper height, it immediately reappeared in full force. So when the feeder-apparatus was used, while there was no water in the passage, there was no electricity; but, on letting in water from the feeder, electricity was immediately evolved."

It thus appears that, without water to condense the steam, there was no electricity, but with condensation an abundance appeared. Other experiments were to the same effect.

Faraday further says (section 2089):

> "If there be no water in the steam-globe upon opening the steam-cock, the *first effect* is very striking: a good excitement of electricity takes place, but it very soon ceases. This is due to the water condensed in the cold passages producing excitement by rubbing against them. Thus, if the passage be a stopcock, while cold it excites electricity with what is supposed to be steam only; but as soon as it is hot the electricity ceases to be evolved; if then, while the steam is issuing, the cock be cooled by an insulated jet of water, it resumes its power. If, on the other hand, it be made hot by a spirit-lamp before the steam be let on, then there is *no* first effect. On this principle I have made an exciting passage by surrounding one part of the exit-tube with a little cistern, and putting spirits of wine or water into it."

Experiments with air were also made. It was compressed within a receiver and allowed to escape, impinging against ice or cones of wood or brass (section 2129). With common undried air electricity was produced. He says:

> "This I attributed to the particles of water suddenly condensed from the expanding and cooled air rubbing against the metal or wood. Such particles were very visible in the mist that appeared, and also by their effect of moistening the surface of the wood and metal. . . . I proceeded to experiment with dry air (artificially dried by absorbents), and found that it was in all cases quite incapable of exciting electricity against wood or sulphur or brass in the form of cones; yet if in the midst of these experiments I let out a portion of air immediately after its compression, allowing it no time to dry, then it rendered the rubbed wood or brass negative. This is to me a satisfactory proof that in the former case the effect was due to the condensed water, and that neither air alone nor steam alone can excite these bodies, wood, brass, etc., so as to produce the effect now under investigation."

Under all circumstances, then, condensation produced electricity. Without it there was none. The theory of friction is wholly unnecessary to the explanation of the phenomena. It has to assume that water, a conductor, rubbing against iron, another conductor, will accumulate electricity. But this is opposed to our experience. It requires friction with a non-conductor to excite electricity. We have instances daily of the passage of water through pipes, sometimes with great force and velocity. Did friction between the two excite electricity, it should be produced in great quantities. But no such effect has been observed.

Mr. Patterson, who experimented with the same boiler that Armstrong used, tried the effect of blowing out water instead of steam through a pipe from the boiler, and no electricity was thereby produced (*Philosophical Magazine*, vol. xvii., p. 459, 1840).

Were it indeed true, as Faraday assumed, that the friction of water against the sides of the exit-pipe produced electricity, it would be conducted away as fast as formed by the metallic tube to the negative boiler. Indeed, when he placed in the tube any saline or acid substance that increased the conducting power of water, no electrical effects were obtained. In some cases negative electricity, like that of the boiler, was manifested.

I do not find, from an examination of Faraday's paper, that he made any experiment upon steam at a distance from its exit, where its condensation to water mostly took place. His mode of experimenting he describes as follows. He says (section 2082):

"When the issuing steam produces electricity, there are two ways of examining the effect. Either the insulated boiler may be observed or the steam examined; but these states are always contrary one to the other. . . . To examine the state of the boiler or substance against which the steam is excited, is far more convenient, as Mr. Armstrong has observed, than to go for the electricity to the steam itself. And in this paper I shall give the state of the former, unless it be otherwise expressed."

I infer, therefore, that, in all the experiments hereinbefore detailed, the tests for electricity were made at or near the boiler, and the very important inquiry of the electrical effects at a distance, where condensation alone was concerned, seems not to have attracted his attention. This point, however, has been fully investigated by others.

Mr. Patterson attached ten or twelve pointed wires to a copper rod. These were bent downward and held in the escaping steam. He says (ibid., page 458):

"The sparks were larger when the points of the conductor were held in the steam about two feet above the valve; but large sparks were obtained by holding the conductor entirely out of the cloud of steam and at a distance from it, for the air in the wooden shed in which we operated became speedily electrical throughout. The electricity was positive."

Mr. Armstrong also states (ibid., page 453):

"Upon trying the steam in the first instance by the method adopted in the previous cases, that is to say, by standing upon an insulated stool and holding with one hand a light iron rod immediately above the safety-valve while the steam was freely escaping, and then advancing the other hand toward any conducting body, sparks of about an inch in length were obtained. But it was soon observed that, by elevating the rod in the steam, the electricity was gradually increased, and that the maximum effect was not obtained until the end of the rod was raised five or six feet above the valve, at which point the length of the sparks occasionally reached two inches. Small sparks were even obtained when the rod was wholly removed from the steam and held in the atmosphere at the distance of two or three feet from the jet; and the electricity thus drawn from the air was positive like that of the steam. When the rod was extended into the cloud of vapor which accumulated in the upper part of the shed, electricity was drawn down as by a lightning-conductor from a thunder-cloud."

These results seem to me to point out very clearly the cause of the electrical excitement. If it were the friction of steam against the sides of the exit-pipe, then at that point should be the greatest manifestation. If, on the contrary, it be condensation, then at a distance from the exit, where the greatest condensation takes place, should be the greatest development—and such is the fact. At the valve, Faraday found no electricity. At five or six feet from it, according to Armstrong and to Patterson, its development was abundant. The conclusion seems to me inevitable. All the facts point to condensation as the cause of the excitement.

A phenomenon that occurs daily at Pike's Peak has been described to me. The tops of the mountain are covered with perpetual snow. During the summer months the snow-line gradually recedes up the sides of the mountain, and from it flow considerable streams of water, that are finally lost in the plains below. The winds coming from the prairies take up this moisture, and, ascending the mountain, reach the frozen regions above. At about eleven o'clock each day, black clouds begin to gather about the tops of the mountain, and soon thereafter pour down floods of rain. Flashes of lightning are almost incessant, with peals of thunder that seem to shake the mountains. I am informed that we have nothing in Eastern States that can compare with the terrific violence of these storms.

Here, certainly, is no friction, but condensation on a large scale; and it is attended with the same electrical effects that were observed in the condensation of steam from the steam-boiler.

Volcanoes sometimes emit great volumes of steam and smoke, and these are usually attended with flashes of lightning in every direction. Were the electricity due to friction, it would be found at the mouth of the crater, where the steam issues; but, instead of that, it is found on the sides of the column, where the steam meets with colder air, and is condensed to water. The effects are analogous in every respect to those of steam from the steam-boiler.

In thunder-storms we have no friction, but condensation, and we need not go beyond the usual effects of condensation to explain all the electrical phenomena.

CONSCIOUSNESS UNDER CHLOROFORM.

By HERBERT SPENCER.

A UNIVERSITY graduate, whose studies in psychology and philosophy have made him an observer able to see the meanings of his experiences, has furnished me with the following account of the feelings and ideas that arose in him during loss of consciousness and during return to consciousness. My correspondent, describing himself as extremely susceptible to female beauty, explains that "the girl" named in the course of the description was an unknown young lady in the railway-carriage which brought him up to town to the dentist's. He says his system resisted the influence of chloroform to such a degree that it took twenty minutes to produce insensibility: the result being that for a much longer time than usual he underwent partial hyperæsthesia instead of anæsthesia. After specifying some dreadful sensations which soon arose he goes on to say: ". . . . I began to be terrified to such a wonderful extent as I would never before have guessed possible. I made an involuntary effort to get out of the chair, and then—suddenly became aware that I was looking at nothing: while taken up by the confusion in my lungs, the outward things in the room had gone, and I was 'alone in the dark.' I felt a force on my arm (which did not strike me as the surgeon's 'hand,' but merely as an external restraint) keeping me down, and this was the last straw which made me give in, the last definite thing (smell, sound, sight, or touch) I remembered outside my own body. Instantly I was seized and overwhelmed by the panic inside. I could feel every air-cell struggling spasmodically against an awful pressure. In their struggle they seemed to tear away from one another in all directions, and there was universal racking torture, while meantime the common foe, in the shape of this iron pressure, kept settling down with more and more irresistible might into every nook and crevice of the scene. My consciousness was now about this: I was not aware of anything but an isolated scene of torture, pervaded by a hitherto unknown sense of terror (and by what I have since learned is called 'the unity of consciousness:' this never deserted the scene, even down to the very last inaudible heart-beat). Yet I call it a 'scene,' because I recognized some different parts of my body, and felt that the pain in one part was not the same as that in another. Meanwhile, along with the increased intensity of convulsion in my lungs, an element of noise had sprung up. A chaotic roaring ran through my brain, innumerable drums began to beat far inside my ear, till the confusion presently came to a monstrous thudding, every thud of which wounded me like a club falling repeatedly on the same spot. . . .

"From this stage my lungs ceased to occupy me, and I forget how the struggle finished. There was a sense of comparative relief that, at any rate, *one* force was victorious, and the distraction over; the strange, large fright that had seized me so entirely when I felt myself ensnared into dark suffocation was now gone also, and there was only left the huge thudding at my ears, and the terribly impetuous stroke of my heart. The thudding gradually got less acutely painful, and less loud; I remember a recognition of satisfaction that one more fearful disturbance was gone. But, while the thunder in my ear was thus growing duller, all of a sudden my heart sprang out with a more vivid flash of sensation than any of those previous ones. The force of an express-engine was straining there, and like a burning ball it leaped from side to side, faster and faster, hitting me with such a superhuman earnestness that I felt each time as if the iron had entered my soul, and it was all over with me forever. (Not that 'I' was now any more than this burning-hot heart and the walled space in which it was making its strokes: the rest of 'me' had gone unobserved out of focus.) Every stroke produced exquisite pain on the flesh against which it beat glowing, and there was a radiation, as from a molten lump of metal between inclosures. Presently the unbearable heat got less, and there was nothing remaining except a pendulous movement, slackening speed, and not painful. Of nothing beyond was I conscious but this warm body vibrating: not a single other part of me was left, and there was not a single other movement of any sort to attract my attention. A fading sense of infinite leisure at last, in a dreamy, inaudible air; then all was hushed out of notice.

". . . . There was the breaking of a silence that might have been going on forever in the utterly dark air. An undisturbed, empty quiet was everywhere, except that a stupid presence lay like a heavy intrusion *somewhere*—a blotch on the calm. This blotch became more inharmonious, more distinctly leaden; it was a heavier pressure—it is actually intruding farther—and, before almost there was time to wonder feebly how disagreeable was this interruption of untroubled quiet, it had loomed out as something unspeakably cruel and woful. For a bit there was nothing more than this profoundly cruel presence, and my recognition [1] of it. It seemed unutterably monstrous in its nature, and I felt it like some superhuman injustice; but so entire had been the still rest all round before its shadow troubled me, that I had no notion of making the faintest remonstrance. . . . It got worse. . . . Just as the cruelty and injustice became so unbearable that I hardly could take it in, suddenly it came out a massive, pulsating *pain*, and I was all over one tender wound, with this dense pain probing me to my deepest depths. I felt *one* sympathetic body of atoms, and at each probe of the pain every single atom was forced by a tremendous pressure into all the rest, while every one of them was acutely tender, and

[1] If there were a noun belonging to the verb "To be aware of," like "recognition" to "recognize," it would be the one to use here.

shrank from the wound—only there was nowhere to shrink. A little before, I had merely *felt* the cruel element in helpless passivity; now, a still more crushing probe came; for an instant it forced all my atoms into one solid steel-mass of intense agony—then, when things couldn't go much farther, and all must be over, a sense of reaction emerged; there was a loosening, and I was urged into relief by uttering from my very depths what seemed not so much (at first) a piteous remonstrance as a piteous 'expression' (like an imitation) of the pain: in fact, the sense of woe had got also *outside*, and I *heard* it, a very low, infinitely genuine, moan. . . . The next second there was a change: hitherto it had been pain *partout*—now there came a quick concentration, the pain all ran together (like quicksilver), and I suddenly was aware that it was (localized) *up on the right;* while, simultaneously with this recognition of locality, a feeling of incipient *resistance* began to be in *other parts* (not that I felt them except just as *other* parts) of me from which the pain had receded. The pain itself was no less intense, rather more vivid, only I seemed to take it in a more *lively* manner: my uttering of a moan was no longer a mere faithful representation out into the air of what was inside me, but I had a slight sense of making an appeal for sympathy: to whom or to what I did not know, for there was no one or anything there. I was just going to utter a yet louder moan—as a fresh, fearful imposition of force plunged into me—when, there in front of me, to the *left* of my pain, was that girl, with those lovely ankles, and the graceful, Zingari brown stockings. . . . I felt, as distinctly as if some one had told me aloud, that I would not make any cry, that it was not the thing.

"Now came an agonizing, cold wrench, and two or three more successively, in such a hideously rough fashion, that the girl went, and everything was tortured out of me but the darkness and the gigantic racking, swaying torture which was excruciating my right side. An iron force, like a million-horse power, had hold of me, and I was being pulled upward and out of where I was, while I myself seemed another million-horse power which would *not* be pulled: the pain was something to be remembered. But up I came, the darkness got denser (I went so fast); it was vibrating, the dense agony vibrated faster; *I* was quivering, struggling, kicking out; everything was a convulsion of torture, my head seemed to come to the surface, a glimpse of light and air broke on the darkness, voices came through to me, and words; I recognized that a '*tooth*' was being slowly twisted out of my jaw, then I groaned imploringly, in true earthly style, as if this was *too much*, and I ought to be let alone now I was getting my head out; then I swallowed in air, made an exertion with my 'chest,' found my 'arms' were pressing something hard, grasped the 'chair,' and pushed myself up out in bewildered light, just as the dentist threw away the second right molar from the upper jaw."

Concerning this account it may be remarked, on the one hand, that the higher consciousness seems not to have been wholly abolished; since there remained certain emotions and certain most general ideas of relation to objective agents. On the other hand, it is to be doubted whether the partial consciousness which the narrator had during anæsthesia is not, in the description, eked out in some measure by the ideas of his recovered consciousness carried back to them. Be this as it may, however, it is clear that certain components of consciousness disappeared and others became extremely vague, while a remainder continued tolerably distinct. And there is much significance in the relations among them: 1. There ceased earliest the sensations derived from the special senses; then the impression of force acting on the body from without; and, simultaneously, there ceased the consciousness of external space-relations. 2. There remained a vague sense of relative position within the body; which, gradually fading, left at last only a sense of those space-relations implied by consciousness of the heart's pulsations. 3. And this cluster of related sensations produced by the heart's action finally constituted the only remaining distinct portion of the *ego*. 4. In the returning consciousness we note first a sense of pressure *somewhere;* there was no consciousness of space-relations within the body. 5. The consciousness of this was not a cognition proper. In an accompanying letter my correspondent says of it: "'Recognition' seems to imply installation in some previously-formed concept (talking in the Kantian way), and this is just what was *not* the case:" that is, consciousness was reduced to a state in which there was not that classing of states which constitutes thought. 6. The pain into which the pressure was transformed was similarly universal instead of local. 7. When the pain became localized, its position in space was vague: it was "up on the right." 8. Concerning the apparition of "the girl," which, as my correspondent remarks, seems to have occurred somewhat out of the probable order, he says, in a letter: "I did not recognize her 'under any concept'—what I saw seemed to be almost unassisted intuition in the Kantian sense." 9. The localization of the pain was at first the least possible—the consciousness was of that part *versus* all other parts unlocalized.

These experiences furnish remarkable verifications of certain doctrines set forth in the "Principles of Psychology." This degradation of consciousness by chloroform, abolishing first the higher faculties and descending gradually to the lowest, may be considered as reversing that ascending genesis of consciousness which has taken place in the course of evolution; and the stages of descent may be taken as showing, in opposite order, the stages of ascent. It is significant, therefore, that impressions from the special senses ceasing early, leave behind, as the last impression derived from without, the sense of outer force conceived as opposed by inner resistance; for this we have seen to be the primordial element of consciousness. Again, the fact that the consciousness of external space disappeared simultaneously with the consciousness of external force, answers to the conclusion drawn that space-ideas are built out of experiences of resistant positions, the relations among which are measured by sensations of muscular effort. Further, there is meaning in the fact that a vague sense of relative position within the body survived; since we concluded that by mutual exploration there is gained that knowledge of the relations among the parts of the body which gives measures through which the developed knowledge of surrounding space is reached. Once more we get evidence that the *ego* admits of being progressively shorn of its higher components, until finally the sensations produced by the beating of the heart remain alone to constitute the conscious self: showing, in the first place, that the conscious self, at any moment, is really compounded of all the states of consciousness, presentative and representative, then existing, and showing, in the second place, that it admits of being simplified so far as to lose most of the elements composing the consciousness of corporeal existence. Whence it is inferable that self-consciousness begins as a mere rudiment consisting of present sensations, without past or future. Lastly, we have the striking testimony that there exists a form of consciousness lower than that which the lowest kind of thought shows us. The simplest intellectual act implies the knowing something as such or such—implies the consciousness of it as like something previously experienced, or, otherwise, as belonging to a certain class of experiences. But we here get evidence of a stage so low that a received impression remains in consciousness unclassed: there is a passive reception of it, and an absence of the activity required to know it as such or such.

HALLUCINATIONS OF THE SENSES.

By Dr. HENRY MAUDSLEY

BY hallucination is meant, in scientific phraseology, such a false perception of one or other of the senses as a person has when he sees, hears, or otherwise perceives as real what has no outward existence—that is to say, has no existence outside his own mind, is entirely subjective. The subject is one which has special medical interest; but it will be seen to have also a large general interest, when it is remembered how momentous a part hallucinations have played sometimes at critical periods of human history. Take, for example, the mighty work which was done in the deliverance of France from English dominion by a peasant-girl of eighteen—Joan of Arc, the famous Maid of Orleans, who was inspired to her mission by the vision which she saw, and the commands which she heard, of St. Michael and other holy persons. Now, as there are few persons nowadays who believe that St. Michael really appeared to this enraptured maiden, and as few, if any, will doubt that she herself sincerely believed that he did, one must needs suppose that her visions were hallucinations generated by the enthusiasm of a mind which was in a singularly exalted strain of religious and patriotic feeling.

The special medical interest of the subject lies in this—that there are a great many persons in the world who, suffering under some form or other of nervous disorder, habitually see figures or faces, hear threatening or insulting voices, even feel blows and taste poisons, which have no existence outside their own minds; and neither argument nor demonstration of the impossibility of what they allege they perceive will shake their convictions in the least. "You assure me," they will say, "that I am mistaken; that there are no such persons as I see, no such voices as I hear; but I protest to you that I see and hear them as distinctly as I see and hear you at this moment, and that they are just as real to me." What are we to reply? I have replied sometimes, that "as you are alone on one side in your opinion, and all the world is on the other side, I must needs think, either that you are an extraordinary genius, far in advance of the rest of the world, or that you are a madman a long way behind it; and, as I don't think you to be a genius, I am bound to conclude that your senses are disordered." But the argument does not produce the least effect.

Let me give an example or two of the character of these hallucinations, and of their persistence in minds that might be thought sane enough to correct them. The first shall be that of an old gentleman who was much distressed because of an extremely offensive smell which he imagined to proceed from all parts of his body: there was not the least ground, in fact, for this imagination. He was scrupulously clean in person, extremely courteous in manner, thoroughly rational in his conversation on every other subject, a shrewd and clever man of business; no one talking with him would for a moment have suspected him of entertaining such extraordinary fancies. Nevertheless, his life was made miserable by them; he would not go into society, but took solitary rambles in the country, where he might meet as few persons as possible; in his own house he slept for the first part of the night on the ground-floor, mounting up higher at a later period of the night; and this he did to prevent the bad odors from becoming too concentrated in one room. He believed that the people in the next house were irritated and offended by the emanations, for he often heard them moving about and coughing; and, when he passed a cab-stand in the street, he noticed that even the horses became restless and fidgeted. He used to hang his clothes out of the window at night that they might get pure, until his housekeeper put a stop to the practice by telling him that the exhibition of them would excite the notice and comment of his neighbors. All the while he was conducting his business with propriety and success; his own partners had no suspicion of his condition. Knowing this, I asked him how it was that no one of the many persons whom he met daily in business had ever complained of any bad smell, and the answer he made was that they were all too polite to do so, but he could see that they were affected nevertheless, as they sometimes put their handkerchiefs to their noses—no doubt for a quite innocent purpose.

Another gentleman was the victim of a very common hallucination: he was much afflicted by voices, which were continually speaking to him at all times and all places—in the quietude of his room and in the crowded streets, by night and by day. He had come to the conclusion that they must be the voices of evil spirits in the air which tormented him. They knew his thoughts, and replied to them before he had himself conceived them; the remarks which they made were always annoying, often threatening and abusive, and sometimes most offensive and distressing, and they disturbed him so much at night that he got very little sleep. He had been driven to the expedient of buying a musical-box, which he placed under his pillow when he went to bed. The noise of the music drowned the noise of the tormenting voices, and enabled him to get to sleep; but, as he said, the measure was not entirely satisfactory, because when the box had played out its tunes, it stopped, and he was obliged to wind it up again. It was impossible to persuade this gentleman, sensible as he seemed in other respects, that the voices had no real existence, and that they were due to the disordered state of his nervous system. After listening attentively to my arguments, he went away sorrowful, feeling that I had no help for him. I may remark, by-the-way, that auditory hallucinations of this kind are apt to occur in prisoners who are subjected to long periods of solitary confinement in their cells: they have no mental resources to fall back upon, and their brooding thoughts, not being distracted by the conversation of others, nor having their usual outlet in their own conversation, become audible by them as actual voices.

I might relate many more examples, but these will suffice. Each sense may of course be affected, and sight stands next to hearing in its liability to suffer. In *delirium tremens*, hallucinations of sight are characteristic features; the patient commonly sees reptiles and vermin in his room, serpents crawling over the floor, rats and mice running over his bed, and pushes them away in a state of restless agitation. In some forms of insanity, the sufferer mistakes persons, believing entire strangers to be near friends or relations; or, again, he may see a person, whom he imagines to be his persecutor, escape from the house, when there was really no such person, and buy a revolver, to be ready for him when next he comes prowling about; and in one form of the deepest melancholy, which is known as *melancholia attonita*, he has sometimes terrible hallucinations—sees, probably, a deep abyss of roaring flames or a vast sea of blood immediately in front of him, and will not make the least movement, lest he should be precipitated headlong into it. There can be no doubt of the mental disorder of persons who suffer in this way, but it must not be supposed that hallucinations of sight do not occur to persons who are free from mental disorder. I cannot help thinking that they furnish the explanation of the firm belief in ghosts and apparitions which has prevailed among all nations and in all times. A belief so universal must have some deep foundation in the facts of Nature or in the constitution of man. One may freely admit that persons have seen apparitions and have heard voices which they thought to be supernatural; but, inasmuch as seeing is one thing, and the interpretation thereof quite another thing, it may be right to conclude that they were nothing more than hallucinations, and that the reason why no ghosts are seen now, when people pass through churchyards on dark nights, as our forefathers saw them, is that ghosts are not believed in nowadays, while we have gained a knowledge of the nature of hallucinations, and of the frequency of their occurrence, which our forefathers had not.

One does not fail to notice, when proper attention is given to the subject, a fact which is full of meaning, viz., that the apparitions which have been seen at different ages were in harmony with the dominant ideas or beliefs of the age. It is not probable that any one could be found at the present day to affirm that he had seen an old woman riding through the air on a broomstick to a witches' meeting, because the belief in witchcraft is happily wellnigh extinct; but two or three hundred years ago, when it would have been thought something like blasphemy to doubt the being and doings of witches, persons of character and veracity might have been found to avouch it solemnly. In like manner, apparitions of Satan were not very uncommon in the middle ages to persons who, like Luther, were in earnest spiritual conflict with him; but there is no instance on record, so far as I know, of such an apparition having ever been seen by an ancient Greek or Roman. The Satan of the middle ages who gave Luther so much trouble had not then been invented. Spirits, ghosts, then, and all apparitions of the same kind, I was prepared to have pronounced unhesitatingly to have been hallucinations, which would be found on examination to reflect pretty fairly the prevailing ideas of the time concerning the supernatural; but it occurred to me that it might be prudent, before doing that, to consult the article on apparitions in the latest edition of the "Encyclopædia Britannica," lest perchance I should be outrunning current authority; and I have there discovered, to my no small surprise, that it is still an open question whether invisible inhabitants of the unknown world did not take human or other shapes and become visible to men. The writer of the article plainly inclines to the opinion that they do, and that there is more in the matter than science has yet dreamed of. So also think the spiritualists.

I now go on to consider the mode of production of hallucinations. At the first blush there might seem to be a great gap between such false perceptions of the senses as I have given examples of and the faithfully-serving senses of a person who is in good health of mind and body. But here, as elsewhere, in Nature we find, when we look closely into the matter, that there is no break; we may be pretty sure, perhaps, that, when we say of any phenomenon, however strange, that it is singular and quite unlike anything else in the world, we are mistaken, and that we shall not fail to discover other things like it if we search intelligently. Certainly we can trace gradational states between the most extreme hallucinations and such temporary disorders of the senses as healthy persons often have. Let any one stoop down with his head hanging low for a minute, and when he raises it he will have, besides a feeling of giddiness, a sound of singing or of ringing in his ears, and may see a flash or two of light before his eyes; and there are some persons who, under such circumstances, see actual figures for the moment. These sensations are hallucinations; there is no light, nor sound, nor figure, outside to cause them; they are owing to the stimulation of their respective nerve-centres by a congestion of blood in the brain, which has been produced by the hanging down of the head. Here, then, we have hallucinations that are consistent with the best health; they are due to temporary causes of disturbance of the circulation, and disappear as they disappear. Going a step further, we may watch at the beginning of a fever how gradually the hallucinations take hold of the mind, until their true nature is not recognized. At first the fever-patient is quite aware of his actual surroundings, knowing the persons and objects about him, and when strange faces seem to appear among the familiar faces, as they do, he knows that they are not real, and will talk of them as visions; perhaps they occur at first only when his eyes are shut, or when the room is dark, and vanish directly he opens his eyes or the room is lit up. After a while they come more often, and whether his eyes are shut or not; he becomes uncertain whether they are real or not, assenting when he is told that they are phantoms, but falling back immediately into doubt and uncertainty. At last they get entire mastery of him, he cannot distinguish in the least between them and real figures, discourses with them as if they were real—is wildly delirious.

If the nature of the process by which we perceive and know an external object be considered, it will be seen that it is much easier to have a false perception than might appear at first sight. When we look at any familiar object—say a cat or a dog—we seem to see at once its shape, its size, its smoothness of coat, and the other qualities by which we know it to be a cat or a dog, but we don't actually see anything of the kind. The proof is that, if a person blind from his birth, who knew the cat and dog perfectly well by touch, were to obtain sight by means of a surgical operation when he was thirty years old, he would not know by sight alone either cat or dog, or be able to tell which was which. But, if he were permitted to touch the animals, he would recognize them instantly, and ever afterward the impression which they produce on sight would be associated with the impression which they produce on touch, and he would know them when he saw them. That is the way in which the perception of a particular object is formed—by the association of all the sensations which it is adapted to excite in our different senses, their combination in what we call an idea. For example, in the idea of an orange are combined the sensations which we get by tasting it, by touching it, by smelling it, by looking at it, by handling it, each sensation having been acquired by its particular sense in the course of an education which has been going on ever since we were born; when we have got them in that way, they combine to form the *idea* of the orange; and it is by virtue of this idea, which has been formed and registered in the mind, that we are able to think of an orange, that is, to form a mental image of it, when it is not present to any sense, and to recognize it instantly when it is. It is plain, then, how large a part, by virtue of its past experience, the mind contributes to each perception; when we look at an orange it tacitly supplies to the impression which it makes on sight all the information about it which we have got at different times by our other senses, and which sight does not in the least give us; the visual impression is no more in truth than a sign to which experience has taught us to give its proper meaning, just as the written or spoken word in any language is a sign which is meaningless until we have been taught what to mean by it. So true it is that the eye only sees what it brings the faculty of seeing, and that many persons have eyes, yet see not.

This being so, it is clear that the idea in the mind will very much affect the perception, and that if any one goes to look at something, or to taste something, or to feel something, with a strongly-preconceived idea of what it is, he will be likely, if it is not what he thinks it, to have a mistaken perception—to see, or feel, or touch, what he thinks it is, not what it really is. This is, indeed, one of the most common causes of erroneous observation, and one which the scientific observer knows well he must always vigilantly guard against. If a man has a foregone conclusion of what he will see, it is not safe to trust his observation implicitly, either in science or in common life. We witness the most striking examples of this dominion of the idea over sense in persons who have been put into the so-called mesmeric state. The operator gives them simple water to taste, telling them at the same time that it is some nauseating and bitter mixture, and they spit it out with grimaces of disgust when they attempt to drink it; when he tells them what he offers them is sweet and pleasant, though it is as bitter as wormwood, they smack their lips as if they had tasted something remarkably good; if assured that a swarm of bees is buzzing about them, they are in the greatest trepidation, and go through violent antics to beat them off. Their senses are dominated by the idea suggested, and they are very much in the position of an insane person who believes that he tastes poison in his food when he imagines that some one wishes to poison him, or sees an enemy lurking about his premises when he believes himself to be the victim of persecution.

Here, then, we are brought to one efficient cause of hallucinations—namely, a vividly-conceived idea which is so intense that it appears to be an actual perception, a mental image so vivid that it becomes a visual image. Everybody knows that the idea or imagination of a sensation will sometimes cause a person to feel the sensation; the mention or the sight of certain little insects which inhabit the bodies of uncleanly persons seldom fails to make the skin itch uncomfortably. John Hunter said of himself, "I am confident that I can fix my attention to any part until I have a sensation in that part." Sir Isaac Newton could call up a spectrum of the sun when he was in the dark, by intense direction of his mind to the idea of it, "as when a man looks earnestly to see a thing which is difficult to be seen." Dickens used to allege that he sometimes heard the characters of his novels actually speak to him; and a great French novelist declared that, when he wrote the description of the poisoning of one of his characters, he had the taste of arsenic so distinctly in his mouth that he was himself poisoned, had a severe attack of indigestion, and vomited all his dinner—a most pregnant proof of the power of imagination over sense, because arsenic has scarcely an appreciable taste beyond being sweetish! Artists sometimes have, in an intense form, the faculty of such vivid mental representation as to become mental presentation. It was very notable in that extraordinary genius, William Blake, poet and painter, who used constantly to see his conceptions as actual images or visions. "You have only," he said, "to work up imagination to the state of vision, and the thing is done." The power is, without doubt, consistent with perfect sanity of mind, although it may be doubtful whether a person who thought it right for himself and his wife to imitate the naked innocence of paradise in the back-garden of a Lambeth house, as Blake did, was quite sane; but too frequent exercise of the power is full of peril to the mind's stability. A person may call up images in this way, and they will come, but he may not be able to dismiss them, and they may haunt him when he would gladly be rid of them. He is like the sorcerer who has called spirits from the vasty deep, and has forgotten the spell by which to lay them again. Dr. Wigan tells of a skillful painter whom he knew, who assured him that he had once painted three hundred portraits in one year. The secret of his rapidity and success was, that he required but one sitting and painted with wonderful facility. "When a sitter came," he said, "I looked at him attentively for half an hour, sketching from time to time on the canvas. I wanted no more; I put away my canvas and took another sitter. When I wished to resume my first portrait, I took the man and set him in the chair, where I saw him as distinctly as if he had been before me in his own proper person—I may almost say more vividly. I looked from time to time at the imaginary figure, then worked with my pencil, then referred to the countenance, and so on, just as I should have done had the sitter been there. When I looked at the chair I saw the man. . . . Gradually I began to lose the distinction between the imaginary figure and the real person, and sometimes disputed with sitters that they had been with me the day before. At last I was sure of it, and then—and then—all is confusion. I suppose they took the alarm. I recollect nothing more. I lost my senses—was thirty years in an asylum. The whole period, except the last six months of my confinement, is a dead blank in my memory."

Or, if the person does not go out of his mind, he may be so distressed by the persistence of the apparition which he has created as to fall into melancholy and despair, and even to commit suicide.

"I knew," says the same author, "a very intelligent and amiable man, who had the power of thus placing before his own eyes *himself*, and often laughed heartily at his double, who always seemed to laugh in turn. This was long a subject of amusement and joke; but the ultimate result was lamentable. He became gradually convinced that he was haunted by himself. This other self would argue with him pertinaciously, and, to his great mortification, sometimes refute him, which, as he was very proud of his logical powers, humiliated him exceedingly. He was eccentric, but was never placed in confinement, or subjected to the slightest restraint. At length, worn out by the annoyance, he deliberately resolved not to enter on another year of existence—paid all his debts, wrapped up in separate papers the amount of the weekly demands, waited, pistol in hand, the night of the 31st of December, and as the clock struck twelve fired it into his mouth."

Were illustrations needed of the production of hallucination by the intensity of the conception, I might take them from Shakespeare, who has given many instances of these "coinages of the brain" which, he says truly, ecstasy is very cunning in. Hamlet, perturbed by the apparition of his father's ghost, whose commands he was neglecting, bends his eyes on vacancy and holds discourse with the incorporeal air. A dagger, sensible to sight but not to feeling, points Macbeth the way to the bed where lay Duncan whom he was about treacherously to stab; he attempts to clutch it, exclaiming justly when he grasps nothing:

> ". . . . There's no such thing:
> It is the bloody business which informs
> Thus to mine eyes."

In the well-known passage in which he compares the imaginations of the lunatic, the lover, and the poet, Shakespeare sets forth the very manner of the production of hallucinations, and illustrates the gradations of the process:

"The lunatic, the lover, and the poet,
Are of imagination all compact:
One sees more devils than vast hell can hold;
That is the madman: the lover, all as frantic,
Sees Helen's beauty in a brow of Egypt:
The poet's eye, in a fine frenzy rolling,
Doth glance from heaven to earth, from earth to heaven;
And, as imagination bodies forth
The forms of things unknown, the poet's pen
Turns them to shapes, and gives to airy nothings
A local habitation and a name."

Or I might adduce the case of the great Protestant Reformer, Luther, who is said—I know not how truly—to have thrown his inkstand at the devil on one occasion; at any rate the mark of the ink is still shown on the wall of the chamber which Luther occupied. True or not, there is nothing improbable in the story; for Luther, though endowed with great sagacity and extraordinary intellectual energy, entertained the common notions of the personality and the doings of the devil which were current among the people of his age. He pictured him very much as a Saxon peasant pictured him. It was the devil, he believed, who caused a great storm, and he declared that idiots, the blind, the lame, and the dumb, were persons in whom devils had established themselves, and that physicians who tried to cure their infirmities as though they proceeded from natural causes were ignorant blockheads who knew nothing of the power of the demon. He speaks of the devil coming into his cell and making a great noise behind the stove, and of his hearing him walking in the cloister above his cell in the night; "but as I knew it was the devil," he says, "I paid no attention to him, and went to sleep."

This, then, is one way in which hallucination is produced—by the downward action of idea upon sense. My illustrations of this mode of production have been taken from sane minds, but the hallucinations of the insane are oftentimes generated in the same way. A person of shy, suspicious, and reserved nature, who imagines that people are thinking or speaking ill of him or going out of their way to do him harm, nurses his habit of moody suspicion until it grows to be a delusion that he is the victim of a conspiracy; he then sees evidence of it in the innocent gestures and words of friends with whom he holds intercourse, of servants who wait upon him, and of persons who pass him in the streets; these he misinterprets entirely, seeing in them secret signs, mysterious threats, criminal accusations. It may be pointed out to him that the words and gestures were perfectly natural and innocent, and that no one but himself can perceive the least offense in them; his belief is not touched by the demonstration, for his senses are enslaved by the dominant idea, and work only in its service. Sometimes an insane patient, who tastes poison in his food and refuses it when it is given to him by one attendant whom he suspects of poisoning him, will take the same food from another attendant, of whom he has no suspicion, without tasting any poison—a proof how much the morbid idea perverts his taste. There is a form of insanity, known as general paralysis, which is marked by an extraordinary feeling of elation and by the most extravagant delusions of wealth or grandeur, and the patient who labors under it often picks up pebbles, pieces of broken glass, and the like, which he hoards as priceless jewels: there is another form of insanity known as melancholia, which is marked by an opposite feeling of profound mental depression and corresponding gloomy delusions, and the patient who labors under its worst form sometimes sees devils in those who minister to him, hears jeers in their consoling words, and imagines torments in their anxious attentions. In each case the hallucinations reflect the dominant morbid feelings and ideas.

A second way in which hallucinations appear to originate is directly in the organ of sense or in its sensory ganglion, which for present purposes I may consider as one. Stimulation of the organ or of its ganglion will undoubtedly give rise to hallucination: a blow on the eye makes a person see sparks of fire or flashes of light, a blow on the ear makes his ears ring; in fact, any organ of sense, when irritated either by a direct stimulus to its nerve-centre, or by a perverted state of the blood which circulates through it, will have the same sensation aroused in it, no matter what the stimulus, as is produced by its natural stimulus. We can irritate the sensory ganglion directly by introducing certain poisonous substances into the blood, and so occasion hallucinations: for example, when a person is poisoned with belladonna (deadly nightshade) he smiles and stares and grasps at imaginary objects which he sees before him, and is delirious. Other drugs will produce similar effects. A French physiologist has made a great many experiments in poisoning dogs with alcohol by injecting it into their veins, and he has found that he can arouse in them very vivid hallucinations: the dog will start up, perhaps, with savage glare, stare at the blank wall, bark furiously, and seem to rush into a furious fight with an imaginary dog; after a time it ceases to fight, looks in the direction of its imaginary adversary, growling once or twice, and settles down quietly.

The hallucinations which occur in fevers and in some other bodily diseases evidently proceed directly from disorder of the sensory centres, and not from the action of morbid idea upon sense; for we have seen that before they are fixed the intellect struggles against them successfully and holds them in check. A well-known and instructive instance of hallucinations, due to bodily causes, and which did not affect the judgment, is that of Nicolai, a bookseller of Berlin, who, being a person of great intelligence, observed his state carefully and has given an interesting account of it. He had been exposed to a succession of severe trials which had greatly affected him, when, after an incident which particularly agitated and distressed him, he suddenly saw at the distance of ten paces a figure—the standing figure of a deceased person. He asked his wife if she could not see it, but she, as she saw nothing, was alarmed and sent for a physician. When he went into another room it followed him. After troubling him for a day it disappeared, but was followed by several other distinct figures; some of them the figures of persons he knew, but most of them of persons he did not know. "After I had recovered," he says, "from the first impression of terror, I never felt myself particularly agitated by these apparitions, as I considered them to be what they really were—the extraordinary consequences of indisposition; on the contrary, I endeavored as much as possible to preserve my composure of mind, that I might remain distinctly conscious of what passed within me." He could trace no connection between the figures and his thoughts, nor could he call up at his own pleasure the phantoms of acquaintances which he tried to call up by vivid imagination of them; however accurately and intensely he pictured their figures to his mind, he never once succeeded in his desire to see them *externally*, although the figures of these very persons would often present themselves involuntarily. He saw the figures when alone and in company, in the daytime and in the night; when he shut his eyes they sometimes disappeared, sometimes not; they were as distinct as if they were real beings, but he had no trouble in distinguishing them from real figures. After four weeks they began to speak, sometimes to one another, but most often to him: their speeches were short and not disagreeable. Being recommended to lose some blood, he consented. During the operation the room swarmed with human figures, but a few hours afterward they moved more slowly, became gradually paler, and finally vanished. This example proves very clearly that a person may be haunted with apparitions, and yet observe them and reason about their nature as sanely as any indifferent outsider could do. It illustrates very well, too, the second mode of origin; for it is reasonable to suppose that they were produced by congestion of blood in the brain acting upon the sensory centres, and that they were dissipated by the removal of the congestion by bloodletting. This is the more probable, as cases have been recorded in which the suppression of an habitual discharge of blood from the body has been followed by hallucinations, and others again in which hallucinations have been cured by the abstraction of blood.

Exhaustion of the nerve-centres themselves by excessive fatigue, mental and bodily, or by starvation, or by disease, will cause a person to see visions sometimes. I may call to mind the well-known case of Brutus, who, as he sat alone at night in his tent before the decisive battle of Philippi, rapt in meditation, saw on raising his eyes a monstrous and horrible spectre standing silently by his side. "Who art thou?" he asked. The spectre answered: "I am thy evil genius, Brutus. Thou wilt see me at Philippi." He replied, "I will meet thee there." The religious ascetic who withdrew himself from the society of men to some solitary place in the desert or to some cave in the hills, there passing his lonely life in prayer and meditation, and mortifying his body with long fastings and frequent scourgings, brought himself to such a state of irritable exhaustion that he commonly saw, according to his mood of feeling, either visions of angels and saints who consoled him in his sufferings, or visions of devils who tempted and tormented him.[1] The shipwrecked sailor, when delirious from the exhaustion produced by want of food and drink, sometimes has attractive visions of green fields and pleasant streams, and cannot be prevented from throwing himself overboard in the mad desire to reach them. The dying person, in the last stage of exhaustion from a wasting disease, has had his deathbed visions of joy or of horror; the good man, whose mind was at rest, has been comforted by visions of heaven; the wicked man, whose troubled conscience would not let him die in peace, has been terrified with spectres of horror—the murderer, perhaps, by the accusing apparition of his victim. These were thought at one time to be supernatural visitations; they are known now to be for the most part hallucinations, such as occur in the last stage of flickering life, when, to use Shakespeare's words—

> "His brain doth, by the idle comments that it makes,
> Foretell the ending of mortality."[2]

[1] This is a Mohammedan receipt for summoning spirits:

"Fast seven days in a lonely place, and take incense with you, such as benzoin, aloeswood, mastic, and odoriferous wood from Soudan, and read the chapter 1001 times (from the Koran) in the seven days—a certain number of readings, namely, for every one of the five daily prayers. That is the secret, and you will see indescribable wonders; drums will be beaten beside you, and flags hoisted over your head, and you will see spirits full of light and of beautiful and benign aspect."—"Upper Egypt; its People and Products," by Dr. Klunzinger, p. 386.

An acquaintance of his, who had undergone the course of self-mortification, said that he really saw all kinds of horrible forms in his magic circle, *but he saw them also when his eyes were shut.* At last he got quite terrified and left the place.

[2] In the second part of "Henry VI.," Shakespeare gives an instance of a fearful death-bed hallucination, when Cardinal Beaufort is at the point of death:

> "*King.* How fares my lord? Speak, Beaufort, to thy sovereign.
> *Cardinal.* If thou be'st death, I'll give thee England's treasure,
> Enough to purchase such another island,
> So thou wilt let me live, and feel no pain.
> *King.* Ah, what a sign it is of evil life,
> Where death's approach is seen so terrible!
> *Warwick.* Beaufort, it is thy sovereign speaks to thee.
> *Car.* Bring me unto the trial when you will.
> Died he not in his bed? where should he die?
> Can I make men live, whether they will or no?
> Oh, torture me no more! I will confess.
> Alive again? then show me where he is:
> I'll give a thousand pounds to look upon him.
> He hath no eyes, the dust hath blinded them.
> Comb down his hair; look, look, it stands upright,
> Like lime-twigs set to catch my wingèd soul.
> Give me some drink; and bid the apothecary
> Bring the strong poison that I bought of him."

I cannot, of course, enumerate all the bodily conditions in which hallucinations appear, but there is one more which I shall mention particularly, because it has been the foundation of a prophetic or apostolic mission. It is not at all uncommon for a vivid hallucination of one or other of the senses, of hearing, of sight, of smell, of touch, of muscular sensibility, to precede immediately the unconsciousness of an epileptic fit. It may be a command or threat uttered in a distinct voice, or the figure of a person clearly seen, or a feeling of sinking into the ground or of rising into the air; and a common visual hallucination on such occasions is a flash, a halo, or a flood of bright or colored light, which makes a strong impression before the person falls unconscious. When he comes to himself he remembers it vividly, and believes, perhaps, that it was a vision of an angel of light or of the Holy Ghost. There can be no doubt that angelic apparitions and heavenly visions have sometimes had this origin. Proceeding from the sensory centre, not from the higher centres of thought, they are calculated to produce the stronger impression of their miraculous nature; for, if the person knows that he was not thinking of anything of the kind when the vision occurred, he will naturally be the more startled and affected by it. I might give many striking examples in proof of what I say, but I will content myself with an ordinary and comparatively recent one. Two or three years ago a laborer in the Chatham dock-yard, who was epileptic, and had once been in an asylum for insanity, suddenly split the skull of a fellow-laborer near him with an adze. There was no apparent motive for the deed, for the men were not on bad terms. He was, of course, tried for murder, but was acquitted by the jury on the ground of insanity, in accordance with the medical evidence, but directly in the teeth of a strong charge of the judge, and much to the disappointment of certain newspapers, whose editorial feelings are sadly harrowed whenever an insane person escapes from the gallows. He is now in the criminal asylum at Broadmoor, and he has told the medical officers there—what was not known at the trial—that some years before the murder he had received the Holy Ghost; that it came to him like a flash of light, and that his own eyes had been taken out, and other eyes, like balls of fire, substituted for them. A characteristic epileptic hallucination! Let us suppose that this man had undertaken some prophetic mission, as epileptics have done, and had put into it all the energy of his epileptic temperament, he would have declared with perfect sincerity, so far as he was concerned, that the Holy Ghost appeared to him in a vision as an exceeding bright light, and, behold! his own eyes were taken out and balls of fire were in their places.

Some persons maintain that the earliest visions of Mohammed, who, like Cæsar, was epileptic, were of this kind, and that his change of character and the assumption of his prophetic mission followed an epileptic vision. Tradition tells us that he was walking in solitude in the lonely defiles and valleys near Mecca, when every stone and tree greeted him with the words, "Hail to thee, O messenger of God!" He looked round to the right and to the left, but discovered nothing but stones and trees. Soon after this the angel Gabriel appeared to him in a vision on the mountain Hira, and announced to him the message of God. The origin of the hallucination seems to have been in this wise: While walking in the valley meditating in solitude on the degrading idolatry of the people, and girding himself to the resolution to undertake a great work of reform which might well seem beyond his strength, and make him pause, the intense thoughts of his mental agony were suddenly heard by him as a real voice, where there was no voice; and the vision which he saw when he next fell into an epileptic trance was deemed to be the apparition of the angel Gabriel.

If this be so, and much more if all the apparitions and visions which mankind have seen at different times were really hallucinations, it is startling to reflect what a mighty influence illusions have had on the course of human history. One is almost driven to ask in despair whether all in the world is not illusion, whether "all that we see and seem is not a dream within a dream." But there are countervailing considerations which may abate alarm. If a great work in the world has been done in consequence of a vision which was not, as it was believed to be, a supernatural revelation, but an hallucination produced in accordance with natural laws, the work done, were it good or bad, was none the less real. And inasmuch as the hallucination, whatever its character, is in accordance with the habit of thought and feeling of the person to whom it occurs, and is interpreted, if it be not actually generated, by his manner of thinking, we may put it out of sight as a thing of secondary importance, as an incidental expression, so to speak, of the earnest belief, and fix our minds on this belief as the primary and real agent in the production of the effect. Had Mohammed never seen the angel Gabriel, it is probable that the great mission which he accomplished—the overthrow of idolatry and polytheism and the welding of scattered tribes into a powerful nation—would have been accomplished either by him or by some other prophet, who would have risen up to do what the world had at heart at that time. Had any one else who had not Mohammed's great powers of mind, and who had not prepared himself, as he had done, by many silent hours of meditation and prayer, to take up the reformer's cross, seen the angel Gabriel or any number of angels, he would not have done the mighty work. Who can doubt that the mission of Mohammed was the message of God to the people at that time, as who can doubt that the thunder of the Russian cannon has been the awful message of God to the Mohammedan Turks of this time?

So much, then, for the nature of hallucinations and their principal modes of origin. Although they sometimes originate primarily in the sensory centres, and sometimes primarily in the higher centres of thought, it is very probable that, in many instances, they have a mixed origin. It can hardly be otherwise, seeing how intimate is the structural and functional connection between the nerve-centres of thought and sense, and how likely so closely connected nerve-centres are to sympathize in suffering when the one or the other is disordered.

No one pretends that a person who, laboring under hallucinations, knows their true nature, as Nicolai did, is insane; but it is often said that he has passed the limits of sanity and must be accounted insane when he does not recognize their real nature, and believes in them and acts upon them. But the examples which I have given prove this to be too absolute a statement. I should be very loath to say that either Mohammed or Luther was mad. When the hallucination is the consistent expression of an earnest and coherent belief, which is not itself the product of insanity, it is no proof of insanity, although it may indicate a somewhat unstable state of the brain, and warn a prudent man to temper the ardor of his belief. When, however, a person has hallucinations that are utterly inconsistent with the observation and common-sense of the rest of mankind; when he cannot correct the mistakes of one sense by the evidence of another, although every opportunity is afforded him to do so; when he believes in them in spite of confuting evidence, and when he suffers them to govern his conduct, then he must certainly be accounted insane: he is so much out of harmony of thought and feeling with his kind that we cannot divine his motives or reckon upon his conduct, and are compelled to put him under restraint. Persons of this class are apt to be troublesome and even dangerous; believing that they are pursued by a conspiracy, hearing the threatening voices of their persecutors wherever they go, seeing proofs everywhere of their evil machinations, smelling poisonous fumes, feeling the torture inflicted by concealed galvanic wires, they endeavor to protect themselves by all sorts of devices—appeal to the magistrates and the police for assistance, become public nuisances in courts of justice, are, perhaps, driven at last, either from despair of getting redress, or by the fury of the moment, to attack some one whom they believe to be an agent in the persecution which they are undergoing. Some of them hear voices commanding them peremptorily to do some act or other—it may be to kill themselves or others—and they are not unlikely in the end to obey the mysterious commands which they receive.

Having said so much concerning the causation and character of hallucinations, I ought, perhaps, before concluding, to say something about the means of getting rid of them. Unfortunately, it is very little that I can say, for, when once they have taken firm hold of a person, they are seldom got rid of. When they occur during an acute case of insanity, where there is much mental excitement, they certainly often disappear as the excitement passes off, or soon afterward, just as they disappear when the delirium of fever subsides; but, when they have become chronic, they hold their ground in defiance of every kind of assault upon them. Over and over again the experiment has been tried of proving to the hallucinated patient in every possible way, and by every imaginable device, that his perceptions are false, but in vain:

> ". . . . You may as well
> Forbid the sea for to obey the moon
> As or by oath or counsel shake
> The fabric of his folly, whose foundation is
> Piled upon his faith, and will continue
> The standing of his body."

There is more to be done to prevent hallucinations, I think, than to cure them; that is to say, by prudent care of the body and wise culture of the mind. Looking to their mode of origin, it is obviously of the first importance, trite maxim as it may seem, to keep the body in good health; for not only will bodily disorder directly occasion hallucinations by disturbance of the sensory centres, but by its depressing influence on the entire nervous system it hinders sound, and predisposes to unsound, thought and feeling. Every one knows how hard a matter it is to perceive accurately, to feel calmly, and to think clearly, when the liver is out of order; there is then a good foundation for hallucination. It has so long been the habit to exalt the mind as the noble, spiritual, and immortal part of man, at the expense of the body, as the vile, material, and mortal part, that, while it is not thought at all strange that every possible care and attention should be given to mental cultivation, a person who should give the same sort of careful attention to his body would be thought somewhat meanly of. And yet I am sure that a wise man, who would ease best the burden of life, cannot do better than watchfully to keep undefiled and holy—that is, healthy—the noble temple of his body. Is it not a glaring inconsistency that men should pretend to fall into ecstasies of admiration of the temples which they have built with their own hands, and to claim reverence for their ruins, and, at the same time, should have no reverence for, or should actually speak contemptuously of, that most complex, ingenious, and admirable structure which the human body is? However, if they really neglect it, it is secure of its revenge; no one will come to much by his most strenuous mental exercises, except upon the basis of a good organization—for a sound body is assuredly the foundation of a sound mind.

In respect of the mental cultivation to be adopted, in order to guard against hallucination, I can now only briefly and vaguely enforce one important principle—namely, the closest, most exact, and sincere converse with nature, physical and human. Habitual contact with realities in thought and deed is a strong defense against illusions of all sorts. We must strive to make our observation of men and things so exact and true, must so inform our minds with true perceptions, that there shall be no room for false perceptions. Calling to mind what has been said concerning the nature of perception—how the most complete and accurate perception of an object is gained by bringing it into all its possible relations with our different senses, and so receiving into the idea of it all the impressions which it was fitted to produce upon them —it will appear plainly how necessary to true perception, and to sound thought, which is founded on true perception, and to wise conduct, which is founded on sound thought, are thoroughness and sincerity of observation. So to observe Nature as to learn her laws and to obey them, is to observe the commandments of the Lord to do them. Speculative meditations and solitary broodings are the fruitful nurse of delusions and illusions. By faithfully intending the mind to the realities of Nature, as Bacon has it, and by living and working among men in a healthy, sympathetic way, exaggeration of a particular line of thought or feeling is prevented, and the balance of the faculties best preserved. Notably the best rules for the conduct of life are the fruits of the best observations of men and things; the achievements of science are no more than the organized gains—orderly and methodically arranged—of an exact and systematic observation of the various departments of Nature; the noblest products of the arts are Nature ennobled through human means, the art itself being Nature. There are not two worlds—a world of Nature and a world of human nature—standing over against one another in a sort of antagonism, but one world of Nature, in the orderly evolution of which human nature has its subordinate part. Delusions and hallucinations may be described as discordant notes in the grand harmony. It should, then, be every man's steadfast aim, as a part of Nature, his patient work, to cultivate such entire sincerity of relations with it, so to think, feel, and act, always in intimate unison with it, to be so completely one with it in life, that when the summons comes to surrender his mortal part to absorption into it, he does so, not fearfully, as to an enemy who has vanquished him, but trustfully, as to a mother who, when the day's task is done, bids him lie down to sleep.—*Fortnightly Review.*

YELLOW FEVER.

By ROGER S. TRACY, M.D.

AN attack of yellow fever is generally quite sudden, though in some cases there are slight premonitory symptoms, such as loss of appetite, general uneasiness, headache, or costiveness. It is commonly ushered in by chilliness, alternating with flushes of heat, or the person may be overcome with languor and extreme debility, while at his usual occupation. These feelings are soon followed by fever, and the bodily temperature rises rapidly, often reaching $102\frac{1}{2}°$ Fahr. in a few hours, the normal temperature being 98.4°. The fever is accompanied by headache, generally located immediately over the eyes, or shooting through from temple to temple, and often very severe. But the headache is frequently trivial in comparison with the frightful pains in the loins, which make the patient writhe in agony. The pulse is generally full, strong, and rapid, beating from ninety to a hundred and twenty times a minute. The skin is hot and dry, the face flushed, the eyes bloodshot, brilliant, and watery, and the tongue covered with a creamy white fur, but with red, clean tip and edges. There is usually some uneasiness of the stomach from the first, and in from twelve to twenty-four hours this develops into nausea and a persistent sensitiveness, which will not allow anything to be retained. The pit of the stomach is very tender on pressure, and vomiting is almost incessant. With all this there is intense thirst, and iced drinks are exceedingly grateful to the patient. The bowels are at first generally costive, and sometimes obstinately so, but, as the disease progresses, they become loose. The patient is usually very much debilitated, but is uneasy and tosses about in bed, and occasionally will try to rise and walk about the room. In most cases there is some confusion of intellect, not amounting to delirium, and the face expresses the greatest anxiety and distress. The fever continues for two or three days, being most severe in the evening, the temperature often reaching 104° or 105°, and, according to La Roche, in malignant cases, even 110°. Then the fever subsides, never to return, and the temperature within twelve hours may become nearly normal. The other symptoms mostly disappear, and the organs resume their natural functions. At this time, i. e., on the third or fourth day, the yellow discoloration of the skin appears upon the face and thence extends over the body. If the attack is mild, recovery is now rapid. In the vast majority of cases, however, this lull in the symptoms is deceitful, and lasts only from a few hours to a day, when the gravest stage of the disease sets in. The pulse soon becomes small and thready, beating only thirty or forty to the minute, and the heart often works vigorously after the pulse can no longer be felt at the wrist. The nausea and vomiting return and become constant, the respiration is often embarrassed, the tongue becomes dry and brown, the skin is cool and dry, there is often a distressing hiccough, and the thirst is insatiable. The mind is often clear, but singularly apathetic, or there may be delirium or stupor. The disorganization of the blood and the tissues has now gone so far that the small vessels of the mucous membranes no longer retain their contents, and blood oozes into the stomach. This produces intense nausea, and the blood is vomited up, changed in color by the acids with which it is mingled. This forms the dreadful "black-vomit," and varies in hue from brown to almost jet black, generally appearing like coffee-grounds floating in a thin, watery fluid. The urine, which becomes scanty early in the disease, may now be entirely suppressed, or, if excreted at all, is black and bloody. The discoloration of the skin increases, until the body is of a dusky brown, livid or mahogany color, and there are frequent hæmorrhages from the mouth, nose, eyes, or even under the skin, forming livid spots and blotches. The body now exhales a cadaverous odor, the tendons of the wrist twitch convulsively, hiccough is constant, the features are pinched and ghastly, cold sweats come on, and the patient passes away in convulsions or coma, though occasionally he retains his intellectual faculties unimpaired to the last.

Patients may recover in either of the three stages above described. A favorable termination is indicated by a gradual amelioration of all the symptoms, or sometimes by profuse perspiration, sudden cessation of nausea, rapid return of the pulse to its natural fullness and strength, or other marked event, which seems to indicate a crisis in the disease.

The symptoms of yellow fever vary exceedingly at different times, in different localities, and in different persons. Sometimes a person is smitten with the disease as with apoplexy, falls into a profound collapse, and dies in a few hours. Others walk about the room, or even out in the street, and insist that they are perfectly well; or, if they acknowledge that anything is the matter with them, complain merely of weariness or debility. They often betray no symptom of the disease to the casual observer; but the physician will see an expression of dullness or listlessness in the face, and a wateriness of the eye, and will find the pulse feeble or even absent. The patient may even be talking, smoking, or reading, when black-vomit comes on, and he is speedily a corpse. To a non-professional person the exceeding variability of the symptoms cannot, perhaps, be better shown than by quoting a line or two from the work of La Loche, of 1,400 pages, on "Yellow Fever:" "The skin is hot, dry, harsh, and pungent, or it may be dry, unctuous, or perspiring, flabby, and cold. . . . The pulse becomes rapid, irregular, and depressed; or, more generally, it is natural in frequency, or even slower than in health." And this, of the *post-mortem* appearances, is a gem in its way: "The liver is usually of a light-yellow, nankeen, fresh-butter, straw, coffee-and-milk, gum-yellow, buff, gamboge, light-orange, or pistachio color; or it may be dark-yellow, brown, red, purple, bluish, slate, chocolate, or livid." Even the characteristic symptoms of yellow skin and black-vomit may occur in other diseases, and they may both be absent in yellow fever. These differences in the disease are largely due, in all probability, to individual idiosyncrasies, and to the simultaneous presence of other morbid processes. Thus, the present terrible epidemic at the South, from all we can learn, seems to be decidedly modified by the malarial atmosphere of that region, and presents so many of the features of the pernicious malarial fevers that some physicians (whether competent or not I do not know) decline to report their cases as yellow fever.

The disease lasts from three to nine days, and in severe cases recovery is apt to be very slow. Relapses are not common. The black-vomit, indicating, as it does, a profound disorganization of the blood, is, in most cases, a fatal sign. Alvarenga states that, in the epidemic of 1857, at Lisbon, out of one hundred and seventy-eight cases of black vomit, forty recovered, but this is an isolated experience, and in this country, at least, such recoveries are rare. The mortality varies between five and seventy-five per cent. of those attacked.

The disease develops in from one to fourteen days after exposure. Those most liable to it are strangers or recent comers. Old residents enjoy a certain immunity, excepting in severe epidemics, and, even if they are attacked, the disease is generally mild. Women and children, old persons, and those of delicate constitutions, are usually less liable to it than robust, healthy men. This year the children are said to have suffered most. The negro natives are generally exempt, though it has been noticed that negroes who have left the South for the North, and have returned during an epidemic, do not possess this immunity. In the present epidemic, even the negroes seem to succumb in great numbers. It is a singular fact that persons exposed to offensive effluvia when working at their trade, as tanners, butchers, soap-boilers, and scavengers, are almost exempt from the disease, while those whose trade exposes them to great variations of temperature, as bakers and cooks, are extremely prone to it. Like small-pox, it may occur more than once in the same person, but, as a rule, those who have had it once are never attacked again.

All methods of treatment agree in the principal points. The bowels must be cleared at the start, and the patient kept perfectly quiet. The temperature is kept down by applications of cold water, and ice is applied to the head if symptoms of congestion of the brain appear. The excessive thirst is relieved by swallowing lumps of ice, and the nausea controlled to some extent by iced lemonade or champagne. In the West Indies, lemon-juice plays an important part in the treatment, and the old negro nurses rub it over the surface of the body. When the appetite revives, great caution has to be exercised, as a premature return to solid food may result fatally.

The first fully recorded outbreak of the disease was in the West Indies in 1647, and since then it has recurred at irregular intervals, and has gradually extended its range. Epidemics have occurred as far north as Quebec and as far south as Montevideo, as far west as Mexico and as far east as Algiers. It is endemic in the West Indies, Venezuela, New Granada, and Mexico, on the easterly coast of the United States as far north as Charleston, South Carolina, and on the northerly coast of Africa. To become epidemic, it requires a mean temperature of at least 72°, and Griesinger holds that the temperature must be as high as 80° for a considerable time before it can acquire a foothold, though West Indian physicians have seen the temperature fall suddenly just before an outbreak. If the temperature falls during an epidemic its severity abates, and at 32° it disappears entirely. It rarely occurs inland, but follows water-courses and lines of ocean-travel, and so usually appears in commercial cities, and begins its march at the wharves. It is uncommon in elevated regions, and 2,500 feet is commonly regarded as its altitudinal limit, but it has been known to occur at Newcastle, Jamaica, at a height of 4,000 feet, and if the belief be true that ancient Mexico was visited by it under the name of *matlazahuatl*, then it has been epidemic at a height of between 7,000 and 8,000 feet above the sea.

There has been no severe epidemic of this disease in New York since 1822, but it breaks out on our Gulf and South Atlantic coasts at intervals, with no appearance of periodicity. It first appeared in New Orleans in 1796, and has often been epidemic there since. The most fatal epidemic was that of 1853, when the deaths were variously stated at from 8,000 to 10,000, or about eight times as many as have occurred there during the present summer, though the population was only half as large. It is the common impression that New Orleans was saved from the disease during its occupation by Federal troops in 1862–'65, because the city was put in such excellent sanitary condition; but Dr. Nott calls attention to the fact that there are often periods of exemption from the disease in all places visited by it, and that in New Orleans in 1859 there were only 91 deaths from yellow fever, in 1860 only fifteen, and in 1861 not a single one; while in 1863 Dr. Harris says there were nearly 100 cases of the disease, with two officially recorded deaths, and in 1864 more than 200, with 57 deaths.

Yellow fever occupies a singular position between the contagious and non-contagious diseases. The poison is not, like that of small-pox, directly communicable from a sick person to a well one; but, although the emanations of the sick are connected with the spread of the disease, they seem to require an appropriate nidus in which to germinate and develop. This nidus must be warm and moist, and there the germs, whatever they are, lie and grow, or, in some way develop until they are able to migrate. The germs are portable, and may be conveyed in baggage or merchandise (*fomites*) for hundreds or thousands of miles. If not so conveyed, its progress is very slow. In 1822 in New York, when it gained a foothold in Rector Street, it appeared to travel about forty feet a day until killed by the frost. It often leaves a house or a block intact, going around it and attacking those beyond, with no assignable reason. A thin board partition seems to have stopped it on Governor's Island in 1856, and an instance is related where it attacked the sailors in all the berths on one side of a ship before crossing to the other. Such apparent vagaries are, in the present state of our knowledge, inexplicable.

BIRD OR REPTILE—WHICH?

By HENRY O. FORBES.

TO most people it may appear not only easy enough to distinguish, but even a matter of some difficulty not to be able to identify, a bird from a reptile or from any other animal whatsoever. No one would hesitate for a moment to assign to the bird tribe, on seeing them even for the first time, forms differing from each other so much as the "wingless" apteryx of New Zealand and the strong-pinioned albatross; the marvelously tinted humming-bird and the raw-necked vulture; or the fleet ostrich and the stolid hornbill; for in each individual the eye at once perceives one character at least common to the whole assemblage which is wanting in all other groups. Yet the question to be discussed in this paper of bird or not-bird, and in particular of bird or reptile, is, as we shall see below, one not without serious difficulty.

In order to a more easy comprehension of the question, let us shortly, and with as few technicalities of expression as possible, pass in review the chief characters of the groups we have placed in apposition.

Birds may be characterized generally as feathered bipeds, whose mouth is modified into a longer or shorter beak incased in a horny sheath, sometimes serrated along the margin, but never presenting true teeth; whose fore-limbs assume the form of wings more or less developed, and having the hind-limbs supported on, at most, four toes, the innermost, however, in many birds being so imperfectly developed as not to reach the ground.

Every one who has handled a living bird knows that it is warm-blooded; and whoever, while not neglecting the "main chance," when dining on partridge or fowl, has nevertheless not been too absorbed to mark the prominent points that distinguished the skeletal remains of his feast from those of a hare, for instance, is aware that along the centre of the breastbone there runs a high crest for the attachment of the wing-muscles; that the collar-bones unite to form the bone of destiny with which he has been familiar from his youth as the "merry-thought;" that the haunch-bone, which incloses the bowels and gives attachment to the hind-limbs, differs from a higher quadruped's in being composed, not of two bones (each of which is in reality made up of three bones ossified together), one on each side articulating with yet separate from the spine, and touching each other in the median line beneath, but of these elements and several vertebræ in addition, consolidated into one, having the margins free and separated by a considerable space from each other below; and that instead of a tail, commonly so called, the rear of the spinal column is brought up by what is known as the "ploughshare" bone formed by the union of several of its segments into a terminal mass for the support of the rudder-quills and of the oil-gland. Several very marked characteristics are to be seen in the hind-limb, to which, without entering deeply into osteological details, we may draw attention. Opening into the hollow shafts of the stronger bones—a character common to those of the wing and parts of the spine—there are to be found small pores, the air-passages by which the air-sacs, themselves extensions of the air-tubes of the lungs, are prolonged into the bones. In the skull also we find numerous air-cavities; these, however, are filled, not from the lung air-system, but from the nasal and ear chambers. No one who has examined the leg-bone, often called the "drumstick" (technically known as the tibia), of a common fowl, can have failed to observe the great ridge, or prominent crest, on the front of its upper extremity, or how easily the pulley-shaped articular surface of its lower end separates off from the shaft in the young bird, especially if the bone has been boiled or macerated for some time in water. This peculiarity vanishes when the fowl attains to its full growth; but till then the separation remains, as if to assert the right of the extremity to be considered, what in reality it is, a separate and distinct bone, the sole representative of a colony of ossicles (corresponding to the bones of the heel in the human foot) once existing in its grandsires at this spot, which for reasons of expediency has here coalesced with its long neighbor. On its outer side the leg-bone is always accompanied by a very slender bone, known as the fibula, attached only at its upper end, tapering gradually to a point about the middle of its fellow. Lastly, to the leg-bone immediately succeeds the hock-bone, the beautiful conformation of whose lower end into the resemblance of a triple pulley, for the articulation of the toes, is a mark by which we can unhesitatingly say that it belonged to a bird.

Bearing in mind these peculiarities, for whose detection no very deep scrutiny is required, which are but a few, yet sufficient for our present purpose, of the more striking characteristics to which the members of the Avian family more or less closely conform, we shall now for a little turn our attention to that other division of the animal kingdom with which we have in the title of this article contrasted the bird.

The reptiles are a wonderfully interesting group on account not only of the marvelous variety of their habits and modes of life, but also of their manifold diversity of form. Our country, in common with the rest of Northern Europe, can claim to be the habitat of but few examples of this tribe, whose home is under warmer latitudes; and consequently only limited opportunities present themselves to the European student for becoming acquainted with their habits and animated forms, unless he happens to live within reach of the menageries of the Zoölogical Societies of London, Berlin, Paris, or Amsterdam; those who are unfortunately distant from such interesting educational centres must make their acquaintance in a mummified or skeletonized form in museums. It cannot but strike the visitor to any zoölogical collection where the vertebrated section is well represented that the cases devoted to the reptilian group contain forms so divergent as the tortoise and the lizard, the snake and the alligator. If, however, the eye be permitted to pass to the sections on either hand—on the one side, to the amphibious animals, such as the frogs and newts, and on the other, to the birds—it is impossible not to perceive that the contrast is very great. A careless or inexperienced classifier might, perchance, be tempted to relegate the lizard to a place among the amphibia, near to the newts, or *vice versa;* but the most unobservant of men could never locate a snake among the birds, nor set a turtle or a crocodile on the same shelf with the swallow or the golden-crested wren.

The first and lowest link of the reptilian segment in the great chain of animal existences commences just above the highest of the amphibian assemblage, and is constituted by the river and mud loving tortoises and the turtles of the warmer seas; while the highest now living embraced the Crocodilian family, in whose membership are included the alligators and jacars of the New World, the crocodiles of the Ganges and the gavials of Northern Africa. The gap between these extremes is filled up by various intermediate gradations. To the tortoises succeeds, according to our best classifiers, a powerful race of long-necked ancient mariners—the plesiosaurs—which hunted their prey by the sea-coasts of the geological middle ages, where they left their bones, the sole testimony to the existence of their race, which became extinct before the chalk-cliffs of England were completed, however long ago that may be. After them comes the large group of the true lizards, comprising, along with several extinct orders, the chameleons, the lizards, and the geckos, both the latter being familiar enough to Continental travelers on sunny spots in Southern Europe; the geckos, especially, attracting attention by their habit of running on ceilings and perpendicular walls, by their sucker-formed toes. The next cohort embraces the serpents—the pythons and boas, endued with a power of crushing almost unsurpassed in the animal kingdom; and the rattlesnakes and cobras, carrying swift and certain death in the lightning stroke of their head. The next place is assigned to the great fish-lizards, or ichthyosaurs, which frequented the deeper waters of the same seas as the plesiosaurs, of whose existence also all knowledge would have perished forever, since they died out leaving no representative to continue their line, had not the kindly mud of the bottom preserved for us fragments of their history in their disjointed bones. Advancing from these "dragons of the prime" we again reach the crocodiles, the most specialized of modern reptiles.

Although between the highest and the lowest of these forms there is nothing like the close bond of union which connects the most distantly related of the birds, yet these diverse families have many characters in common, separating them from the other divisions of the animal world. Their bodies are protected by modifications of the skin into scales, enormous rugosities of almost impenetrable horny plates or flat shields of various forms. No reptile ever has feathers, for, on account of a peculiarity of the circulation of the blood by which the aërated and unaërated portions mingle together, they are cold-blooded, and therefore do not require so heat-conserving a covering for the body. Most reptiles possess two pairs of legs, of which the fore limb conforms much more closely to the hind in structure than is the case between the anterior and posterior extremities of the bird. On these they crawl rather than walk, their bellies, which are dragged along the ground, assisting in the support of the body; some have both pairs adapted for aquatic life, while others are entirely devoid of progressional appendages. No member of the class can be called a true volant, notwithstanding that a few, such as the flying dragons of the Philippine Islands, are able, by means of membranous expansions of the skin, to sustain themselves in the air while passing from one tree or support to another. With the exception of the tortoises, the majority are carnivorous and possess powerful jaws set with strong, sharp teeth.

So much lies on the surface.

From an examination of the chief points of their internal framework we learn that the "collar-bones" do not unite to form a "merry-thought;" nor does the breastbone develop a median keel. In general the tail is more or less elongated, but its terminal segments do not unite to form a "ploughshare" bone. The leg-bone of the reptile differs from the bird's in having a well-developed fibula lying parallel to it throughout its whole length; it does not present a strongly-marked crest at its upper end, nor is the articular surface of the narrow lower extremity formed by the coalescence with the shaft of a separate bone into a pulley-shaped termination. The coalescence never takes place at all; but each retains a separate existence throughout life. In the situation of the hock in the bird the reptile has at least four distinct bones to which are articulated as many toes; and, lastly, the haunch-bone, instead of being a consolidated mass, is composed of two halves, one on each side, articulating with, but not united by, bony tissue to the spine, and meeting each other below—a character in which the struthious birds, such as the ostriches, agree. It may be remarked, also, that in their keelless breastbone, as well as in the disunion of their collar-bones, these birds present other similitudes to the reptiles.

Every student of osteology is well aware that all bones in their embryonic condition are composed of cartilage, wherein, as the animal grows older, bony spots or "centres" appear, whence the ossification spreads till the whole structure is converted into bone. Among the higher animals these centres are seen only during the earlier years of life, while with increasing age their outlines, becoming gradually fainter, are at length entirely lost. But among the reptiles many of the bones either continue throughout life with their component parts unsolidified together, or else indicate by clear marks their lines of union, so that it is always easy to tell the number and configuration of which each is composed.

Thus far the characters which separate a reptile from a bird stand so widely apart—the interval between the highest living crocodile and the nearest living bird (represented by such forms as the New Zealand kiwis, the mooruk of Australia, the cassowary of the Moluccas, and the rheas or ostriches of South America) is of such enormous magnitude—that it would seem needless to entertain any fear of mistaking a member of the former group for one of the latter. Meanwhile let us withhold any decided opinion.

On November 29, 1871, a letter to Prof. Dana, dated from San Francisco, written by Prof. O. C. Marsh, of Yale College, New Haven, Connecticut, announced the discovery of a portion of a large headless skeleton in the upper chalk formation of Western Kansas, consisting of the nearly entire posterior limbs, portions of the haunch-bones, several segments from the neck and tail of the spinal column, and numerous ribs all in excellent preservation. The long leg-bone exhibited on the front aspect of its upper extremity the large crest which, as we have already pointed out, is a remarkably Avian character; along its shaft lay a fibula developed as among the diving birds of the present day, to whose thigh-bone also that of the fossil bore considerable resemblance. The "hock-bone," in presenting a trifid pulley-shaped lower end, was bird-like; while in the oblique arrangement of these divisions it again claimed affinities with the divers, whose toes are articulated in this manner to facilitate the forward stroke of their feet through the water, The external division, however, which projects beyond the other two, and is twice the size of either, is developed in a way unknown in any recent or fossil bird, and the bones of the toe supported by it are peculiarly articulated to produce rigidity and prevent flexion, except in one direction, in order by the interlocking of the bones to increase the strength of the joints during the act of swimming; for the whole limb is unquestionably adapted for rapid motion through water. The haunch-bone presents some resemblance to what is seen among the reptiles, in the permanence as separate bones of some of the portions of which it is composed, and in its not being firmly joined to the spine by bony union as in ordinary birds.

The examination so far of these interesting remains proved that the skeleton was certainly a bird's. On comparing its various bones with the corresponding ones in existing representatives, its affinities, notwithstanding considerable divergences from all known recent or ancient species and genera, were evidently with the swimming-birds, of which it is the largest known exponent, and of these it most resembled the great northern diver, near which, for a time, it received a niche with the appellation of Royal Bird-of-the-Dawn (*Hesperornis regalis*).

On September 26, 1872, *Silliman's American Journal of Science* announced the disinterment of another skeleton from the chalk of Kansas, "one of the most interesting of recent discoveries in paleontology." The remains included, among other bones, a number of biconcave vertebræ, that is, having the bodies, or solid central piece of the spinal segments, cup-shaped at both ends, a configuration which obtains, as every one has observed, in the divisions of the backbone of the common cod. This characteristic of the spine is frequent enough among reptiles; but it never occurs among birds met with nowadays. If among them there be any tendency that way, as there is in a few birds, the concavity is invariably found in the posterior end, the rarest form of vertebræ among reptiles. "The neck, back, and tail vertebræ preserved, all show this character, the ends of their bodies (centra) resembling those in the plesiosaurs;" notwithstanding the strongly non-Avian description of the spine, all the other bones—the prominently keeled breastbone, the collar-bone united to form a "merrythought," as well as the leg- and long wing-bones—exhibit those marks which we have found to be most typical of the bird tribe. The wings were large in proportion to the posterior extremities; and the lower end of the leg-bones is incurved as in swimming-birds. Prof. Marsh, therefore, judging from their relative proportion, concludes that the bones belonged to a bird about the size of a pigeon, in many respects resembling the aquatic birds. He has christened it *Ichthyornis dispar*.

In October of the same year this indefatigable geologist once more announced through the pages of *Silliman* a new "find" from his favorite and fruitful mine in Upper Kansas. This time it was "a new reptile from the cretaceous . . . a very small saurian, which differs widely from any hitherto discovered." The only remains found on this occasion were two lower jaws, nearly perfect, and with many of the teeth in good preservation. The jaws resemble in general form those of an extinct family of marine reptiles whose remains were first found in the chalk formation near Maestricht; but apart from their very diminutive size they present several features which no species of that group has been observed to possess. Noticeably, the teeth are implanted in distinct sockets, and are directed obliquely backward. There are apparently twenty in each jaw, all compressed, with very acute summits. Then there is no distinct groove on the inner surface of the jaws as in all known Mososauroids—as the family of Maestricht reptiles is named. "Clearly," says Prof. Marsh, "the specimen indicates a new genus."

A more careful removal of the surrounding shale brought to light a fact that enormously enhanced the importance and value of this "most interesting of recent discoveries in paleontology." The jaws, which had been accredited to "a new genus" of reptiles, belonged most undoubtedly, from the position in which they were found with reference to the other bones, to the *Ichthyornis dispar*, which owned the spine with double cup-shaped segments. Here was a dilemma! The ichthyornis had on what seemed reliable data been adjudged a bird; but not only was no bird ever known to have teeth set in sockets, but no bird had ever yet differed so far from its fellows as to affect teeth at all, not to mention the fact of its having resuscitated the fashion of a by-gone day in having its spinal vertebræ cupped at both ends. When it lived, was this creature, in which the types have become so strangely mixed, a reptile, or after all a bird? was a question that for a time made the brows of the philosophers anxious even in the midst of their happiness at the new discovery. They finally declared for the latter. There was, therefore, no resource left but to extend the boundaries which had hitherto confined the avian territory, and institute a new sub-class for its reception, whereat the ornithologists were greatly pleased and cordially welcomed the toothbills among their feathered friends.

Among the treasures which on December 7, 1872, Prof. Marsh and his Yale College explorers brought back to New Haven, as the results of their autumn reaping among the Rocky Mountains, was the nearly entire skeleton, containing all the missing bones, of the royal hesperornis and of another bi-concave vertebrated bird.

The breastbone of the gigantic diver of the chalk is thin and weak, and entirely without a keel; in front it resembles the ostrich's or that of the apteryx of New Zealand—a group of birds presenting the greatest range in time and also the widest geographical distribution over the globe—but in some respects it approaches to the penguin's also. The wing-bones are diminutive, and the wings are rudimentary and useless as organs of flight. The bones that girdle the thigh clearly exhibit a resemblance to the corresponding bones of a cassowary; yet, although avian in type, they are peculiar and present some well-marked reptilian proclivities.

Furnished with these bones alone, and judging from his experience of bird architecture, in plan hitherto undeviated from, no ornithologist would have hesitated to relegate the remains to a place among the birds; and, had he been asked to restore the missing portions, he would in all probability have devised some cross between the corresponding parts of the divers, of the dabchicks (for their knee-cap resembles that of the hesperornis), and of the ostrich-like birds, adding thereto a tail somewhat after the model of the penguin's. Certain it is, however, he would never have approached the features presented by the actual bones. This primeval bird possessed a skull in its general form like that of the great northern diver, but with a less pointed beak. The jawbones, however, though they were originally covered with a horny bill as in ordinary birds, are widely different. They are massive and have throughout their length a deep groove which was thickly set with sharp-pointed teeth—evidence of carnivorous habits—their crowns covered with enamel and supported on stout fangs. In form of crown and base they most resemble the teeth of the reptiles found in the Maestricht beds, to which we have referred above, as well as in the method of replacement, for some of the teeth preserved have the crowns of their successors implanted in cavities in their fangs. This peculiarity in the manner of teeth-shedding is characteristic of some reptiles, each of whose teeth is merely a hollow cone filled in the interior with a soft pulp which supplies the material for the external bony layer. When the tooth becomes worn and useless, a new one is formed beneath the shell of the first by the pulp in the interior, which gradually ousts the old from its socket. In addition to these, the hesperornis possessed other reptilian characters. While the formation of the spinal column in the neck and back is of the true avian type, the structure of the tail, where there have been discovered no fewer than twelve segments, is very peculiar, and differs entirely from anything hitherto seen in birds. The bones of its middle and posterior portions have very long and horizontally flattened processes which prevent all motion in a lateral direction : a peculiarity from which we may certainly infer that, like the beaver's, this appendage was moved vertically, and doubtless was an efficient aid in diving, perhaps compensating for want of wings, which the penguins use with such wonderful dexterity in swimming under water. The last three or four bones are firmly united together, forming a flat terminal mass analogous to, but quite unlike, the "ploughshare" bone of modern birds.

Here, again, is another form half doubtful whether to assume the reptilian or the avian garb, a protestant against the hard and fast lines within which the various groups of the animal kingdom have hitherto been confined. The hesperornis certainly approaches the ichthyornis so far as to come under the new sub-class instituted for the reception of that bird ; but, inasmuch as it differs in having its teeth not in sockets but set in a groove, and since, rejecting the conservative bi-concavity in the matter of spinal segments, it has adopted a newer and more high-class "cut," it has been necessary to give to each the honor of heading a separate section.

Though no living bird has so long a tail as this bird-of-the-dawn, yet there was in 1862 disinterred from the lithographic slates of Solenhofen part of the skeleton of a feathered biped—the archæopteryx (the existence of which was foreshadowed by the discovery of a feather the year before), exhibiting in most of the bones preserved the marks of a true bird. In the length of its tail, however, it is peculiar. This appendage contains the enormous number of twenty distinct bones gradually decreasing in size to the last, and each supporting a pair of quill-feathers. To the skeleton no head is attached ; but a portion of a small separate jaw on the same slab has been the subject of much controversy as to whether it belongs to the accompanying bones or not. Hermann von Meyer, the illustrious anatomist and paleontologist, holds that there can be little doubt but that they are parts of one and the same skeleton. If this be so, these remains belonged to a toothed bird ; and

Prof. Marsh thinks that probably it possessed bi-concave segments in its backbone, indicating, therefore, some alliance with the ichthyornis. The structure of its wings, Prof. Huxley points out, differs in some very remarkable respects from that which they present in a true bird. In the archæopteryx the upper arm-bone is like that of a bird, and the two bones of the forearm are more or less like those of a bird; but the fingers, which in all modern avian representatives are fused together into one mass, are not bound together—they are free. What the number may have been is uncertain, but several, if not all, of them were terminated by a strong-curved claw; so that in the archæopteryx we have an animal which to a certain extent occupies a midway place between a bird and a reptile. It is a bird in so far as its foot and sundry other parts of its skeleton are concerned; it is essentially and thoroughly a bird by its feathers: but it is much more properly a reptile in the fact that the region which represents the hand has separate bones with claws resembling those which terminate the fore-limb of a reptile. Teeth and a long tail, moreover, have certainly been considered hitherto non-avian characteristics.

More recently in our own country there has been brought to light from the London clay, in the island of Sheppey, a skull with the margins of the jawbones armed with larger alternating with smaller denticulations. It has been submitted to the examination of Prof. Owen, *facile princeps* among the restorers of osteological remains, who concludes that it belonged "to a warm-blooded feathered biped with wings"—to a bird, in fact—"and further, that it was web-footed and a fish-eater, and that in the catching of its slippery prey it was assisted by the peculiar armature of its jaws." Many living birds, such as the mergansers or saw-bills, have denticulations on the borders of the horny covering of the bill; but no modern bird has ever the underlying bone elevated into ridges or denticulations like those seen in the London-clay fossil. On the palate, however, of the rare Phytotome, a South American perching bird belonging to the group of the Leafcutters, which bears in its structure many "marks of ancientness," we find two rows of bony denticulations, the remains of what are apparently but recently lost teeth, if we calculate time by the geological horologe, and which may be faint memorials of the dental arrangement seen in the chameleon. Certainly, "they are not the less of interest, seeing that as yet we have nothing else intervening between them and the teeth of the Sheppey fossil." How far this fossil may have resembled any of the avian remains which we have described above, we must wait to know. To conjecture would be dangerous, considering how wide of the mark would have been, in all likelihood, the restoration, had any been attempted, of the hesperornis, whose true structure when revealed so greatly surprised the most experienced naturalists. All that can at present be said is, that the owner of the solitary skull could not have claimed a place within the old avian province. It is interesting, however, in affording a suggestion as to the possible steps by which the toothbills, as regards the armature of their jaws, may have passed into modern toothless birds.

The Stonesfield slates have yielded up an almost entire skeleton of a wonderful extinct form, unique as yet, described under the name of *Compsognathus*, which possesses a singularly long neck supporting a head whose structure is light, and, except in the possession of teeth, birdlike. Its anterior limbs are small, while the leg-bone of its very long hind-limb exhibits the prominent crest of which we have so often spoken, a ridge on its outer side for the fibula, and the pulley-shaped articular surface of its lower end identical in conformation with that seen in the bird. This skeleton diverges from the bird type, however, in the absence of a "merry-thought," and in having the single hock-bone of the bird replaced by three distinct bones, fitting immovably together, of which the trifid extremity of a fowl's, for example, indicates the coalescence. The haunch-bone, moreover, indicates relationship with the reptiles, in its form and in the manner in which it unites below with its fellow of the opposite side—a feature in which it agrees with the arrangement of the corresponding bone in the crocodiles and in the rheas. This strange creature, bird or reptile, "must, without doubt," Prof. Huxley remarks, "have hopped or walked on its hind limbs after the manner of a bird, to which its long neck, slight head, and small anterior limbs, must have given it an extraordinary resemblance." There is reason for believing that it was possessed of a long tail, which must have greatly helped to support it in the erect position.

The extinct group to which this singular Stonesfield fossil has been assigned contains some of the largest known terrestrial animals, such as the carnivorous giant-lizard (*Megalosaurus*), thirty feet in length, whose structure in many points resembles that of the bird, especially in the form of its hip-girdle and hind-limbs, on which, in the late Prof. Phillips's opinion, it moved with free steps, sometimes, if not habitually, claiming a curious analogy, if not some degree of affinity, with the ostrich. Another example is the still more gigantic herb-eating iguanodon, from beds in Sussex, taller than an elephant and vaster in size, wherein, also, are mingled avian and reptilian characters. In the form of its vertebræ, which, except in the neck, are double-cup-shaped, it is reptilian—in the absence of collar-bones it is non-avian; but in the formation of its three-toed hind limbs, which are larger than the fore, as well as of the supporting haunch-bone, it is distinctly birdlike. Again, it is unbirdlike in regard to its teeth, whose general form and crenated edges are somewhat like the iguanas', which now frequent the tropical woods of America and of the West Indies; but they differ from them in having a flat surface on the crown of the tooth, worn down evidently by the process of mastication, whereas the herbivorous reptiles of the present day clip and gnaw off, but do not chew, the vegetable productions on which they feed.

On the same sands at Hastings there have been found large impressions of the three-toed foot of some biped, the length of whose stride was so great that it is impossible not to conclude that they were made by the hind-feet of one or other of the seventy monsters whose bones have been found scattered about within the narrow area of what was once the banks and delta of a great Wealden river, and which, like the giant-lizards, probably walked occasionally, if not always, on their hind-limbs with their fore-feet elevated in front. The question again arises, nor is it easy to answer, whether these forms should be called reptilian birds or avian reptiles.

In the northern gallery of the British Museum there is a very instructive specimen of a reptile, the frilled lizard of Australia, caught near Port Nelson while perching on the stem of a tree. Its long tail recalls at once the same appendage in the kangaroos, inasmuch as by its position in the stuffed specimen the creature would seem to use it as a support to its body. Its fore feet are much smaller than its hind, and an Australian resident, to whom the specimen was shown in presence of Dr. Günther and himself—so Dr. Woodward tells in a paper read before the Geological Society—remarked that it not merely sits up occasionally, but habitually runs on the ground on its hind-legs without allowing its fore-paws to touch the earth. The edges of its jawbones are elevated into enamel-tipped denticulations, which remind us of those in the jawbone of the Sheppey fossil. In the same slates which have given us the long-tailed reptilian bird and the long-necked, birdlike lizard, there has been found a three-toed bipedal track which "reminded me," said Dr. Woodward, "at once of what the frilled lizard or the compsognathus might produce under favorable conditions. The slab presents a median track formed by the tail drawn along on the ground; the two hind-feet with outspread toes leave their mark, while the fore-paws just touch the ground, leaving a dot-like impression on either side of the median line. The median track is alternately stronger and fainter. Since the tail of the archæopteryx is bordered all the way by feathers, it will at once be seen that it could not leave behind a clean, simple furrow, but a broad smudge composed of many lines, while the tail of a lizard, progressing by hops and supporting itself on its hind-limbs and tail, would produce just such an impression.

There is yet another interesting group of extinct forms to which we would refer shortly, termed "winged reptiles, or flying dragons." In the Woodwardian Museum, at Cambridge, there is a large collection of these bones, belonging to many species, from the soft marl in the neighborhood of that town, about which there have been entertained the most diverse opinions by the most eminent naturalists. They have been variously held to belong to bats, to forms between birds and mammals, to reptiles, and even to dolphins. Prof. Huxley finds in them great resemblances to birds; Prof. Owen thinks that they are reptilian remains; while Prof. Seeley, judging from the form of the cranium, is of opinion that these flying dragons "had a brain indistinguishable from a bird's."

They are all remarkable for their great proportionate length of head and neck, for in some the lizard-like and in others the birdlike length of tail, and for the large size of the fore-limb, which, quite unlike the same extremity in a bird, was terminated by four digits, whereof three were clawed, while the clawless fourth or little finger was enormously elongated to support the outer edge of an expansion of the integument like the wing of a bat. The bones of the hind-limb and of the haunch differ widely from the bird type; nevertheless, air-passages, such as characterize no other kind of skeleton, are met with in the bones of the head, of the spine, and of the fore and hind limbs, often coinciding identically in situation with those in birds, and indicate, according to Prof. Seeley, a system of air-circulation from the lungs similar to what is found in birds. From this he argues the existence in these gigantic volants of warm blood, and of a heart similar to the bird's in construction. They have the breastbone broad, strongly keeled, and unlike that of other reptiles; there is evidence also that the jaws were incased in a horny sheath. On these considerations, therefore, it is held that, as far as the skeleton indicates, their differences from birds are much less than the differences between the several orders of mammals or reptiles. The same paleontologist has made careful casts of the interior of the skull, and, from the position of certain lobes whose distance or proximity distinguishes the brains of modern birds and reptiles, he says in an interesting paper on the subject in the Linnæan Society's "Transactions" for 1876: "The resemblance of form and arrangement of parts between this fossil animal's brain and the brain of a bird amounts, as far as the evidence goes, to absolute identity; no more perfect specimen could add to the force of the conclusion that its brain is an avian brain of a typical structure. Since brain and lungs are organs of incomparably greater value in questions of organization than fore and hind limbs—organs in which, according to Prof. Huxley, they depart most widely from the bird type—the flying dragons on the whole are very reptilian birds rather than very avian reptiles."

The Solenhofen stone preserves not only bones and hard parts, but even the cutaneous characters of its old inhabitants. It shows casts of the down and feathers, impressions of the fine foldings or wrinkles of thin expansions of naked skin, as well as of delicate tendons. Prof. Owen, therefore, thinks that if the flying dragons had possessed any plumose clothing it would in all probability have been preserved, and, as no such indications (but contrariwise, several genera undoubtedly had their body-covering hardened into bony scales, sometimes produced into prodigious spines) have been discovered, though the Oolitic mud has entombed the greatest number and variety of these beings, he concludes that they were cold-blooded, as other reptiles are; whereas, if they had been warm-blooded, they would have possessed feathers, as their contemporary the archæopteryx did; for the constant correlative structure with hot-bloodedness is a non-conducting covering for the body. Prof. Huxley, on the other hand, differing from this anatomist, thinks that, judging from the air-passages in their bones, they were warm-blooded, but that, nevertheless, they were reptiles with special modifications for special purposes.

It would, therefore, appear that we are again face to face with a group which the most eminent authorities are far from agreed whether to regard as reptiles or as birds.

We have now passed in review various remarkable forms—living birds and living reptiles, separated by an immeasurable distance from each other, and forms which have so mingled the characters of both as to present great difficulties to their being included among the members of either group. Starting from the groveling crocodile, we have seen that there existed gigantic crocodile-like forms, such as the giant-lizard and the iguanodon, that walked, sometimes at least, on their hind-limbs; others, like the long-necked, long-tailed compsognathus from the Solenhofen slates, that hopped on the ground after the manner of a bird; then "flying dragons," with birdlike brain and bones that cleft the air with their twenty-feet expanse of wing; next, undoubted birds, with toothed bills, the one with reptilian vertebræ, the other with a beaver-like tail; while last of all, omitting the imperfectly known Sheppey fossil, the feathered archæopteryx whose twenty caudal segments bar its entrance to every existing family of birds.

Without by any means asserting—what is not only far from being ascertained fact, but is indeed very improbable; for we are not in a position to state that they appeared on the earth intermediately between the two groups—that these forms are the direct terms in the series of progressions from reptiles to birds, we can, in their intelligent contemplation, without overstraining the imagination or violating our reason, picture still more modified forms wherein the reptilian and the avian types would so harmoniously blend that we should find it impossible to say, "At this point the line between reptiles and birds must be drawn." There can be no reasonable doubt but that the remains, which only through the circumstance of a happy burial have been preserved to us from the second great era of the world's history till now, are no more than a very few examples with many a blank between of the fauna which has lived and died, whose tombs no man knoweth. Moreover, it seems easy enough to believe, after studying these forms, that, could any human eye have followed from that day to this the waxing and waning of the various animal groups, he could have constructed for us a marvelous chain of existences between reptiles and birds, the conformation of whose unknown links we can almost fabricate in our minds, between which no abrupt transitions harshly jarring would occur, no stepping-stones too wide to stride across; and, handing on to us, besides, the traditions of a still earlier time, he could have pictured to us the whole of living Nature, each varied offshoot fitly joined together, sloping gently back along the vast converging lines of ordinary generation to one grand starting-point, wherein till the fullness of time every living thing, from the microscopic diatom to the giant sequoia, and from the shapeless amœba to the stateliest of bipeds—

"Lay hidden, as the music of the moon
Sleeps in the plain eggs of the nightingale."

—*Belgravia.*

THE PLANET VULCAN.

By Professor DANIEL KIRKWOOD.

THE discovery of an intra-Mercurial planet during the total eclipse of July 29, 1878, has given new importance to any previous speculations on the question of its existence. A brief historical review of the subject will not be without interest.

In an article by the writer, "On the Probable Existence of Undiscovered Planets," written immediately after the discovery of Neptune, and published in the *Literary Record and Journal of the Linnæan Association of Pennsylvania College*,[1] the question was thus considered:

"The distance from the centre of Jupiter to the nearest satellite is about three times the equatorial diameter of the primary. If, therefore, we suppose the distance of the nearest primary planet to have the same ratio to the diameter of the sun, the orbit of such planet will be somewhat less than 3,000,000 miles from the sun's centre. Consequently, in the interval of 37,000,000 miles there may be four planets, the orbit of the nearest having the dimensions above stated, and their respective distances increasing in the ratio of Mercury's distance to that of Venus. Such bodies, however, in consequence of their nearness to the sun, could hardly be detected except in transiting the solar disk."

It is well known that the disturbing influence of the other planets causes an advance in the position of Mercury's perihelion. In a century this change amounts to 1̇0′ 43,″ which, according to Leverrier, is 38″ more than can be accounted for by the influence of the known planets. This great astronomer inferred, therefore, that a planet, or possibly a zone of extremely small asteroids, must exist within the orbit of Mercury.

The conclusions of Leverrier were communicated to the French Academy in the autumn of 1859. Soon after their publication Dr. Lescarbault, an amateur astronomer as well as a medical practitioner of Orgères, some forty miles southwest of Paris, announced that, on March 26, 1859, he had observed the passage of a dark circular spot across

[1] Vol. iii., April, 1847, p. 131.

the sun's disk, which he thought might have been the transit of an intra-Mercurial planet. He stated further that he had delayed the publication of the fact in the hope of obtaining confirmatory observations. On the appearance of this statement Leverrier at once determined to seek an interview with the observer, in order to test the truth of his discovery. With the details of this interview the public is familiar. After a thorough examination of Lescarbault's original memoranda, as well as of his instruments and methods of observation, Leverrier was satisfied that the amateur astronomer of Orgères had really observed the transit of an intra-Mercurial planet. From the notes furnished by Lescarbault, the director of the Paris Observatory estimated the period of the planet at nineteen days seventeen hours; its mean distance from the sun, 13,000,000 miles; the inclination of its orbit, 12° 10′; and the greatest elongation of the body from the sun, 8°. The apparent magnitude of the solar disk, as seen from Vulcan's estimated distance, is fifty times greater than as seen from the earth.

The sun was again watched during the last days of March in 1860 and 1861, in the hope of reobserving the new member of the system. The search, however, was unsuccessful until March 20, 1862, when Mr. Lummis, of Manchester, England, between eight and nine o'clock A. M., observed a perfectly round spot moving across the sun. Having satisfied himself of the spot's rapid motion, he called a friend, who also noticed its planetary appearance. From these imperfect observations two French astronomers, MM. Valz and Radau, computed elements of the planet: the former assigning it a period of seventeen days thirteen hours; the latter, one of nineteen days twenty-two hours. From 1862 to 1878 the planet was not seen, or at least no observation was well authenticated. The transit of Mercury, however, on May 6, 1878, afforded new evidence of the truth of Leverrier's theory that Mercury's motion is disturbed either by a planet or a zone of planetary matter within his orbit.

We must now refer to a very unpleasant incident in the history of this interesting discovery. This is nothing less than the charge, by an eminent astronomer, that the observations and measurements claimed by Dr. Lescarbault were a pure fabrication. M. Liais, a French astronomer employed at Rio Janeiro by the Brazilian Government, claimed to have been engaged in an examination of the sun's surface with a telescope of twice the power of Dr. Lescarbault's, at the very time of the latter's alleged discovery of the planet. M. Liais says, therefore, that "he is in a condition to deny, in the most positive manner, the passage of a planet over the sun at the time indicated." The weight of this negative testimony has, perhaps, been over-estimated; and Lescarbault, who for eighteen years has quietly submitted to the charge of falsehood and dishonesty, may perhaps yet retort that, if M. Liais was examining the sun at the time referred to, his merit as an observer cannot be highly rated.

But the astronomer of Brazil did not stop with denying the truth of Lescarbault's observations. He boldly called in question the conclusion derived by Leverrier himself from a laborious discussion of the observed transits of Mercury. It now appears, however, that in this case also his position was most unfortunately taken.

It has been frequently said that if an intra-Mercurial planet exist, of any considerable magnitude, it ought to be visible during total eclipses of the sun. But who has not remarked the difficulty of finding a small or faint object when we know not where to look for it, and how easily it may be found when its position has been once pointed out? Mitchel's detection of the companion of Antares and Clark's discovery of that of Sirius are cases in point. Fortunately, however, neither argument nor explanation is any longer necessary. The new planet was undoubtedly seen during the total eclipse of July 29, 1878, by two astronomers, Prof. James C. Watson, director of the Ann Arbor Observatory, and Mr. Lewis Swift, of Rochester, New York. The former is the discoverer of more than twenty asteroids; the latter is an amateur, who has detected several new comets. Prof. Watson was stationed at Separation, Wyoming Territory. The planet was not found by him till half the time of totality was past. It was about $2\frac{1}{2}°$ southwest of the sun, and appeared about as bright as a $4\frac{1}{2}$ magnitude star. Mr. Swift, who selected a position near Denver, Colorado, took with him his excellent comet-seeker for the special purpose of searching for intra-Mercurial planets. Two stars were seen by him at the estimated distance of 3° southwest of the sun. They were of the same magnitude—about the fifth—and at a distance apart of six or seven minutes. A straight line drawn through them pointed very nearly to the sun's centre. Mr. Swift supposed one of the stars to be Theta Cancri. The other was doubtless the planet observed by Prof. Watson, although the estimated distance from the sun was somewhat greater. Both observers describe it as a *red* star. According to Prof. Watson, "it shone with an intensely ruddy light, and it certainly had a disk larger than the spurious disk of a star." Its appearance in the telescope indicated that it was approaching its superior conjunction, or, in other words, was situated beyond the sun.

The distance of Vulcan from the centre of the system, though still uncertain, is supposed to be about one-seventh that of the earth. If this estimate be nearly correct, the solar light and heat at its surface must be about fifty times greater than at the surface of the earth. The corresponding period is nearly twenty days. In other words, Vulcan's year is believed to be less than three weeks in length. The sun is twenty-five days in completing its axial rotation; so that in the new planet we have probably another instance in which, as in the case of the inner satellite of Mars, a planetary body performs its orbital revolution in less time than is occupied by the central orb in completing its rotation. Again, as seen from the sun's surface, all the old planets rise in the east and set in the west. But this is reversed in the case of Vulcan. It rises in the west, and, after having been fifty-seven days above the horizon of any point in which the plane of its orbit intersects the sun's surface, must set in the east.

But it is useless to speculate in regard to the elements of this planet's orbit, its magnitude, physical constitution, etc. It ought certainly to be found near its greatest elongation by some of the powerful telescopes now in use. When so detected a few observations will furnish data for the complete determination of its period and distance, together with the form and inclination of its orbit.

The interesting observations of Prof. Watson and Mr. Swift will not only stimulate astronomers to renewed search for the planet so fortunately detected, but must lead also to a more thorough examination of the space within Mercury's orbit. It is not improbable that the detection of Vulcan may be merely the first in a series of similar discoveries.[1] The solar disk will doubtless be closely watched about February 11th–17th, March 19th–27th, and October 1st–14th, as it has been claimed that at these epochs small round spots have been seen passing across the sun. In short, the prospect of planetary discoveries in this part of the system is at present more hopeful than in the space beyond the orbit of Neptune.

THE GENESIS OF DISINTERESTED BENEVOLENCE.

By PAUL FRIEDMANN.

DISINTERESTED benevolence, about the genesis of which so much has been written, is a name for two distinguishable things. It is in some cases meant to designate that feeling which prompts us in a special instance to do good to some individual object. In other cases, the same name is applied to the quality of the mind which predisposes to all special benevolent impulses. But these two are of course not the same thing, and when I inquire into their origin I shall have to consider them separately. This, however, I shall do in an order the reverse of that commonly adopted, beginning with the special sentiment, and then inquiring into the general quality of the mind.

Benevolence, in the first sense, may be defined as the wish that the object of this feeling may be well—as the wish for the welfare of something. In so far as, with a certain class of beings, welfare is accompanied by pleasure or happiness, benevolence is a wish for the

[1] It has frequently been noticed that astronomical discoveries occur in clusters, separated by intervals comparatively fruitless in great results or important observations. Thus, from the epoch of Cassini's discoveries to that of Sir William Herschel's—nearly a century—no new planets, primary or secondary, were added to our system.

pleasure or happiness of the object. But I should think it a great mistake to define it in this latter way. It would reduce the field of benevolence by excluding all inanimate beings, and make the definition far too narrow. Benevolence, I assert, can be felt quite as well toward inanimate, non-sentient beings as toward sentient organisms. It can be felt toward any being of which it is believed that its welfare or perfection can be procured. As the parent toward his child, the master toward his dog, so the sculptor feels benevolence toward his statue, the author toward his book. The perfection of it makes him happy, its imperfection or destruction causes him pain. Whether the object is a living being or not, whether it is real or imaginary, the sentiment of benevolence is the same in all cases.

Disinterested I shall call such benevolence, if its origin cannot be traced directly to some egoistical motive or to some other moral or æsthetic feeling. Gratitude, which is dictated by a feeling of equity, admiration, which takes its origin in an æsthetic judgment, or the aversion to inflict pain, which is the result of our habits, I shall not call disinterested benevolence, and in this short essay I do not inquire into their origin.

To explain the growth of the special sentiment of disinterested benevolence I must assume a certain number of qualities of the mind, the existence of which, however, has generally been admitted. Whether these qualities are native or acquired is here of no importance; all I require is that they be found in man very soon after his birth. These qualities are, first, the impulse toward self-preservation and self-augmentation inherent to every living organism, and without which it could not exist and develop itself; the wish to be and to be more and more, in a word, to grow. The second quality of mind which I have to assume is the consciousness of existing, not only as a passive sentient being, but as an active being too. And these two qualities once admitted, there follows from them a third, which is the wish to exist as an active being either actually or potentially, to be either acting or capable of acting—the wish for power. The fourth quality is that known under the name of capacity of associating ideas, and the fifth the capacity and tendency of the mind to fuse or confuse such associated ideas, so as not to distinguish them any longer from one another. The first four qualities just enumerated have long ago been generally admitted and amply illustrated. The fifth, that of confusing ideas, has likewise been admitted; it has even been most admirably illustrated in the works of many a philosopher of great repute, but I am not aware that its importance for morals has ever been sufficiently insisted upon.

The specimen case of confusion is that between the ego and the body. All men in early life confuse the two notions of self and body, and most men continue to do so forever. Here already the confusion produces a kind of disinterested benevolence; we feel well inclined toward our body irrespective of any advantage to ourself.

But it is not from this simplest form of the mental quality that moral benevolence takes its rise. Besides the confusion just spoken of, there is another, the outflow and consequence of that between body and mind, nearly as common among children and uneducated men. It is the confusion between the acts of ourself, of our mind, and those of our body; between intended effects and willed acts.

This confusion is to be found in the laws of all rude and semi-barbarous nations. Their criminal codes punish the result of an act irrespective of the intention of the agent; they make, for instance, no difference between murder and manslaughter. In more civilized countries, where generations of lawgivers have for centuries developed the theory of criminal responsibility, the law is even now far from perfect. The result of an act, even when not intended, continues to be taken into account for punishment. A man who would be let off with a small fine for an illegal act producing no direct harm would be fined more heavily, or even imprisoned, if by such an act some harm were unintentionally done. Even if the legislator wished to correct this irrational state of the law, the general opinion of the uneducated majority would prevent him from doing so. It will be long ere the theory of criminal responsibility is generally understood.

But if in criminal law, which it is the interest of so many persons to clear up, the confusion still exists, how much the more will it continue in those matters where no great interest is at stake! If a man kills another man, fear of punishment, fear of his own conscience, will prompt him to consider whether the death was intended or not, whether he is guilty of murder or of simple manslaughter. But, if a man by mere chance does some good to another man, there is nothing which incites him to a similar mental effort, while on the contrary the agreeable sense of power which the consciousness of the effect produces, the gratitude of the benefited individual and the approbation of society, will make the idea that he is the author of the benefit pleasant to him and prevent him from too closely analyzing his motives. He will easily assume that he is the author of the benefit, and so it happens that, when an act of his body has produced a beneficial result upon some one else, an average man thinks that he himself has done good to that individual.

From this confusion real disinterested benevolence will take its origin. The agreeable sense of power, produced by the unintended beneficial effect, will continue as long as the agent can remember that effect. This, however, will only be the case if the benefit persists for some time, so that it may hereafter be remembered, and it will be all the more the case if that benefit continues for a long time so as to be actually perceived. There is, then, an inducement so to act that it may persist. This inducement is of course very weak at first, and will produce no action if there is not a considerable spontaneous energy. But there is already a germ of benevolence, the wish that a benefit conferred upon some individual may subsist. And if this sentiment under favorable circumstances produces further action, this time intentional, it will become stronger thereby; far more power is felt to be exerted, and more interest is consequently felt in the effect. The wish to maintain the effect increases in proportion to the exertions already made, and it may finally become strong enough to overcome counteracting influences of considerable moment.

But this is not all. As it is a condition of the persistence of the beneficial effect, that the being upon whom it has been produced continues to exist, a secondary wish, very slight at first, will be generated, that the whole individual may continue to be. At the same time that the wish for the persistence of the beneficial effect becomes stronger, this secondary feeling augments and may produce action tending to the conservation and the welfare of the individual benefited. But, as soon as the fact is realized that good has been done to the whole individual, this new secondary benefit will become the starting-point of a growing disinterested benevolence, directed no longer toward a single quality but toward the whole being. The secondary feeling may now grow much quicker than the primary one, which may in due time be entirely forgotten, and nothing will remain but true disinterested benevolence toward the individual. A benefit conferred by mere chance has produced true devotion.

To illustrate my meaning, which otherwise might remain obscure, let me adduce an example: A man had to throw away some water, and, stepping out of his house, threw it upon a heap of rubbish, where some faded plants were nearly dying. At that moment he paid no attention to them, took no interest in their pitiable state. The next day, having again some water to throw away, the man stepped out at the same place, when he remarked that the plants had raised their stems and regained some life. He understood that this was the result of his act of the day before, his interest was awakened, and, as he held a jar with water in his hand, he again threw its contents over the plants. On the following day the same took place; the benevolent feeling, the interest in the recovery and welfare of the plants augmented, and the man tended the plants with increasing care. When he found one day that the rubbish and plants had been carted away, he felt a real annoyance. The feeling of the man in this case was real disinterested benevolence. The plants were neither fine nor useful, and the place where they stood was ugly and out of the way, so the man had no advantage from their growth. Nor had the man a general wish to rear plants, for there were a number of other plants sorely in want of care, but to which the man did not transfer his affection. He had loved those individual plants; the benevolence toward the effect he had at first produced had by confusion become benevolence toward the plant itself, and the first feeling had been entirely forgotten.

In this case there was a complete confusion between the effect and the recipient of it, rendered easy by the fact that, by continuing the special benefit, the whole welfare of the plant was assured. But such is not always the case. If the benefits have all been of one and the same kind, if the benefactor has been prevented from extending the sphere of his beneficial action, the feeling of benevolence will remain in its primitive state, directed toward one quality of the individual. However strong it may become, it will never extend to the whole being.

Cases of this kind are by no means rare, but they are generally misunderstood. We assume that A feels benevolence toward B, and that, if he lays so much stress on a single quality of the latter, this arises from an error of judgment as to what is good for B. In reality the error of judgment is ours, and the man whose folly we condemn is intellectually quite in the right. Having never learned to love B, but only to love one of his qualities, A favors this latter even to the detriment of the holder.

In the first example adduced by me, benevolence took its origin in a chance act, no effect at all having at first been intended. This is not necessarily the case. A benefit may be intended in a limited degree, for instance, as an equivalent for a benefit received. The spring of action here is gratitude, based on equity. But, while this benefit is conferred, a benevolent feeling, first, toward the special quality furthered, and, finally, toward the whole individual, may arise in exactly the same manner in which it arose from a chance act. Gratitude will be forgotten, and disinterested benevolence felt instead. One moral feeling has here given rise to another; equity to disinterested benevolence. In our social system this latter genesis will be most common; it is only where social relations are rare that benevolence will commonly be produced as a consequence of a chance act. But, in all cases it will be a necessary condition to the perfection of the feeling, that it be extended to the whole individual, as else it may often tend rather to injure than to favor this latter.

My meaning, I hope, is now sufficiently explained. It remains to be seen how far my theory is in accordance with the known facts about benevolence. For this I hold to be the indispensable test of every psychological theory—that it will offer an easy explanation of the facts known from experience; and this test I shall now apply.

The strongest feeling of benevolence on record is probably the love a mother bears to her infant child. The strong feeling that she has given it life, that the child is her creation, explains the energy of the affection. This is further strengthened by the consciousness, that by nourishing and tending her child she confers constantly new benefits, indispensable to its welfare. But, as the child grows up, this benevolent feeling may, with mentally undeveloped persons, lose much of its power. When the child becomes independent, when it is no longer in want of the maternal care, the maternal affection will cool down or turn toward a younger child still in need of its mother's help. This is already apparent in the lower races of mankind, but much more so among the higher animals. Among these latter a mother will risk her life to defend her young, but, when they are grown up, she does not care for them in the least.

Among uneducated people paternal affection is seldom very strong toward an infant. Some culture of mind is necessary to realize all the indirect benefits the father at first confers. But, when the direct influence becomes considerable, the paternal affection augments and may assume a very great energy. Among animals paternal affection, I think, exists only in those species in which the father assists the mother in rearing and feeding the little ones, as, for instance, among birds.

During the proscriptions of Marius and Sulla, there were many sons who out of fear gave up their father, but it was never known that a father had denounced his son; a fact that somewhat startled the Roman moralists, who were unable to explain it. Upon my theory the explanation is easy enough. In Roman society the son could confer no benefit upon his father, and the mere feeling of gratitude for the benefits received from the parent was not sufficient to counterbalance the fear of the bloody edict. Filial affection can indeed become very strong, but, whenever it does, it is easy to perceive that the parent has in some way become dependent on the child—has received benefits from him.

The relations between man and wife are such that the two are called upon to complete one another—that they have a fair opportunity of conferring great benefits without a corresponding sacrifice or exertion. The facility renders the feat all the more attractive, and strong affection follows upon it.

That friendship is based upon numerous mutual benefits is a fact daily seen. Prevent a friend from doing you good, impress him with the idea that he is of no use to you, and his affection will cool. But ask a man for little services he is ready to render, let him know and keep in his mind that he has conferred a benefit upon you, and he will like you all the more for it, become interested in your welfare, and finally feel real devotion for you. I have never known the experiment to fail.

In public life those who receive the greatest benefits from the community are not the men most ready to make any sacrifice for the general good. Patriotism, I think, is not exactly rampant in workhouses, though the inmates owe everything they enjoy to the munificence of the public. The pauper who has done no good to his country, who, on the contrary, is a continual burden to it, feels no benevolence toward it.

On the other hand, a man in the higher ranks often enters the public service, either to earn in an easy way a sufficient income or out of ambition, and in order to gain fame. If such a man by his energy or by some distinctive talent becomes useful to the state, in most cases he will become a really patriotic citizen. The official will devote more than the strictly due time and energy to the fulfillment of his task, the statesman will give up his personal ambition, and often risk what must be dear to him, popularity and power, in order to carry the measures he thinks necessary to the welfare of his country.

And when some extraordinary man has made a discovery, has introduced a measure or proclaimed a truth beneficial to the whole world, the sentiment that he has been useful to so many millions of people gives a distinctive character to his benevolent impulses. Such a man, the benefactor of humanity, will refuse his sympathy to no part of it ; he will at once feel benevolence toward any man with whom he comes into contact. He knows that he has done him some good, and is well inclined toward him.

I hope I have now shown that my theory agrees with the facts known by experience, that it can bear the crucial test. That being so, I think myself entitled to hold that the genesis of every single benevolent sentiment is that some good is done to an individual, either unintentionally or from another motive than that of disinterested benevolence, as from gratitude, sense of equity, religious feeling, or hope of advantage, and that, the benefit itself being loved by its author, this love or disinterested benevolence is by confusion extended to the individual upon whom the benefit has been conferred and maintained. It now remains for me to explain how, from single benevolent feelings, there arises a general benevolent disposition, how the benevolent character is formed.

I think we shall again have to trace back the origin of the benevolent disposition to confusion. After having felt benevolence toward a number of individuals of a class, we come to confuse them with one another, and to transfer part of our feeling to the whole class. When any member of it presents itself, benevolence is at once excited.

That such is the case will appear more clearly if we remember how often we are favorably disposed toward a perfect stranger, simply because in his outward appearance, his manner, his voice, or any other characteristic, he is like some other person we love. We have a confused but strong benevolent feeling toward a cluster of attributes belonging to the friend we have learned to cherish. Some of these attributes are suddenly and strikingly presented to us, and we feel well inclined toward them. We confuse the attributes with the present possessor of them, and benevolence is felt toward the stranger. In this case the genesis is so clear, the confusion so glaring, that they cannot be overlooked. In other cases they will not be so apparent, but the process will be the same. The cluster of attributes—man, Englishman, or man of a certain type—is liked, because a number of persons dear to us possess these attributes. Men of another type or nation are often not liked at all, even by such people as are generally considered benevolent. The difference in this case is stronger than the likeness, and no confusion is made. What holds good of men holds good equally of all other beings. I have observed this genesis in myself; formerly rather hostile to dogs, now that I have a dog myself, I feel well inclined toward the whole canine species, but most to that part of it which has some characteristic feature in common with my favorite. This, then, is the genesis of the benevolent disposition, that, after having by confusion become well inclined toward certain things, we feel the same benevolence toward each of their attributes; when we find these attributes in other things, we feel equally well inclined toward them, and by confusion extend this benevolence to the individual possessing the attribute. Hence it follows that the greater the diversity among the individuals toward whom we acquire a benevolent feeling when young, the wider the range of our sympathies, of the benevolence we feel at once toward those with whom we come in contact—a fact of some importance in educational science.

I do not know whether I shall have convinced my reader of the soundness of my theory. Limited space and an inadequate power over the language may have prevented me from attaining this end. But the question is so important that even the mere suggestion of a possible theory might be accepted as of some use toward the final solution of the problem, and as such I offer the foregoing pages.—*Mind.*

SKETCH OF CLAUDE BERNARD.

CLAUDE BERNARD died at Paris, in February, 1878, in the sixty-fifth year of his age. The nineteenth century produced Magendie, Flourens, Johannes Müller, Charles Bell, Marshall Hall, and others, who made great discoveries in human physiology; but none of these great men did more for the advancement of knowledge in this direction than the subject of our sketch. Bernard was a pure physiologist; and, in his day, he was recognized as the great exponent of the experimental school. His name is connected with important discoveries in nearly every department of human physiology, and the influence of his method has borne fruit wherever this science is studied.

The career of Claude Bernard is a most interesting and instructive chapter in the history of the progress of physiology for the past thirty-five years. The accounts of his life which have appeared in the French journals give little information with regard to his early life. It is simply stated that he was born in the village of Saint-Julien, near Villefranche (Rhône), on the 12th of July, 1813, where he studied pharmacy. When about twenty-one years of age, he went to Paris with the manuscript of a tragedy. He had written a *vaudeville*, which had been represented at Lyons; it is not said with what success, but probably he had been encouraged sufficiently to lead him to seek for fame as a playwright. Upon his arrival at Paris, he formed the acquaintance of Prof. Saint-Marc Girardin, who induced him to give up his purely literary aspirations, and to enter upon the study of medicine. In 1839 he became an *interne* in the Paris hospitals, where his remarkable talents were soon recognized. Very early in his career he published a large and superbly illustrated work upon "Operative Surgery," in connection with M. Huette. This work was translated into many foreign languages, and met with great success; but his distinguished reputation as a physiologist, which dates from about 1848, afterward became so extended that his writings upon surgery have almost been forgotten.

In 1843 he discovered the nerve which gives the sense of taste to the anterior portion of the tongue.

In 1844 he made important advances in the knowledge of digestion by the stomach, following the discovery of the properties of the gastric juice in 1833, by Dr. Beaumont, an American physician.

In 1848 he discovered the production of sugar by the liver, which had not before been even suspected. At about the same time he discovered the digestion of fats by the pancreas, a fact of great physiological importance.

In 1844 he discovered the nerve which presides exclusively over the voice.

In 1847 he fully described, for the first time, the digestive properties of the secretions of the different salivary glands.

About 1853 he devised an accurate method of estimating the gases of the blood, and he did more than any of his predecessors to advance our positive knowledge of the process of interchange of gases in respiration.

His researches in the physiology of the nervous system were most extensive. He did more than any one before to illustrate the mechanism of secretion and excretion, and the influence of the nervous system over the action of glands. He was the first to fully and accurately describe the properties of the woorara poison, which is now so largely used in physiological research. It would be impossible, within the limits of this sketch, to give a comprehensive and intelligent account of Bernard's original investigations. Within the last twenty-three years he has published fifteen volumes upon subjects connected with physiology, embodying the results of his original work. He constantly and powerfully advocated the experimental method, and his dexterity in vivisection was truly marvelous. While he was at the zenith of his fame, nearly all physicians who visited Paris attended his lectures or witnessed the experiments in his laboratory. To all he was uniformly courteous and communicative; and the success of the demonstrations with which his lectures were profusely illustrated created the greatest enthusiasm. Between the years 1859 and 1865 he published very little, being in feeble health. During this time his thoughts must have been directed more toward general physiology than before; and the first volume of lectures, published after his health had become partially restored, was more philosophical in its scope than his earlier writings. Still, his tendency was always toward original investigation, and, in his reasoning, he closely followed the deductive method.

It is difficult for one who has not followed closely the progress of physiology for the past quarter of a century to appreciate the full merit of the original work accomplished by Bernard, and the immense influence which he and his followers have exerted by the impulse they have given to the experimental and deductive method. His studies in the nervous system resulted not only in a number of important discoveries, but in the adoption of many entirely novel methods of experimentation. His discovery cf the production of sugar by the liver gave the first definite idea of the possible function of a ductless gland. The discovery of the digestion of fats by the pancreas gave to physiologists the first positive fact with regard to intestinal digestion. The discovery of the influence of the sympathetic system of nerves over animal heat, made in 1851, opened the subject of the relations of the nervous system to nutrition and the action of the vaso-motor nerves; and examples of this kind might be largely extended in number.

The importance of the labors of Bernard was fully recognized in France, where he long held the highest professorial positions, and was the recipient of many honors from his government. He was assistant and prosector to Magendie from 1841 to the time of the death of Magendie in 1855, and acted as his substitute at the College of France from 1847 to 1855. In 1843 he took his medical degree. In 1853 he took the degree of Doctor of Sciences, and was appointed to the chair of General Physiology which was created for him at the Faculty of Sciences. In 1855 he succeeded Magendie as Professor of Medicine at the College of France. In 1868 he was appointed professor at the Museum of Natural History. He was elected a member of the Academy of Medicine in 1861, perpetual President of the Society of Biology in 1867, and a member of the Institute of France in 1869. In 1867 he was appointed commander in the Legion of Honor, and Senator of France in 1869. At the time of his death he was a member of most of the learned societies of Europe, and of several in America. In the French Chamber of Deputies, when his death was announced, his memory received the unusual honor of a unanimous vote decreeing that his funeral be conducted at the expense of the state.

Such, in brief, was the career of one who was the greatest physiologist of the nineteenth century. His labors extended over a period of thirty-five years. They were untiring and most fruitful in practical results. It may be truly said that he ended his work only with his life, and he corrected the last proofs of a series of lectures, published after his death, upon the bed of sickness from which he never arose.

EDITOR'S TABLE.

THE SCIENTIFIC ASSOCIATIONS.

THE American and British Associations for the Advancement of Science have again assembled in their customary annual meetings, the former in St. Louis, and the latter in Dublin. The American meeting was not large, its location being unfavorable to draw people from remote distances in the heat of August. But a fair amount of work seems to have been done, as those who came were interested and active men in their several departments of science. The chief event of the session seems to have been, as it undoubtedly should be, the delivery of the presidential address. President Newcomb wisely chose a topic of general interest, and, moreover, did not hesitate to enter boldly upon the discussion of questions of a high philosophical character, and concerning which the mind of the age has by no means settled down into the repose of unanimity. He considers the scientific method of thinking, as contrasted with the theological method, and pictures the progress of scientific thought in clearing away the old theological interpretations of Nature, and giving us a new and truer view of the realities and method of the universe. The doctrine of teleology, of final causes, or ends to be secured in the economy of Nature is instructively discussed, and the influence of science in doing away with this mode of viewing the course of things is well pointed out. The addresses given before the sub-sections of the Association were meritorious on their several topics, and we are glad to see that Prof. Grote, in his address on "Education as a Succession of Experiences," went into the grounds of scientific education, and made a forcible appeal to the body to take a deeper interest in the work of diffusing science and bringing its influence to bear more directly upon the schools of the country in respect of their scientific teaching. He says:

> "The demand has come up from teachers throughout the country that they should be better informed as to the manner in which the sciences may be introduced into the schools, and the matter to be taught. It is the duty of this Association to furnish such information. If we have not sympathized with this inquiry in the past, let us assist it in the future. It is quite evident that the sooner it commits itself, as a matter of principle, to the furtherance of science among the people, the more following it will have and the greater influence. The Association must be prepared to demand more time for scientific studies from the public school authorities, and it must show that education in this aspect of it is a matter that not only falls properly under its cognizance, but which it is also prepared to take hold of."

These are wise and weighty words, and we hope they will be heeded in conducting the future operations of this body.

The British Association had a large and successful meeting in Dublin, to one feature of which we desire to call attention, as worthy of imitation by the American society. The British Association admits members each year called "associates," which may consist of strangers, citizens, ladies, or anybody who wishes to join without any regard to scientific qualifications. They, of course, take no part in the business, and merely enter into social relations with the body for the time being, but they pay the same fees as regular members. Five hundred associates joined in Dublin, which not only gave fullness to the attendance, and increasing interest to the proceedings, but secured $2,500 to the treasury to aid in the various projects of the search which it is one of the aims of the organization to carry out. President Spottiswoode's address was an elaborate and excellent performance, treating first of the history, influence, and policy, of the Association with which he has long been connected as treasurer, and then taking up the subject of mathematics, which is the specialty he cultivates. His treatment of this subject is highly instructive, and at the present time most opportune. He not only presents very forcibly the general interest and claims of the subject, but he takes up certain curious aspects of it that have recently excited much curiosity and attention, and among these the perplexing topic of the fourth dimension of space. His address in full, together with that of Prof. Newcomb, will appear in the next issue of THE POPULAR SCIENCE MONTHLY SUPPLEMENT.

THE STUDY OF PROTOPLASM.

WE print this month the third and last installment of an introductory essay on the nature and properties of protoplasm, by Dr. Montgomery. The author has made this subject a matter of observation, experiment, and profound reflection, for many years; and his views cannot fail to receive the critical attention of philosophical biologists. Dr. Montgomery is deeply impressed with the immense scientific importance of this comparatively new field of exploration, and we think he does not in the least exaggerate the serious interest of the questions opened by this line of study. Protoplasm is the physical basis of life, and its problems are the initial problems of life. Protoplasm is a living substance endowed with capacities of vital movement, and the question of the origin of life is narrowly and sharply a question of the origin and production of protoplasm. It may never be answered, and many think it would be a dreadful thing if it should be answered. All other mysteries of Nature, they hold, may be properly explored, but to explore and explain this is nothing short of stealing a divine secret. Yet if the mystery can never be cleared up, as they assure us, then surely there is no harm in probing it; while, if it can, the fact itself is proof that it ought to be done, and that no harm will result.

But, whatever may be the final event, Dr. Montgomery has at any rate put the issue in a nice little nutshell. There is a gulf between the organic and the inorganic worlds which we are impressively assured is broader than the Pacific, and can never be fathomed; Dr. Montgomery says that, by the chemical substitution of an atom of hydrogen for an atom of oxygen, it will disappear. He remarks:

> "Is not protoplasm a chemical compound like other substances, merely varying from them in its degree of molecular complexity? Its most characteristic manifestation, its distinguishing mode of motion, its peculiar force—the one specific activity constituting its most vital difference—is better known to us than any quality which forms the distinguishing feature between other substances. Do we greatly concern ourselves about the origin of MgO,SO_3+7H_2O, or any other mineral substance? Why, then, should the origin of some combination of C, H, N, O, be made a question of the life and death of our principal philosophies? Has it actually come to this, that the scientific foundation of our creed rests on the decision whether COO is or was once changed into CHO by natural or supernatural means; and this when there is plenty of H about in our world? Yes, it is even so, however incredible, however little flattering to our intellectual pretensions. The contending claims of naturalism and supernaturalism, the fate of the most momentous question touching the guidance of our life, turn actually, in the field of science, upon the paltry issue of the synthesis of ternary carbon-compounds, whether this be chemically or whether it be super-chemically effected. COO is undisputably an inorganic compound. CHO is indisputably an organic compound. This designates accurately the actual depth of the gulf existing between organic and inorganic Nature."

YELLOW FEVER, AND WHAT TO DO ABOUT IT.

The rapid spread and appalling mortality of the yellow-fever plague in the towns of the Lower Mississippi have profoundly moved the sympathy of the country, and very naturally raised the urgent question as to what shall be done in so fearful an emergency. Governor Bishop, of Ohio, has made a proclamation, calling upon all the Christian people of his State to assemble in their houses of worship at a given date, and offer their united prayers to Almighty God, imploring him to interfere and stop the pestilence. It seems to us an entirely proper thing to appeal to religious feelings on such an occasion as this; but it should be done in such a way as not to evade the lessons they teach, and we trust it will not be thought ungracious if we point out Governor Bishop's presentation of the case as seriously at fault. Moreover, he brings science into the case in a way that is open to objection.

There are different views in regard to the expediency of such public action as Governor Bishop has taken. Many think it does more harm than good, but that depends entirely upon the way it influences human conduct. If reliance upon Divine help, which, it is supposed, can be especially secured by conspicuous demonstrations of public prayer, has the least effect in checking human effort, such action as that of Governor Bishop is injurious. Only when prayer quickens human exertion in such instances as this is it beneficial; if substituted for it, it is ill-judged and detrimental.

This is simply the dictate of common-sense, which enlightened rulers have already acted upon. It is well known that when the Scotch Presbyterians petitioned Lord Palmerston to appoint a day of national prayer, to induce the Almighty to stretch forth his hand and stop an epidemic, his lordship declined to do it, on the rational ground that, until the people had done everything in their power to prevent it, it would be impertinent to call upon Providence to interfere; in other words, they had no warrant to ask him to protect them from the consequences of their own neglect.

The Ohio governor does not proceed upon the sensible view of the British premier. He assumes the incompetency of science and the insufficiency of human effort, both of which he declares to be "unavailing" to arrest the plague; and, these agencies having failed, he proposes, as a last resort, to utilize "the intervention of Almighty God."

But it is not true that human science and human effort have proved unavailing. They have indeed not stopped the yellow fever, but does Governor Bishop assume that they have been thoroughly tried, and accomplished every thing that is humanly possible? But they *have* proved availing and greatly efficient in checking the pestilence and diminishing its fatality; and to deny this is to convict the whole nation of folly in the exertions it has put forth to limit the ravages and mitigate the sufferings of the plague-smitten districts. Yellow fever may not now be wholly preventable, but nobody denies that it is partially so; and nobody knows the degree to which it may be repressed and escaped until far more vigilant, efficient, and comprehensive measures of precaution are resorted to than have yet been undertaken.

But, besides basing his action upon a wrong theory, which is to invoke miraculous intervention, to obtain that which can only be procured by natural means, Governor Bishop's view is, besides, not in the highest sense reverential and religious. He instructs the pious people of his State to ask the Almighty to stop the devastating progress of the plague, as if that progress was not in perfect accordance with providential intentions. To ask the Deity to interfere in this way is to counsel him to reverse his own plans, and abandon that method of governing the world through the operation of inflexible laws which all truly religious people must regard as the Divine method. Ohio wisdom suggests to Divine Wisdom such a change of policy as, if carried out, would simply turn order into chaos. There may be many things about the providential government of the world that we cannot explain, but it is not difficult to see the large benignity of severe and inexorable punishment for violated laws. In nothing is the sacredness of these ordinances so attested as in the death-penalties that follow their transgression.

Governor Bishop arraigns human science and human effort as having failed to stop the progress of this scourge, and says that now the only hope is God's promise to answer prayer. But has not prayer—fervent, agonizing, soul-rending prayer—been already resorted to day and night in the private closet, and at the family altar, as well as in the places of public devotion, and that, too, all over the land? Yet the epidemic has not been stayed. Why did the governor not rank all this impassioned supplication with the other failures which he offers as reasons for *his own* intervention. And, if he has faith in the efficacy of a State-appointed appeal to Heaven, why did he postpone the demonstration for a week, when hundreds are dying daily?

We are far, as has been already said, from condemning the appeal to religious considerations and influences in an extremity like this, but it should be put on enlightened grounds, and become a means of incitement to nobler action. Prayer is efficacious just in proportion as it reacts upon the suppliant to inspire a higher activity, and in this way it may become a potent agency for moving men in great emergencies. This being the true point of view, in place of the proclamation issued by Governor Bishop, we should have preferred to see something like the following: "Whereas, a plague is desolating various Southern cities, which all means hitherto adopted have failed to arrest, let the devout people of Ohio gather in their several places of worship without delay, and, reverently recognizing the Divine wisdom in this fearful dispensation of suffering, humbly confess their sins of neglect and omission, their ignorance, carelessness, and culpable apathy in regard to all sanitary matters, and their want of quickened sympathy with the afflicted communities, and register solemn vows to Heaven that they will at once enlarge their measures of help to the devastated towns, and will in future be more vigilant and faithful in discharging the religious duty of guarding and promoting private and public health."

COOKERY AND EDUCATION.

We are getting familiar with the closer collocation of these hitherto widely-separated ideas, and their permanent unification in our common thought will constitute an important step of progress in domestic improvement and social amelioration. It will be slow work to connect cookery and education in this country, and attempts to bring about its practical accomplishment will meet with many impediments. Meantime we hail with satisfaction every indication that this desirable result is being attained anywhere. If our English friends are to be the pioneers in this most useful movement, let them have the honor of it. We notice that the following paragraph is going the rounds of the papers:

> "Regular instruction in practical cookery is a part of the new system in the public schools of London. In every girls' school in which domestic economy forms part of the school course, one of the teachers is required to give lessons on food and its preparation; and for advanced classes twenty-one kitchens are to be established in different parts of London, each of them fitted with suitable appliances, and to be presided

over by a practical teacher of cookery. This is a comparatively recent innovation, and has only been adopted after a sharp struggle."

Of course no such measure could be adopted except after severe struggle. The time in schools and the ground in education are all occupied, and new subjects are resisted instinctively by those in control of existing schools. The London advocates of the cooking-schools made a strong point by representing that, while the school board was spending a great deal of money for ornamental studies, the knowledge of the arts and interests of common life was dying out among young people. This does not imply that these practical arts have ever had a fair chance in the schools, but that absorption in other subjects stifles even the ordinary interest that would be felt in more useful studies. The difficulty in linking cooking-schools on to the common schools is, that the practice of cookery is not regarded as education, and this is but a part of the old notion that nothing practical or manipulatory is properly education. There was once the same objection to considering practice in the chemical laboratory as truly educational work. That prejudice has been gotten over now; but what is a kitchen but a chemical and physical laboratory where intelligence ought to be developed in connection with practical processes? Culinary changes go according to law as well as transformations of matter anywhere else, and they just as much require cultivated thought to guide them. No doubt a brainless automaton in a kitchen may by long practice and mere imitation acquire a certain successful facility in work, but this has always been the case in all the arts. Mind has come in play and the advancement of other arts to such an extent that to go back now to mere blind, imitative practice would be almost to abolish them. The art of preparing food is still in the empirical condition, and, what is worse, is generally abandoned to a specially ignorant class. We have no sanguine hopes about the renovation of the kitchen by the better teaching of the culinary art, but the work is nevertheless thoroughly begun, and is certainly to go steadily, though perhaps slowly, onward.

LITERARY NOTICES.

INTERNATIONAL SCIENTIFIC SERIES, No. XXIV.

A History of the Growth of the Steam-Engine. By Robert H. Thurston, A. M., C. E., Professor of Mechanical Engineering in the Stevens Institute of Technology. New York: D. Appleton & Co. Pp. 490. Price, $2.50.

In the preparation of this work Prof. Thurston has made an important contribution, alike to the excellent series of works of which it will form a part, and to the historical literature of the arts and sciences. There was a niche for such a book, which ought to have been filled before. We have had many works on the steam-engine, from elementary catechisms to ponderous treatises, all of which have given more or less attention to its origin; but there was still wanting a volume that should tell the entertaining story of the growth of this wonderful machine in a way to interest the popular mind without impairing the dignity or diminishing the instructiveness of the narrative. Prof. Thurston may be congratulated on having executed his task in a manner not unworthy the remarkable interest of the subject.

And this, it must be confessed, is saying a good deal, for the steam-engine is unique and incomparable both in its present position of commanding influence, and in the romantic elements of its historical development. It is now the most powerful agency the world possesses for the improvement and extension of civilization, and its noble efficiency in this respect is but a measure of the immense intellectual labor that has been expended in producing it. It was not struck out by the creative genius of any one man, nor constructed by the combined inventive effort of any one age, but it is a product of centuries of mental exertion; and, looking back to its crude beginnings and tracing the slow stages of its progress, we may take its condition at any time as indicating the progress in man's knowledge of the laws of Nature. It has grown with the growth of science and the advance of the human mind.

It was known thousands of years ago that, when fire is applied to water, vapor is formed that is capable of producing mechanical effects, and centuries before the Christian era attempts had been made to use this force in impelling a machine. The revolving Æolipyle of Hero, the Alexandrian, was a toy for a thousand years. During the middle ages many a mechanical genius played with it, but in vain, for there was no knowledge, and consequently there were no valuable results and no progress.

With the modern awakening of inquiry the subject was pursued by many ingenious experimenters, in different countries and at different times, until at the beginning of the eighteenth century so much had been found out about the properties of heat, water, and air, and so many devices had been hit upon to apply them, that it became possible to combine the different elements into a steam-machine that could perform work. Newcomen's engine of 1705 embodied the ideas and artifices that had been previously gained, and, though very imperfect, was still available for useful mechanical effects. The steam-engine then first became a fact and a success.

From this time onward, to the patenting of Watt's double-acting engine in 1769, was a period of great activity in improving and developing the machine. Scientific research led the way in working out chemical and physical principles, and inventors were busy in perfecting and combining contrivances which were crowned by James Watt, who, by introducing the principles of separate condensation and double-action, gave to the steam-engine its modern form and made it available for innumerable applications.

After Watt's great success we have a hundred years of still further improvements and refinements in the mechanism, and an enormous extension of its uses. From a contrivance supposed to be mainly valuable for pumping water, it became a universal motor equally valuable for manufacture and for locomotion on sea and land.

But, though it has been greatly perfected, the steam-engine is confessedly still imperfect. It has been undergoing steady improvement in recent years, and its theory is now so well understood, through the refined elucidations of physical research, that the pathway of future improvement is clearly discerned by sagacious engineers.

The history of the growth of this remarkable mechanism, that has now become so potent in the operations of human society, has an epic interest of grander meaning than can be found in any history of those destructive spasms in society that are sung and celebrated as war. The steam-engine is a triumph of peace, a victory of the pacific and constructive agencies of civilization, a conquest of Nature through the pursuits of science, and a symbol of the rise of modern industrialism and its successful conflict with the malign military spirit by which the world has been scourged through all the past.

Prof. Thurston has therefore chosen a theme of great interest in writing the history of the steam-engine, and it has not suffered in his hands. He has done admirable justice to its large and varied elements. The principles involved in the mechanism at all its successive stages are analyzed and stated with clearness, and the numerous contrivances and constructions by means of which the steam-engine has been built up and adapted to various ends are plainly, perspicuously, and fully described. The characters, circumstances, and labors, of the great men who have had a share in producing it are pleasantly sketched, and the narrative is enriched by anecdotes and personal episodes that relieve and enliven the more serious discussions of the book. Solidly instructive throughout, it is at the same time most agreeable reading, while many of the narrative parts are spirited and exciting.

Nothing further needs to be said to the readers of The Popular Science Monthly respecting the merits of Prof. Thurston's work, as they are already acquainted with them through portions of it which have appeared in these pages during the past year. One feature of the book, however, deserves especial recognition, and that is the elegance and profusion of its illustrations. In this respect no popular work upon the subject has ever appeared that can at all compare with it. The woodcuts are in the most finished style of the engraver's art, and have been prepared at a lavish expense. Besides the array of fine woodcuts, illustrating the steam-engine in all its phases, there is a collection of elegant portraits interspersed through the work of all the principal men whose names are associated with its progress. These excellent likenesses cannot fail to heighten the interest that will be felt in the biographical features of the volume.

The Journal of Physiology. Edited by Dr. Michael Foster, of Cambridge, with the coöperation in England of Professors Gamgee, Rutherford, and Burdon-Sanderson, and in the United States of Professors Bowditch, Martin, and Wood. London and New York: Macmillan & Co. $5.25 per year.

This new project in scientific journalism, though under the responsible control of the eminent English physiologist, Dr. Michael Foster, has nevertheless so international a make-up as to give it a strong claim to liberal American support. Dr. Foster's corps of assistant editors are all very able men; and when we say that the American coöperating editors are Prof. H. P. Bowditch, of Boston, Prof. H. M. Martin, of Baltimore, and Prof. H. C. Wood, of Philadelphia, it will be seen that American science is well represented, so that there will be no excuse if the physiological work of this country is not fairly chronicled. We are glad to see these indications of a growing scientific unity and practical co-working between the two countries. The politicians will continue to nurse antagonisms and alienations in the interest of what they deem patriotism; it remains for Science to undo their work as far as it may by cultivating a policy of harmony and mutual helpfulness.

The Journal of Physiology is to be a record of original research and progress in this branch of science; but its editors give a wide and rational construction to the term "progress" as applied to physiology. While experimental manipulation will remain the fundamental means of getting at facts, it will still be recognized as legitimate to *think* about the facts and find out their *meanings*. The editors say in their announcement:

"The physiologist works not only by experiment, but also by observation, and indeed by what is often depreciatingly spoken of as speculation. The conductors of the *Journal* would be the last to wish that its pages should be occupied by idle writing and the exposition of baseless views; but they would be equally unwilling to refuse a paper because it threw light on a subject by rearranging old facts rather than by bringing forward new ones."

The relations which the periodical will sustain to the medical profession, from which it ought to derive a strong support, are thus indicated:

"No branch of study during recent years has been more fruitful in physiological truths than the investigations into the action on living organisms and tissues of the various chemical bodies known as poisons and drugs. Between such investigations and those into the action of medicines no logical separation is possible, and the physiologist who does not welcome the physiological truths gained by medical practice as warmly as those coming from the laboratory is unworthy of the name. So also a little reflection teaches us that the phenomena of disease are in reality the deeper and more hidden events of the body thrust up to the surface by some dislocation of the economy. Hence all communications, in which the results of pathological observation or experiments are discussed with the view of elucidating their causation rather than in the interests of clinical science, may fairly find a place in a journal devoted to physiology."

As *The Journal of Physiology* will be occupied with substantial original work, and as the supply of this kind of matter is not steady and regular, the issue of its successive parts and the amount of material they contain will be subject to the discretion of the managers. Instead of appearing at strictly regular intervals, the numbers will be issued at periods varying from two to three months, while from four to six numbers will form the annual volume of about five hundred pages. The Germans are falling into this mode of publication, which seems sensible for a periodical of this kind. One of its obvious advantages is, as the editors say:

"That it prevents a discovery made by one man from being forestalled by another, whose observations, although really made later in point of time, might sometimes obtain priority under the ordinary method of publication."

Of the importance of the science of physiology, nothing needs here to be said. A great body of physiological truth has been established which is of such moment to the welfare both of individuals and of the community at large that the subject ought to have great prominence in education and to be taught to every child at school. But while many physiological principles and facts are so well established that they require to be understood for practical ends, yet the subject is still undergoing rapid development, and new results are being constantly reached which throw further light upon the operations of the vital economy, and are often immediately useful. *The Journal of Physiology*, therefore, has a valid claim upon the attention of many outside of scientific and medical circles. It is such a work as every teacher of physiology, especially in our higher schools, should have at hand, to illustrate the exact state of present knowledge upon numberless questions in relation to which current text-books may be insufficient or behind the times. Where teaching has not become purely mechanical and perfunctory, and all care and conscience have not died out, the teacher of physiology might give freshness and authority to his instructions by subscribing to this new magazine, and making himself familiar with its contents.

American Journal of Mathematics, Real and Applied. Editor-in-Chief J. J. Sylvester, LL. D., F. R. S. Published under the auspices of the Johns Hopkins University. *Second notice.*

The second number of the *American Journal of Mathematics* reaches us. It is very handsomely printed in quarto, and the formulas look as inviting as formulas can. It undoubtedly belongs to the highest class of mathematical periodicals. We will not presume to pass judgment upon the utility of all those speculations concerning space of four dimensions, the exact movements of the moon, the abstrusities of pure algebra, the phyllotactic numbers, etc. There certainly is such a thing as economy in research; and, fully admitting that each principle of pure mathematics is likely some day to find an application, it is a question to be considered whether it is worth while to spend time upon a theorem a thousand years before it will probably be needed. The principles of compound interest apply as much to brains as to money. If, instead of expending a certain portion of energy upon the resolution of a distantly useful problem, I devote it to something which has immediate applications, an advantage will have been gained which will have its effect through all future time. Here is a little question which we may leave to the mathematicians to solve, if anything so simple can interest them: Suppose that a certain mathematical study is destined to find an application as important as the conic sections have found, but only after a thousand years. What, upon the principles of compound interest, is the present worth of it as compared with that of an equal expenditure of energy in any immediately practical way?

When we call to mind what an army of intellects have devoted themselves to such subjects as, say, the resolution of cubic equations, we can hardly help suspecting that such researches, though of a higher order of activity than chess-playing, are chiefly of value for the amusement they afford. What is really useful is not the solution of this or that problem, but the existence of the mathematician himself. The civilization of our time has been more promoted by engineers, inventors, and popular writers on science, than by almost any other classes of men. But these persons are led by scientific men. The scientific men are certainly led by the physicists, and these in turn by the mathematicians. Thus, notwithstanding the smallness of the class who read mathematics, the influence of the great geometers spreads in concentric circles, until there is no one, not even the common day-laborer, who is not better off for it. It is not necessary that the problems in which the mathematicians most delight should be particularly useful. It is not necessary that the most profound minds, whose real value to civilization is the greatest of all, should ever concern themselves with the applications of mathematics. Their business is especially to work out fruitful conceptions, and to impress them upon other minds; and this they do not only by their writings, but also by their personal conversation.

The truth is, that productive industry only builds the substructure upon which civilization rests. The fairy palace itself is due to the pursuit of pleasure, to luxury, to the doing of useless things. Every amusement tends toward corruption, but every one tends also toward culture. An amusement is more or less beneficial according as one or other effect predominates in it.

Mathematics may be loved by a sybarite, but it will never be his occupation. Yet it is a most gentlemanly amusement, pursued far from vulgar passions and applause, in the calm of a library, nothing sordid mingling with it. Those harsh and crabbed formulas which fill us outsiders with such dismay, and from which we flee in terror, doubtless become, after a while, to the devotee as musical as is Apollo's lute, and are regarded by him as affectionately as a chess-player regards his finely-carved queens and castles.

Everybody, of course, knows that the practical utility, not to say necessity, even of the highest mathematics, is immense. But we have preferred to consider it in relation to the purely theoretical or very remotely practical departments which will no doubt occupy a large portion of the *American Journal of Mathematics*. Even so considered, the present mathematical revival which the coming of Mr. Sylvester has occasioned, and the establishment of this journal, may be characterized as important events for the highest welfare of the country—important even for its material welfare. It is not to be expected that the actual readers of such a journal should be very numerous, and, though subscriptions will be drawn from Europe, yet the success of it must depend upon its finding subscribers who do not read it, but who appreciate its value. Whether a sufficient class exists in America which understands the importance of intellectual activity of the profoundest kind to enable such activity to exist here, is a vital question for our destiny.

Not to close this notice without a bit of criticism, we may mention that one of the editors of the *Journal* has by means of a "Crelle's Table" found in a few minutes that the number 191,071 is either a prime or else divisible by a factor less than 137. This is pronounced by another of the editors to be "a real stroke of genius." We should like to have the glory of it a little further elucidated. We have put Crelle's Table into the hands of a computer, and requested him to find the divisors of the number in question. Having no pretensions to genius, he did not stop at 137, but, proceeding in the ordinary humdrum way, announced absolutely, in a quarter of an hour, that the number was prime. We confidently look for an article in the coming number setting out and explaining the wonderful stroke of genius in question, the marvel of which does not seem to have lain in its reaching a very speedy or complete solution of the problem undertaken.

Democracy in Europe: A History. By Sir Thomas Erskine May. New York: W. J. Widdleton. 1878. 2 vols.

In an appropriate introductory essay to this work the author sets forth the principles that constitute its foundation. It can scarcely be said that he offers anything new here; he, however, points out truths that can never be too sedulously insisted upon. After stating that by democracy he understands "the political power or influence of the people under all forms of government," that "it denotes a principle or force and not simply an institution," he discusses the moral, social, and physical causes of freedom, supporting his assertions, the while, with historical instances. He next shows that, as the constant development of popular power is the result of the intellectual and material progress of a nation, it must be accepted as a natural law; and that, instead of striving to breast the current, statesmen should endeavor to urge it forward in the most advisable channels. As a matter of course, the author has not avoided the opportunity of commenting upon the excesses of democratic ideas, and of breaking lances with devotees of communism and socialism.

Sir Erskine May enters the historical field with a gloomy portraiture of the constitutions of the old Eastern nations, and, in order to show that freedom is a growth wholly peculiar to European soil, he endeavors to prove that in all times—even the present—the main characteristics of Eastern society have been immutability and immobility. He begins with an examination of the constitution of India, and claims that the Hindoos have never known freedom; that their ignorance has been opposed to it; that their enslavement has fostered their ignorance; and concludes that "England has already given more 'liberty' to India than ever she aspired to under her former rulers." In the histories of Persia, China, Japan, Phœnicia, Carthage, and Egypt, the author likewise fails to discover germs of democratic ideas. It will not be amiss for us to state that Von Schlegel, Ferrari, and the more distinguished modern critics, have agreed that the East, too, has been always progressing, steadily if slowly, in the path of civilization, and that at no period was democracy entirely unknown in Eastern countries; the village communities of India, old as the nation itself, bear witness to this assertion.

Chapters II.-VI. are devoted to Greece and Rome. An attempt to go over the whole of his ground with the author would be a trespass upon the limits of this notice. We can only refer the reader to the work itself, where, among many absurd theories and startling declarations, he may nevertheless find many good ideas.

We cannot, we are sorry to say, so recommend that portion of the work which treats of the fortunes of democracy during the middle ages. Like the older writers who had not comprehended the philosophy of history, Sir Erskine May persists in calling this epoch by the now exploded title of "the dark ages," and seems to see in it nothing beyond vandalism and ruins. In love with "the old world," he has failed to realize its shortcomings, and accordingly the necessity of demolishing it in order to rebuild with the old materials one more in keeping with democratic ideas. He is forced, however, later on, to acknowledge that "this general prostration of the people of Europo was gradually lessened by the operation of several causes, which contributed to the ultimate regeneration of society and the advancement of freedom. These causes are to be sought in the 'free' institutions of the conquerors themselves, in the traditional laws and customs of Rome, in the influence of Christianity and the Catholic Church, and in the increasing enlightenment and general expansion of mediæval society." Here he presents the Church as the protector of the people's rights, and as counteracting the absolutism of kings and barons, and therefore as a democratic institution; afterward he notices the Church as directly antagonistic to freedom, and in the end hits upon the truth by saying: "Any pretensions of the Church which impaired the absolutism of rulers were so far favorable to liberty; but the pope was contending for ecclesiastical domination, not for civil freedom; and, if the latter cause sometimes profited by his intervention, it was because kings were weakened—not because the Church was the apostle of liberty." As he proceeds, our author shows how the cause of democracy was gradually helped along by the growing refinement of the barons, by minstrelsy, chivalry, and the crusades; which, "by weakening the aristocracy, increased on one side the power of the monarchs and on the other the freedom of the people," and led to the enfranchisement of the rising communes, to the revival of towns and the growth of municipal liberties; how all this brought about a revival of learning, an impulse of new life in the universities, to which was due the development later on of the liberty of thought and the Reformation.

Resuming his way backward, Sir Erskine May devotes the seventh chapter to the Italian republics, and, in presenting their history, shows how several causes, foremost among them being the earlier intellectual revival, operated to bring about an early development of municipal liberties in Italy. He explains how feudalism never firmly took root in Italy; how, after Charlemagne, the weakness of its kings favored the political power of the cities; how the fusion of the sturdy northern races with the Italians similarly assisted the assertion of popular rights; how a comparatively equal distribution of lands contributed toward social and political equality; how from all these varying causes no less than two hundred free municipalities or republics arose in this fair land, in which, in short, democracy attained to an unprecedented development. But here, we are afraid, the author has over-estimated this "freedom" of the Italian republics, each of which aimed at liberty only for itself—each party in every city determining upon the exclusion of its rivals from the enjoyment of all franchises. He concludes with a comparison of the Italian republics with one another, and with the old republics of Greece, and surveys, briefly and accurately, the causes that led to Italy's enslavement and its regeneration in our own day.

Next follows a review of the history of Switzerland, which offers one of the most interesting examples of the purest and simplest democracy and of well-contrived and enduring republican institutions to be found in the annals of Europe. The two chapters on this country are, perhaps, the most praiseworthy in the whole book; Calvin is judged without fanaticism, if we overlook the too great importance attributed to his reforms in connection with the freedom and democracy of the country.

The progress of democracy in the Netherlands is followed up in the first two chapters of the second volume. "Two aspects of democracy," says the author, "are here illustrated, the growth and political power of municipal institutions and the assertion of civil and religious liberty." He delineates the first of these aspects by recounting the civil history of the Netherlands up to the reign of Charles V.; the second aspect is developed in the description of the bloody measures adopted by Charles V. and Philip II. of Spain to crush out the growing spirit of the Reformation, and in the subsequent struggles of these countries for political independence. The career of William of Orange, the shrewdness and bravery he opposed to craftiness and revolting barbarity, the fruitless attempts of the persecutors to corrupt him, and the finally successful attempt to assassinate this apostle of civil and religious liberty—these are necessarily interwoven into the story of the struggle for the rights of conscience—the first and most memorable of the kind in the world's history. After dwelling at length on the share of freedom afterward enjoyed by the Low Countries, and the subsequent decline of their fortunes, he closes with a short notice of ultramontanism in Belgium and of the contemporary prosperity of that country and Holland.

Report on Forestry. By F. B. Hough. Washington: Government Printing-Office. Pp. 650. Economic Tree-Planting. By B. G. Northrop. From "Report of the Secretary of the Connecticut State Board of Agriculture." Pp. 29.

Dr. Hough's industry in collecting the materials of this "Report" is worthy of all praise; not less so is the intelligent use which he makes of them. The volume is indeed a storehouse of facts relating to forestry, and the information which it contains is of very great practical importance. The destruction of forests brings about great climatal changes, and the history of Spain and other countries shows how regions that once were fruitful have been changed into barren deserts by the reckless clearing of woodland. The time has come for taking concerted action toward "reforestation" in the United States. Dr. Hough considers in detail many of the problems which present themselves for solution—as the comparative advantages of *sowing* and *planting*, the proper number of trees to an acre, the adaptedness of different species to different localities, etc.; and Mr. Northrop goes over much of the same ground, though of course less fully, and with especial reference to the needs of the State of Connecticut. On these and sundry other points Dr. Hough quotes the experience of practical and scientific men, giving in full many documents of the highest value. Then follow statistical tables showing the consumption of wood in different industries, for household uses, railroads, etc. The relations between forests and climate are discussed *in extenso*, and Becquerel's "Memoir" on that subject is given in full. A sketch of the "Schools of Forestry" in various European countries is given, with a view to suggest hints for the guidance of forest-conservators in the United States. We recommend both of these publications to the earnest attention of our readers.

A New Cyclopædia of Chemistry, Theoretical, Practical, and Analytical, as applied to the Arts and Manufactures. By Writers of Eminence, on the Basis of the Late Dr. Muspratt's Work. Illustrated with numerous Woodcuts and Steel-Plate Engravings. Philadelphia: Lippincott & Co. 50 cts. per number.

This comprehensive and valuable work, which is announced to consist of forty parts, has now reached the thirty-fifth part, and its completion may therefore be soon expected. The work has been executed with care and ability, and we have found it useful and satisfactory for habitual reference on the extensive and important subjects of chemical manufacture. Its illustrations are numerous and elaborate, the text clear and attractive, and the treatment of subjects full, copious, and trustworthy.

Physics of the Infectious Diseases. Comprehending a Discussion of Certain Physical Phenomena in Connection with the Acute Infectious Diseases. By C. A. Logan, M. D. Chicago: Jansen, McClurg & Co. Pp. 212. Price, $1.50.

The author of this work spent four years on the west coast of South America, a region remarkable for two things: 1. Certain peculiar physical features and aspects; and, 2. A marked exemption from infectious diseases. He assumes a connection between these two facts, and has aimed to trace it out, and to derive important medical conclusions from the results. The problem of the influence of physical conditions upon health and disease is fundamental but at present obscure, and, while its investigation is of the greatest moment, advanced conclusions built upon it must be received with caution. The volume is instructive, and opens a special inquiry, which will no doubt be followed up by medical observers.

A Science Primer; on the Nature of Things. By John G. MacVickar, D. D. Edinburgh: Blackwood & Sons. Pp. 112.

This little book may claim the position of distinguished preëminence in absurdity among the mass of absurd publications with which we have been lately deluged, under the title of "Science Primers." We by no means intimate that those little books are without merit, but as rudimentary treatises, as books for beginners, as primers, they are with hardly an exception ridiculous. He who writes a primer of science should know two things—the subject he deals with, and the state of mind to which such a book is addressed. It matters nothing how sound and careful and accurate and trustworthy the writer's statement may be in itself; if it is not adapted to the mental condition of those ignorant of the subject, it will be a senseless and stupid failure. Our science primers are nearly all of this kind. They are written by men who seem to have not the slightest notion of what is needed for the minds of the young, and are in fact addressed to adult minds, and for these they are generally instructive and valuable.

Dr. MacVickar's "Science Primer on the Nature of Things," we might almost suppose, had been written as a burlesque on this class of books. It deals throughout with the most profound and abstract subjects, with remote and contested questions of cosmical science, with knotty problems of theology, and with speculations on chemism, ethers, and the geometrical constitution of molecules. The writer seems, indeed, to be not unconscious of the absurd misappropriateness of his work, and excuses it on the plea that all science is a good deal of a humbug. He says in his preface: "It may, indeed, be alleged that these primers present to their readers merely a smattering of science. But may it not with truth be replied, in similar terms, that the actual science of the day, in all its details, when viewed in reference to a satisfactory view of Nature and its economy, is itself merely a smattering?"

Putnam's Art Hand-Books. Edited by Susan M. Carter, Superintendent of the Woman's Art School, Cooper Union. I. The Art of Sketching from Nature. By Thomas Rowbotham. 27 Illustrations. Pp. 74. Price, 50 cents. II. The Art of Landscape-Painting in Oil-Colors. By W. Williams. Pp. 74. Price, 50 cents.

These neat little hand-books, which have gone through many editions in England, are now reprinted for the use of American art-students, and are to be soon followed by others on "Flower-Painting," "Figure-Drawing," and "An Artistic Treatise on the Human Figure." They seem to be prepared by experienced artists, and the name of the editor is a guarantee that they will prove useful to the cultivators of practical art in this country.

The Principles of Light and Color. Including among other Things the Harmonic Laws of the Universe, the Etherio-Atomic Philosophy of Force, Chromo-Chemistry, Chromo-Therapeutics, and the General Philosophy of the Fine Forces, together with Numerous Discoveries and Practical Applications. Illustrated by 204 Exquisite Photo-Engravings, besides Four Superb Colored Plates printed on Seven Plates each. By Edwin D. Babbitt. Science Hall, New York: Babbitt & Co. Pp. 560. Price, $4.

This is an elaborate and elegantly illustrated volume which we have not yet had time to read. The writer is a bold speculator, and seems to differ very widely and profoundly from the accredited expositors of physical, chemical, biological, and psychological science. He has a new philosophy of molecules and ethers, and the inner nature of things, interprets the large phenomena of the universe in his own way and includes magnetism, clairvoyance, psychic force, odic force, chromo-mentalism, chromo-therapeutics, and many other curious things, in his conception of Nature, and claims to educe their laws from "the etherio-atomic philosophy of force." The writer has bestowed a vast amount of labor upon his work, and, whatever amount of truth it will be ultimately found to contain, it will meet the wants of many, and be read with satisfaction by those interested in its peculiar topics and its author's independent treatment of them.

The Native Flowers and Ferns of the United States. By Thomas Meehan. Parts III., IV., V. Boston: Prang & Co.

The interest of this work is well sustained in its recent numbers. The colored illustrations are beautifully life-like, and the accompanying text interesting, and prepared with excellent judgment as to what a popular work requires. We cordially renew the commendation passed upon this worthy enterprise upon the appearance of its earlier numbers.

Science Lectures at South Kensington. New York: Macmillan & Co. Vol. I. Pp. 290. Price, $1.75.

This is the first installment of a valuable series of expositions upon chemical and physical subjects, on the whole popular, and all thorough and trustworthy. It contains lectures by Captain Abney on "Photography;" by Prof. Stokes on "The Absorption of Light and the Colors of Natural Bodies," and on "Fluorescence;" by Prof. Kennedy on "The Kinematics of Machinery;" by F. J. Bramwell on the "Steam-Engine;" by Prof. Forbes on "Radiation;" by H. C. Sorby on "Microscopes;" by J. T. Bottomly on "Electrometers;" by S. H. Vines on the "Apparatus relating to Vegetable Physiology," and by Prof Carey Foster on "Electrical Measurements." The subjects are interesting, the authorities are good, and the lectures valuable.

How to take Care of Our Eyes. With Advice to Parents and Teachers in regard to the Management of the Eyes of Children. By Henry C. Angell, M. D. Boston: Roberts Brothers. Pp. 70. Price, 50 cents.

The neglect, exposure, and abuse of the eyes in recent times, from many causes and in many ways, have become so great an evil as to call forth many books on the care of vision and the hygiene of the eye. Dr. Angell's contribution to the subject has the merit of being very clear in style, with but a sparing use of technical terms, while it is also condensed, and furnished at a low price. It is full of useful suggestions, which, if followed, would prevent a great deal of the annoyance and suffering that arise from misuse of the eyes.

Short Studies of Great Lawyers. By Irving Brown. Published by the *Albany Law Journal*. Pp. 382. Price, $2.

This volume contains upward of twenty sketches of the most eminent English and American lawyers from Coke to Choate. The notices originally appeared in the *Albany Law Journal*, where they attracted so much attention that the author has been induced to issue them in a collected and separate form. They are not designed as biographies so much as estimates of character and career, yet they contain a good deal of personal incident and delineation, which make the sketches anything but dull reading. As lawyers are always interesting objects to contemplate, good lives of lawyers are always interesting books.

The Dance of Death. By William Herman. New York: American News Company. Pp. 131.

A vehement denunciation of the immorality of waltzing.

PUBLICATIONS RECEIVED.

Elements of Sidereal Astronomy. By Jacob Ennis. Philadelphia: Collins print, 705 Jayne Street. 1878. Pp. 7.

American College Directory and Universal Catalogue. Vol. II. (1878). St. Louis: C. H. Evans & Co. Pp. 110. Sent free on receipt of 10 cents postage.

Iowa Weather Report for 1877. By Dr. Gustavus Hinrichs. Iowa City, Iowa. Pp. 70.

Proceedings at the Eleventh Annual Meeting of the Free Religious Association. Boston: 1878. Pp. 90. 40 cents.

Report of the New Jersey State Commission on a Plan for the Encouragement of Manufactures of Ornamental and Textile Fabrics. Trenton: Naar, Day & Naar print. 1878. Pp. 90.

Proportional Representation. By John H. Ward. Louisville: *Courier-Journal*, printers. 1878. Pp. 26.

Native Flowers and Ferns of the United States. By Thomas Meehan. Boston: Prang & Co. Parts 6, 7 and 8. 1878. 50 cents each.

Some Common Errors respecting the North American Indians. By Garrick Mallory. Philadelphia: Collins print, 705 Jayne Street. 1878. Pp. 6.

Former and Present Number of our Indians. By Garrick Mallory. Reprint from Proceedings of Nashville Meeting of the American Association for the Advancement of Science, August, 1877. Pp. 27.

Researches into the Early History of Mankind and the Development of Civilization. By Edward B. Tylor, D. C. L., LL. D., F. R. S. New York: Henry Holt & Co. 1878. Pp. 388. $3.50.

The Palmetto Literary Compendium. Vol. I., No. I. (August, 1878). Lexington, S. C.: Daley & Harmon. Monthly. Pp. 36. $2 per year.

Report of Committee to collect Information relative to the Meteor of December 24, 1873. Read April 7, 1877. Bulletin of the Philosophical Society of Washington. Pp. 21, with Map.

Address on Man's Age in the World. By James C. Southall, A.M., LL.D., at the Opening of the Lewis Brooks Museum, University of Virginia, June 27, 1878. Pp. 60.

The Unknown God. Lecture by J. W. Stillman. New York: For sale by D. M. Bennett, 141 Eighth Street. Pp. 34.

Erupted Rocks of Colorado, pp. 73, and Catalogue of Minerals found in Colorado, pp. 25. By F. M. Endlich. Washington: Government Printing-Office. 1878.

New Method of detecting Overstrain in Iron and other Metals. By R. H. Thurston, C. E. From Transactions of American Society of Civil Engineers. Pp. 7.

A Conspectus of the Different Forms of Phthisis. By Roswell Park, A. M., M. D. Reprint from Chicago *Medical Journal* for September 1878. Pp. 19.

Preliminary Studies on the North American Pyrolidæ. I. Illustrated. By A. R. Grote. Washington. 1878. Pp. 36.

How to keep Plump. By T. C. Duncan, M. D. Chicago: Duncan Brothers. 1878. Pp. 60. 50 cents.

The Therapeutic Forces. By Thomas J. Mays, M. D. Philadelphia: Lindsay & Blakiston. 1878. Pp. 143. $1.25.

Annals of the Harvard Astronomical Observatory. Vol. IX. Photometric Researches. By C. S. Peirce. Leipsic: W. Engelmann. Pp. 181, with Plates.

Principles of Light and Color. By E. D. Babbitt. New York: Babbitt & Co. Pp. 560, with Colored Plates. $4.

Monthly Record of Scientific Literature. Nos. 51-74. New York: Van Nostrand. 25 cents per year.

Goethe's Faust. Erster Theil. Edited by J. M. Hart. New York: Putnams. Pp. 257. $1.25.

Stricture of the Male Urethra. By Dr. F. N. Otis. Same publishers. Pp. 352. $3

Report of the Chief Signal-Officer (1877). Washington: Government Printing-Office. Pp. 570.

The Commonwealth reconstructed. By Charles C. P. Clark, M. D. New York: A. S. Barnes & Co. 1878. Pp. 216. $1.50.

First Annual Report of the United States Entomological Commission for the Year 1877. Relating to the Rocky Mountain Locust. With Maps and Illustrations. Washington: Government Printing-Office. 1878. Pp. 771.

Lessons in Elementary Chemistry. By H. E. Roscoe, F. R. S. New edition. London and New York: Macmillan & Co. 1878. Pp. 416. $1.50.

Geographical Surveying. By Frank de Yeaux Carpenter, C. E. New York: D. Van Nostrand. 1878. Pp. 176. 50 cents.

POPULAR MISCELLANY.

Systematic Promotion of Research.—Prof. R. H. Thurston, Vice-President of the American Association, chose as the subject of his address to Section A, "The Science of the Advancement of Science." Having asked, "Why is the advancement of science to-day so apparently difficult and irregular and toilsome?" he attributed this state of things to the lack of systematic encouragement of scientific studies. The right men, he said, in substance, have never been sought out, and trained for this work. Men of science themselves have chosen rather to pursue their own favorite lines of research instead of investigating in the directions which would yield the best results. The endowment of research has not been urged with sufficient persistence. The materials and the apparatus placed in the hands of men of science for the prosecution of their labors have been too incomplete to permit the most effective application of their efforts. For these and other reasons we are not to-day, as we have not been in the past, prepared to do all that we should in the advancement of science and of the arts. By what practical measures, then, is scientific research to be promoted? The "science of the advancement of science" dictates that we shall seek:

1. To determine what are the most promising and most important directions of exploration in the great universe of the knowable.

2. That we shall endeavor to find young men fitted to become successful observers, discoverers, and philosophers; aid them to gain positions in which their talents may have full scope, and assist to make useful the results of their labor.

3. That we make it a part of our work to obtain for these investigators the means

of research and the material aid which are necessitated by the rapid and ever-accelerating advances of knowledge for which we are indebted to them; to secure the endowment of new schools of science, the more complete organization of older schools, and liberal provision of apparatus and material for every investigator.

4. That we seek to improve our methods of instruction in science, to introduce into our educational systems a better scientific curriculum and far more extended courses, both of pure and of applied science, and to make the position of a teacher of science, viewed from the world's standpoint, a far more desirable one than it has yet become.

5. To make the organization and the operation of our academies of science, and of our societies for the advancement of science, far more thoroughly effective.

6. To endeavor to exhibit to both classes the fact that there exists between the man of science and the man of business a community of interests; the fact that he who accumulates wealth is largely indebted for his success to him who is unselfishly revealing to him the laws by which wealth is increased and business prosperity secured.

Proposed Silk-School Farm.—Certain capitalists in Philadelphia have signified their approval of plans of a silk-school, farm, and village, proposed by Mr. Samuel Chamberlain, and a company is to be formed for the purpose of putting the project into execution at an early day. In a communication to the *Polytechnic Review*, Mr. Chamberlain writes that the plans provide for legal interest on the investment, independently of the silk produced. They provide for a return of the capital by means of improved real estate, and for a profit beyond legal interest by retaining intermediate sections of the land, which, it is expected, will later be sold at a great advance, in consequence of the improvements. They provide growers of trees, silk-worm eggs, and silk, in addition to those to be produced by the school, namely, the renters of forty cottages, each surrounded by an acre of mulberry-trees. They provide cottage culturers, and in a few years teachers of cottage culture, who will show by precept and example how silk may be raised in the midst of family duties. The danger of strikes is obviated by the fact that the renter of a cottage may in the end be an owner, and thus become directly interested in the uninterrupted progress of the work. In the school young persons will be trained to those habits of care, patience, and watchful attention, which are necessary for the successful raising and reeling of silk. The work is light and easy, and, when skill is acquired early, is highly profitable. It is peculiarly suitable for the deaf and dumb, whose misfortune cuts them off from so many occupations. When one such school shall have shown the way, like establishments will arise in many places; and in this way it is hoped to help in turning back into the country the tide of population now flowing into our cities. The failure to introduce silk-culture in 1840 was chiefly due to want of perseverance. The three years of actual trial were not enough to carry it on to success. But a school, farm, and village, whose continuance will be maintained sixteen to twenty years, will secure a permanent source of knowledge, example, and instruction, from which the culture will extend year by year.

Water for Domestic Uses.—The question of pure water-supply has been taken up for discussion by the London Society of Arts, and circulars have been sent out to civil engineers, sanitary officers, and other persons whose callings would appear to make them familiar with the conditions of the problem, inviting from them suggestions and plans for insuring to the whole population of England a sufficiency of pure water for domestic uses. A "Congress," too, has met in London, at which a number of papers, prepared by some of the most competent engineers and sanitarians, were read. In one of these papers, written by Mr. Samuel C. Homersham, the qualities of water fit for domestic uses are stated as follows: 1. Such water should be wholesome, free from animalcules or other organisms, animal or vegetable, either living or dead, and at no time or season of the year, or in periods of epidemics, liable to propagate disease or cause the death of those who drink it. 2. It should be soft and pleasant to use with soap both for washing the person and clothes, for baths and other detergent purposes, and of a quality such as would not dissolve lead, or form a deposit when boiled. 3. It should be clear and bright, agreeable to the eye, and refreshing to the taste. 4. It should be well aërated, of a nearly uniform normal temperature, and not like river or surface water, unduly warm in summer and unduly cold in winter. All that is needed, in the opinion of Mr. Homersham, and most of the other authors of papers, to insure abundance of such pure water, is that public opinion be educated to insist upon it. Works adequate to provide a regular supply of wholesome water, whether for towns or for small groups of dwellings in the country, might be constructed at moderate expense.

How Teleological Ideas are acquired.— In the course of his able address on "Education a Succession of Experiences," Prof. Grote, Vice-President of the Natural History Section of the American Association, remarks as follows upon the futility of teleological arguments: "From the imperfection and limitation of our senses comes not only a succession of experiences which are incomplete, but a general concept with regard to external matters, which must be of necessity misleading. We are here but a short time, and see little of the outcome of passing events, and can know nothing of the outcome of the world itself. Thus it has come to pass that what we have not fully observed we have assigned to an unknown cause. We have fitted Nature into our own measure, directly led thereto by the imperfection of our knowledge, and we have arrived at the concept that design exists in the world about us as it is displayed in our own handiwork and the work of animals, which, with ourselves, exhibit design in their operations. But in reality what we see in the details of the structure of animals and plants is not design, but adaptation. Suppose we leave a coat in a closet, and while it is there it is visited by a female clothes-moth, which deposits thereon numerous eggs. The little worms hatched from the eggs would at once commence to make free with the nap, and eat holes in the coat with a good appetite. If they ever thought about the matter, would they not conclude that the coat was hung there for their special benefit? They would do so merely because the coat was there. The fact that they adapted it to their own use would be construed by them into a belief that it was designed for their benefit. They would inevitably regard the owner of the coat, could they arrive at this conception, as their benefactor and the preserver of the whole race of maggots. They would know nothing of the thousands of clothes-worm eggs that perish because they never get anything to eat. The fact that life is sacrificed by the wholesale in Nature tells against the argument of design. And Nature is as careless of the species as of the individual. In the crust of the earth are contained the remains of millions of types of form of which Nature has not been careful, but has crushed them out, because they could not adapt themselves to the changing conditions which surrounded them."

Is the Evolution Theory atheistic?— Prof. Simon Newcomb's address, on his retiring from the annual presidency of the American Association, is a singularly lucid exposition of the state of the case as between the *teleological* and the *mechanical* explanations of the operations of Nature. The drift of his argument is best seen in the summary with which the address concludes, and which is in substance as follows: First, when men study the operations of the world around them, they find some of these plainly determined by law, while others appear to be purely arbitrary. This latter class of operations men attribute to the direct action of supernatural beings, gods; and they further ascribe to these gods aims, designs, to be attained through these interventions in the course of Nature. Further, men believe themselves able to discern these designs, and thus to explain these arbitrary operations. But, as knowledge advances, one after another of these operations is found to be really determined by law. Final causes having thus, one by one, disappeared from every thicket which has been fully explored, the question arises whether they now have or ever had any existence at all. On the one hand it may be claimed that it is unphilosophical to believe in them when they have been sought in vain in every corner into which light can penetrate. On the other hand, we have the difficulty of accounting for those very laws by which we find the course of Nature to be determined. Take the law of hereditary descent: how did such a law, or rather, how did such a process, first commence? If this is not as legitimate a subject for inquiry as the question how came the hand, the eye, or the first germ, into existence, it is only because it seems more difficult to investigate. When the doctrine of the universality of natural law is carried so far as to include the genesis of living beings and the adaptations to external circumstances which we see in their organs and their structure, it is often pronounced to be atheistic. Whether this judgment is or is not correct, Prof. Newcomb would not undertake to decide, but said that it is very easy to propound the test question by which its correctness is to be determined: "Is the general doctrine of causes acting in apparently blind obedience to invariable law in itself atheistic?" If it is, then the whole progress of our knowledge of Nature has been in this direction, for it has consisted in reducing the operations of Nature to such blind obedience. If the doctrine is not atheistic, then there is nothing atheistic in any phase of the theory of evolution, for this consists solely in accounting for certain processes by natural laws.

A New Calculating-Machine.—Mention is made, in the presidential address of Mr. Spottiswoode to the British Association, of a calculating-machine, devised by Prof. James Thomson, which for simplicity of construction compares favorably even with Edison's phonograph. The description given of this ingenious instrument is extremely meagre and insufficient, and does not give any notion of its *modus operandi.* "By means of the mere friction of a disk, a cylinder, and a ball," says Mr. Spottiswoode, "this machine is capable of effecting a variety of complicated calculations which occur in the highest application of mathematics to physical problems. By its aid it seems that an unskilled laborer may, in a given time, perform the work of ten skilled arithmeticians." It is applicable to the calculation of all sorts of periodic phenomena—as those of the tides, and of magnetic and meteorological variations. It will solve differential equations of the second, and perhaps even of higher orders. And through the same invention the problem of finding the free motions of any number of mutually-attracting particles, unrestricted by any of the approximate suppositions required in the treatment of the lunar and planetary theories, is reduced to the simple process of turning a crank.

Grass and Straw as Domestic Fuel.—The Mennonites, who, for a few years past, have been immigrating to our Western and Northwestern States and Territories from the Russian Empire, have introduced into their new homes the "grass-burner stove," by means of which their houses are warmed in winter, and all their cooking done throughout the year. The grass-burner is destined to be generally adopted by settlers in regions destitute of coal or timber, since by its use straw and dried prairie-grass are made to serve as perfectly satisfactory fuel. A description of this peculiar stove, with illustrations, is given by Prof. J. D. Butler, in the *Gardener's Monthly*, from which we copy the following notes on its construction and performance: The material is unimportant; some use brick, others stone, while still others prefer a mixture of sand and clay. The size is considerable, not unfrequently five feet in length, six in height, and two and one-half in width. The stove is erected as centrally as may be in a dwelling, so as to heat all the rooms as far as possible. The structure may be said to have six stories, viz., first, the ash-box; second, fire-box; third, cooking-oven; fourth, smoke-passage; fifth, hot-air chamber; sixth, smoke-passage to chimney or to a drum in an upper room. The fuel box is about four feet long, and in width and height a foot and one-half. The grass or straw is thrust in with a fork. The author says that, in the house of Bishop Peters, the grass or straw is pitched into the fire-box of the stove for about twenty minutes twice or at most three times in twenty-four hours; that amount of firing-up suffices amply for cooking and heating in the climate of Nebraska. It now remains for American ingenuity to improve on this Russian contrivance—to make it simpler, smaller, cheaper, of better materials, of more elegant design, and of more economical combustion.

How Mountains are made.—In a paper by Prof. Joseph Le Conte, read before the National Academy of Sciences in April, and since published in the *American Journal of Science*, the formation of mountains is explained by the action of horizontal pressure resulting from interior contraction of the earth. The author considers all the principal types of mountain-structure, and appears to account for them very satisfactorily by this theory of horizontal pressure. It would be impossible, within the limits of a Miscellany article, to give an intelligible outline of the entire argument, and we must content ourselves with a synopsis of the author's remarks on the formation of *mountains of a single anticlinal fold*—the simplest conceivable mountain-structure. Here

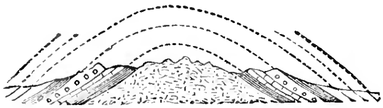


Fig. 1.—Ideal Section of Simple Anticlinal Fold (unsymmetrical).

the deeper strata are thickened and swelled upward by the horizontal pressure, while the upper strata are raised into a vault with little or no thickening, or may even be thinned and broken by tension. The vault is nearly always unsymmetrical, the yielding being greater on one side than on the other. In such cases a great fissure and slip is apt to occur on the steeper side, as shown in Fig. 2. Perhaps the best illustration of a

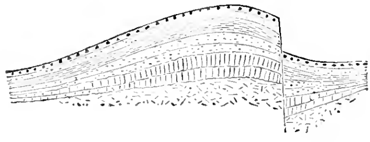


Fig. 2.—The same, with the strata fissured and faulted.

range of mountains of this simple type is the Uintah Mountains. A cross-section of this range shows a prodigious fault of 20,000 feet on the northern or steeper side of the original fold. If the crust of the uprising region be *extremely* rigid, the vault, instead of being forty or fifty miles across, as in the Uintah Mountains, may be one hundred or several hundred miles across; we have then a *great plateau*. And since an arch of such span, whether filled or not beneath with fused or semi-fused matter, cannot sustain itself, such elevated plateaus are peculiarly liable to *fissure* by breaking down of the arch, and to *slips* by gravitative adjustment of the broken parts. The result is conspicuous escarpments or conspicuous mountain-ridges in the general direction of the axis of the plateau. Such, according to the author, is the origin of the north and south escarpments of the plateau-region of the Colorado, described by Powell, and of the north and south monoclinal ridges in the Basin-region, described by Gilbert and Howell. Again, a monoclinal fold may be modified by *metamorphism*. This, says the author, is especially apt to be the case if the strata be *very thick* and the fold *narrow and high*; that is, if the compression in a given space, and therefore the *heat* of compression, be very great. If, now, such a sharp fold, metamorphosed in its deeper strata along the line of greatest compression, be subjected to profound erosion, it forms a common type of mountain, viz., one consisting of a highly-metamorphic axis, flanked on either side by tilted strata corresponding to each other.

The Differences between Atlantic and Pacific Forests.—The differences between the Atlantic and Pacific forests of the United States are very striking in many respects. Prof. Asa Gray, in a recent lecture, presents a long list of Atlantic forest-trees that are either not at all or but feebly represented on the Pacific slope. For instance, the Pacific forest has no magnolias, no tulip-tree, no papaw, no linden or basswood, and is very poor in maples; no locust-trees, nor any leguminous tree; no cherry-tree large enough for a timber-tree; no gum-trees, nor sorrel-tree, nor kalmia; no persimmon; not a holly; only one ash that may be called a timber-tree; no catalpa, or sassafras; not a single elm nor hackberry; not a mulberry, nor planer-tree, nor maclura; not a hickory nor a beech, nor a true chestnut nor a hornbeam; barely one birch-tree, and that only far north, where the differences are less striking. As to coniferous trees, however, the only missing type is our bald cypress, the so-called cypress of our Southern swamps. "But as to our ordinary trees," writes the author, "if you ask what takes the place in Oregon and California of all these missing kinds which are familiar on our side of the continent, I must answer, nothing or nearly nothing. There is the madroña (arbutus) instead of our kalmia (both really trees in some places); and there is the California laurel instead of our Southern red bay-tree. Nor in any of the genera common to the two does the Pacific forest equal the Atlantic in species. It has not half as many maples, nor ashes, nor poplars, nor walnuts, nor birches, and those it has are of smaller size and inferior quality; it has not one-half as many oaks; and these and the ashes are of so inferior economical value that (as we are told) a passable wagon-wheel cannot be made of California wood, nor a really good one in Oregon." He then states that, whereas the Atlantic forests contain sixty-six genera and one hundred and fifty-five species, the Pacific has only thirty-one genera and seventy-eight species.

Artificial Cold in the Treatment of Yellow Fever.—Dr. Bushrod W. James proposes, in the Philadelphia *Ledger*, a method of treating yellow-fever patients by artificial cold. He would have in every quarantine-station a ward or room capable of holding several patients, and so arranged that ventilation can be effected solely through ventilators and by means of small anterooms with spring-doors. There must be no entrance or exit to the ward save through the anteroom. The anteroom should be kept at the same low temperature as, or even lower than that in the ward, so that the temperature in the latter may not be raised by the opening and closing of doors by the attendants, nor any of the disease-producing germs escape before they are thoroughly subjected to the low temperature and destroyed. The ward and anteroom must be kept at a temperature not higher than 25° Fahr., the patients being made comfortable by a sufficient amount of bedclothing; and everything that goes from the room, such as clothing, excretions, all emanations, etc., must be exposed a sufficient length of time to the cold. This will kill the poisonous germs, or reproducing cause, and prevent, as far as the cases under treatment are concerned, any risk of the disease spreading. If patients cannot bear so much cold during treatment, an adjoining warmer room can be made, with no mode of access or ventilation except through the cold room, and everything going out of the warmer room must be allowed to remain a sufficient length of time to get rid of the contagion. If no attendant occupies the anteroom, the degree of cold can be kept near zero, in order the more quickly to destroy all the disease-producing agencies.

A Drought-Proof Fodder-Plant.—In a paper on the progress of agriculture in Natal, South Africa, Dr. P. M. Sutherland, surveyor-general of that colony, speaks of the advantages possessed by the Caucasian prickly comfrey (*Symphytum asperrimum*) as a fodder-plant, in regions characterized by annually-recurring seasons of drought. His remarks will doubtless be of interest to farmers settled in some of our States and Territories where like meteorological conditions exist. The plant named is allied to the borage, is a native of the mountainous regions of Circassia, and has long been used as forage both in that country and in Russia. Its original home is at a height of 4,000 feet above the sea, but it thrives well in a great diversity of climates, and bears hot and dry seasons with impunity, on account of the depth to which its strong root penetrates into the ground. There are two varieties of the plant, one with a hollow and the other with a solid stem. The latter is an excellent food for stock of all kinds; especially does it increase the quantity and improve the quality of cows' milk. It grows with marvelous rapidity and luxuriance. Land which yields eight tons of grass per acre gives from sixty to a hundred and fifty tons of comfrey. The plant is four or five feet high when near flowering, and the leaves attain a length of three feet. The flowers abound in honey. The solid stem is like a succulent root, and the plant is easily propagated by cuttings from this stem, containing a couple of eyes each. When once well rooted it will go on producing from fifteen to twenty years. The fodder may be cut six or even eight times a year; and if the leaves are stacked green, or partially dried, with a little salt between the layers, they keep well through the winter.

The Coat of the Rocky Mountain Sheep.—Western huntsmen who have chased the Rocky Mountain sheep, or big-horn (*Ovis montana*), generally believe that the animal wears only a coating of hair, never wool; but, in a communication to the *American Naturalist*, Dr. F. M. Endlich shows that this is an error, and that the big-horn varies in the nature of its covering according to the seasons, being clothed with hair in summer, and with wool in winter. On July 17, 1877, Dr. Endlich, while engaged in work connected with the survey of the Territories, found himself among the Wind River Mountains, at an elevation of 12,000 feet above sea-level, and amid large fields of snow. While contemplating the scenery around, he heard the sound of tramping feet, and, looking up, saw four mountain-sheep approaching, though at first he scarcely recognized the species. They were of a totally different color from any he had seen before, and seemed to have a very rough skin. Eight days later Dr. Endlich ascended a high peak in the same range, and, as he reached the timber-line, he saw a band of over a hundred big-horns. Some of these he shot and killed. The "hair" was shorter than usual. It was apparently growing rapidly, and pushing before it a layer of very fine *wool*, about half an inch in thickness. In other words, the sheep were shedding their wool, which is exceedingly fine, and of a light-gray color. Some portions of the body were already clear of it. This explained the peculiar color and appearance of the sheep seen a week previously.

New Method of annealing Glass.—A new method of annealing glass is proposed by Messrs. Albert and Weyer, of Paris. It consists in burying the articles to be annealed in powdered stone, plaster, lime, etc., or in grease, oil, melted nitrates of potash and soda, in short, in any liquid or solid capable of receiving the required heat, and remaining in a condition suitable for the process. By imbedding the articles in powder, they can be annealed at a very high temperature—a thing impossible unless some means are provided for supporting the objects and maintaining their shape when reduced to the softened state necessary to secure perfect annealing. By the new process the articles are filled with the powdered stone or other substance, and are then placed in crucibles and completely surrounded with the pulverized substance employed. They are then subjected to a heat gradually increasing to 200° Cent., or even 1,000° C. from four to six hours, and are then slowly cooled. When there is little danger of spoiling the shape of the articles, they can be annealed by the use of liquids and at less cost. In this case two boilers are employed, so placed that the liquid can be run from the upper into the lower. If nitrate of soda is employed, the temperature will be over 260° C. before the salt is melted, and the articles are then immersed in the cold state, and the temperature raised to 800° C. Then they are allowed to cool slowly, and when the temperature has fallen to nearly 260° C.—the solidification point—the nitrate is run off into the lower boiler, and a small fire is maintained beneath the upper boiler to prevent the too rapid cooling of the glass.

Influence of Chemical Research on Character.—Prof. Maxwell Simpson, President of Section B of the British Association, in his address makes some very judicious remarks on the influence of chemistry upon the intellectual habits and moral character of its cultivators. He first notes how the study of chemistry, or rather original chemical work, promotes accuracy, thoroughness, and circumspection. An organic analysis requires six weighings; if any one of these is inaccurate, the results are worthless. Unless the analyst is sure of every step in his research, his results are doubtful, and therefore of no value. Again, the original worker must be ever on his guard against error, and laboratory-work teaches us to use our senses aright, sharpens our powers of observation, and prevents us from reasoning rashly from appearances. Then, as regards the effect of original work on the character, in developing the virtues of courage, resolution, truthfulness, and patience: the chemist is often obliged to perform experiments which are attended with great danger, and no man can hope to fight long with the elements without carrying away many a scar. Sometimes fatal accidents occur. But the chemist must not be discouraged by fear of accident, neither must he be disheartened by the temporary failure of his experiments, nor at the slowness of his processes. "Bunsen was obliged to evaporate forty-four tons of the waters of the Dürcheim springs in order to obtain two hundred grains of his new metal, cæsium. It took Berthelot several months to form, by a series of synthetical operations, an appreciable quantity of alcohol from water and carbon, derived from carbonate of baryta. Many years ago, in the laboratory of Wurtz, a poor student was carrying from one room to another a glass globe which contained the product of a month's continuous labor, when the bottom of the globe fell out, and the contents were lost. Nothing daunted, he recommenced his month's work, and brought his research to a successful issue. Above all things, the chemist must be *true*. He must not allow his wishes to bias his judgment or prevent him from seeing his researches in their true light. He must not be satisfied that his results appear true, but he must believe them to be true; and, having faithfully performed his experiments, he must record them faithfully. He may often be obliged to chronicle his own failures and describe operations that tell against his own theories, but this hard test of his truthfulness he must not shrink from."

A New Form of Galvanic Cell.—When rods of zinc and copper are placed in mercury, and connected with an electrometer, no change is observed; and, whether the zinc and copper are in contact outside the mercury or not, the amalgamation of the zinc appears to proceed at the same rate. According to a communication to the London Royal Society, from Profs. Ayrton and Perry, of the Tokio Engineering College, the impurities and great conductivity of the zinc, with the great liquidity of the amalgam, and the close proximity of foreign particles to pure metal, cause the amalgamation to be produced by local action alone, so that the supply of available chemical energy for the production of a current from the zinc to the copper is exceedingly small: at low temperatures, when the amalgam loses its liquidity, such an arrangement would, the authors conjectured, become a simple voltaic cell. To test this they substituted, for zinc, magnesium, whose amalgam is nearly solid at ordinary temperatures. Strips of platinum and magnesium, metallically attached to the electrodes of the electrometer, were dropped into mercury which had been washed with distilled water and then well dried. There was a sudden large deflection, afterward fluctuating very much, but keeping always on the same side of zero. On successive reversals of the electrometer key, the deflections to the right and left of zero were found to be nearly equal to one another. To determine the electro-motive force of the arrangement, strips of platinum and magnesium, scraped very clean, were dipped into pure mercury. The maximum electromotric force obtained was 1.56 volts—equal to one and a half time the electromotrive force of a Daniell cell. The authors remark that, by mechanical or other means, or by using another metal than magnesium, it may be possible to give constancy to this arrangement; and as its internal resistance is extremely small, the cell may be of great practical use for the production of powerful currents. As an amalgam may be easily separated into its components by distillation, such a cell might be kept in action for an indefinite time.

An Interesting Geological Question.—Though the Triassic rocks of New Jersey and the Connecticut Valley are commonly regarded by geologists as intrusive igneous rocks, the direct proof of their intrusive nature is not readily accessible. Indeed, some geologists have supposed that, so far from being intrusive, they were formed contemporaneously with the shales and sandstones amid which they occur, as a bed of igneous rock at the bottom of a shallow sea in which the stratified rocks were being deposited. But Mr. I. C. Russell shows, in the *American Journal of Science*, that these trap-rocks were forced out in a fused state among the sedimentary strata after the consolidation of the latter, and hence that they are more recent than either the rocks above or below them. The evidence of this he finds in a ravine on the western slope of the First Newark Mountain, directly west of Westfield, New Jersey. Here the trap-rock which appears in the bed of a little brook presents its usual characteristics of a hard, bluish, crystalline rock, with a conchoidal fracture. In other places it swells up into bosses and rounded masses which are thrust up into the overlying rocks. The outside of these masses presents a scoriaceous or slag-like appearance; in the interior the cavities are filled with infiltrated minerals. For the first two or three feet above the trap the shales which rest directly on these igneous rocks have been intensely metamorphosed, and are scarcely to be distinguished from the trap itself. At a distance of six or eight feet above the trap the shales are still very much altered and filled with a great number of small spherical masses of a dark-green mineral, resembling epidote. Midway up the sides of the ravine, which is about thirty feet deep, the shales present somewhat of their usual reddish appearance, but are traversed by a great number of irregular cavities formed by the expansion of vapor while the rocks were in a semi-plastic condition. At a distance of twenty-five or thirty feet above the trap, the shales and sandstones are changed but slightly, if at all, from their normal condition. A bed of limestone from two to three feet in thickness, which is here interstratified with the shales and sandstones where it approaches the trap, is considerably altered and forms a mass of semi-crystallized carbonate of lime. All this furnishes indisputable evidence that the igneous rocks composing the First Newark Mountain were intruded in the molten state between the layers of the stratified rocks subsequent to the consolidation of the latter; and by analogy we are justified in extending this conclusion to all the trap ridges which traverse the Triassic regions of New Jersey.

Agricultural and Mineral Resources of Alaska.—The following notes on the mineral and agricultural wealth of Alaska we take from a communication published in the *Chronicle* of San Francisco. The Territory is as yet virtually unexplored, yet gold, silver, copper, graphite, lead, iron, sulphur, and coal, have already been found in sufficient quantity to pay for working the deposits. "Eight well-defined ledges of gold-bearing quartz have been prospected on Baronoff Island, close to the town of Sitka; their owners owe their discovery and partial development to the enterprise and energy of one Haley, who was formerly a soldier of the garrison that was stationed here. Haley began to utilize his gold discoveries about three years ago by quarrying out rock and crushing it in a common hand-mortar. By this primitive process he obtained money enough to support his family and pay the cost of a visit to Portland and San Francisco in search of capital to develop his mines. Little is known of that section of Alaska which lies back of the coast between Cross Sound—where the Alexander Archipelago, with its 1,100 islands, ends—and Prince William's Sound. On Prince William's Sound are several Indian villages, and several tracts of prairie-land which may be easily cultivated. Beyond this large inlet lies Kodiac and Cook's Inlet. As a fishing and agricultural district this is undoubtedly the best section of the whole Territory of Alaska. The climate is milder, the winters less severe, and the rainfall less, than in the southern counties of Scotland. Both on Kodiac and the shores of Cook's Inlet are large tracts of prairie-land, which now afford excellent pasture for cattle and sheep, and which can be easily cultivated for all the hardy vegetables, barley, and oats. Timber is abundant and easily accessible from the water. A large deposit of coal has been prospected, the quality of which is declared by Prof. Newberry to be fully equal to any coals found on the Pacific coast, not excepting those of Vancouver Island and Bellingham Bay. The Indians who come down to the head of the inlet report large deposits of native copper a short distance inland, and exhibit ornaments and utensils of the same. Lead of sufficient purity to be moulded into bullets is also found there. The waters literally swarm with fish; and it is safe to say that there is no district of country on the whole Pacific coast which offers so many advantages for the profitable establishment of fish-canning and fish-curing works. With a comparatively moderate investment of capital, exports of fish to the value of several millions of dollars annually may be sent from Cook's Inlet, which would pay a large profit to the owners of the works, and would support many thousand fishermen, laborers, and mechanics. Nothing but the power of monopoly has hindered Alaska's growth thus far."

A New Theory of the Flow of Sap.—In a new theory of the ascent of sap in trees, proposed by Joseph Böhm, the elasticity of the plant-cells plays an important part. When the superficial cells have lost through evaporation a portion of their water, they partly collapse under the action of the air-pressure; but, like elastic bladders, they tend to resume their original form. This they can do only by drawing in either air or water from without. But since moist membranes are but little permeable by air, the cells draw from the cells farther toward the centre a portion of their liquid contents; these in turn draw on the cells farther down, and so on down to the roots. The author illustrates his theory by an apparatus which represents a chain of cells. A funnel closed by a bladder represents the evaporating leaf; to it are connected below several glass tubes about two inches wide, closed at one end with a bladder, and joined together in series by means of thick caoutchouc tubes. As evaporation goes on, the membrane which closes the funnel-mouth is bent inward, and, when it has reached a certain tension, water is sucked into the funnel out of the cell next below, which covers its loss in the same way. Manometers connected with certain cells of the apparatus indicate the amount of suction at different heights.

NOTES.

Complaint is made in the newspapers that fish and fowl are dying by millions in different parts of the country, poisoned, it is supposed, by Paris-green. In the valley of the Connecticut Paris-green is freely used to destroy the potato-beetle, and the recent heavy rains have washed it into the rivers, together with untold millions of poisoned beetles. It may be doubtful whether the Paris-green suspended in the stream could destroy many fish, but there is little doubt that eating the poisoned beetles would prove fatal both to fish and fowl. "There is no reason advanced," says the Hartford *Courant*, "to explain the wide-spread destruction of fish more plausible than this, and it is a singular fact that sportsmen on land have complained of a fatality among birds, the same as fishermen do of the fatal effects upon fish. Quail have been found dead in various parts of the State, and there is no doubt that the death of the birds is due to agricultural poisoning."

According to a Pittsburg newspaper, Messrs. Gemill and Wampler, of McKeesport, at 10 p. m. of July 11th, while observing the planet Jupiter with a five-inch telescope, noticed on the eastern limb a dark round spot, just above the northern belt of the planet. Soon it moved rapidly westward, just touching the belt and passing off the face of the planet at 1.24 a. m. of the 12th. It had the appearance of a perfect sphere much larger than any of Jupiter's satellites, sharply defined, and intensely black. It could not have been a spot on the disk of Jupiter, for it passed over the face of the planet in three hours and nineteen minutes, while a spot would have taken five hours. Neither was it a satellite, or the shadow of one, for all the four Jovian satellites were in full view the whole time.

Dr. Hermann J. Klein, of Cologne, has discovered a new crater on the moon's surface, situated in the Mare Vaporum, a little to the northwest of the crater Hyginus. The new crater is nearly as large as Hyginus, and is a conspicuous object. Klein, though he had previously again and again observed the same region, had never seen this crater; neither had it been noticed by other selenographers. The inference would appear to be that volcanic action is still going on in the moon.

During a session of an educational committee, the Bishop of Gloucester in the chair, one of the members lamented the very imperfect education given to girls under the present system. "The fact cannot be denied, I fear," said the chairman, "but there is one consolation—the boys will never find it out."

A numerously-attended meeting, of persons of both sexes, was recently held in Indianapolis, Indiana, for the purpose of forming a cremation society. A committee was appointed to draft a constitution and bylaws.

It is a pleasing picture that Sir David Wedderburn draws of the social usages of the people of Japan—"a country where men never lose their temper, where women and children are always treated with gentleness, where common laborers bow and beg pardon of each other if they happen to jostle accidentally, where popular sports do not inflict suffering on the lower animals, and where cleanliness takes such a high rank among social virtues as to be carried almost to a ludicrous excess;" and their courtesy is "singularly free from servile or mercenary considerations."

Some twenty-five years ago the British Association for the Advancement of Science met in a certain cathedral town, and in the Geological Section a rather warm debate arose about the truth of the Mosaic account of the Deluge. The dean of the cathedral stoutly defended Moses, but he was badly defeated by the geologists. The next Sunday he preached a sermon on the Deluge, and proved, to his own satisfaction at least, the absolute accuracy of the story in "Genesis." He thus had the last word, for, as he remarked afterward, "none of those fellows could answer him there!"

According to Mr. A. C. Ranyard, of the British Astronomical Society, maxima of sun-spots, though their average periods are 11.11 years, occasionally occur at intervals of 13 or 14 years. In one instance, in comparatively recent times, viz., 1788.1 and 1804.2—16.1 years elapsed, while between the *maxima* years 1829.9 and 1837.2 there was an interval of only 7.3 years. An examination of the records of sun-spots proves the irregularity in their appearance to be so great that only vague prognostications can be made as to the time of an approaching maximum; and what is true of periods of maxima is also true of periods of minima. M. Faye, too, in a communication to the Paris Academy of Sciences, shows that the two phenomena of sun-spots and magnetism are not related, as they have not the same period. According to Wolf, the sun-spot period is 11.11 years, while the declination period of the magnetic needle is, according to Lamont and others, 10.45 years.

While exploring the desert region east of the Lob-Nor, the Russian traveler, Colonel Prejevalsky, made inquiries of the natives concerning the existence of wild camels in that country, and learned from them that those animals were still to be found in the Kum-Tag Desert, which extends over three degrees of longitude from east to west (91°–94° east), and is bounded north and south by latitude 39° and 40° north. The wild camels in summer seek the upper valleys of the Altyn-Tag, a mountain-chain on the southern edge of the Kum-Tag, and retire into the most inaccessible deserts in winter. Their sight, hearing, and smell, are exceedingly quick, in striking contrast to the domesticated camel, in which these senses are very dull. Colonel Prejevalsky employed hunters to procure the skins of these animals, and three skins were brought to him, representing a male, a female, and a colt.

In Germany, according to the *Polytechnic Review*, sawdust is employed in the production of sundry articles both useful and ornamental. A plastic mass is prepared, composed two-thirds of hard-wood sawdust and one-third glue, resin, or other binding material. This is compressed in brass moulds, and the moisture driven out by heat. The articles made are bass-reliefs, piano-keys, door-knobs, brush handles and backs, etc.

The excessive "militancy" of the people of Montenegro is well illustrated by their estimate of the comparative values of male and female infants. If a man has a daughter born to him, he regards the event almost as a misfortune—at least as a sore disappointment; he goes and sits on his threshold with downcast eyes, as though begging pardon of his neighbors and friends! But if several daughters are born in unbroken succession, the mother must call in seven priests, who bless oil and sprinkle it about the house, remove the old threshold and put in a new one, thus purifying the house which was bewitched on the wedding-day. On the other hand, if a boy is born, the entire household is almost crazy with joy; a feast is spread, and friends and acquaintances come thronging in to offer their congratulations and to express the wish—so characteristic of the national spirit—that the new-born babe may never die abed!

Workmen employed in nail-manufactories are liable to contract a grave lung-disease known as "nailers' consumption," caused by the deposit of iron particles in the cells of the lungs. The best preventive of nailers' consumption is no doubt the use of a respirator, such as that contrived by Prof. Tyndall for the use of firemen. The respirator would exclude from the respiratory organs the minutest particles of solid matter; it is far more effectual than any of the other devices which have been proposed, such as moist sponges or false mustaches.

The exorbitant price demanded by the patentees of the Bell telephone for their instruments causes no little discontent in England, where that form of the telephone has the field to itself, so far as the law is concerned. It does seem rather extortionate to levy from twenty-five to thirty-five pounds sterling on the purchase of an instrument that could be sold with a profit for half as many shillings. The result is, that the patent is boldly infringed: the separate parts of the telephone are for sale everywhere at a low price, and so people are enabled to make telephones for themselves. It is not probable that the decrees of courts which seek to uphold so odious a monopoly can be enforced.

William Laidlaw, native of Congo, now a freedman living in the island of Dominica, was born with six fingers on each hand. He is the father of four children, two boys and two girls, each born with six fingers on the hands, one of the girls having also six toes on each foot. One of the sons is the father of two boys who have six fingers on each hand; and the five children of the other son were born with the same peculiarity. This family well illustrates the wonderful persistence of sedigitism.

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